California Invasive Species Council (CISAC)
Invasive shothole borers Subcommittee
Research Working Group

Co-chairs: Shannon Lynch; sclynch@ucdavis.edu
Bea Nobua-Behrmann; benobua@ucanr.edu

The Research Working Group of the CISAC ISHB Subcommittee was tasked with identifying and prioritizing research projects addressing the invasive shot hole borers (ISHB) that have become established in California. As a group, we developed and provided justifications for those projects and estimated the length and costs associated with each. This document contains the 22 identified projects, organized into the following research categories: Epidemiology, Biology, Control, Monitoring, Integrated Pest Management (IPM), and Social Science. Each project is designed to contribute toward solving the broader FD-ISHB problem.

By July 17th, please:

- Review each research project Justification and Objectives
- **Identify your top 5 priorities by its identification number**
- Come to the meeting prepared to share your top 5 priorities

Epidemiology

1: Model establishment and spread of FD-ISHB over space and time

Leads:
Shannon Lynch: UC Davis, Plant Pathology Department
Jon Detka: CSU Monterey Bay, Applied Environmental Science Department

Justification
Fusarium dieback–invasive shothole borer (FD–ISHB) is an urgent and growing threat to California's forests, urban trees, and agricultural landscapes. To protect these vital resources, we need smarter tools that can tell us not just *where* infestations are most likely to occur, but also *how quickly* and *how widely* they'll spread once they do. Our existing model provides a strong foundation by identifying areas where tree communities and climate conditions make establishment more likely. These results will soon be available through a new interactive map tool hosted at ishb.org, which visualizes spatial patterns of risk across 170 California cities with complete street tree inventories from the California Urban Forest Inventory, the largest dataset of individual urban trees in the U.S. However, this still represents only a fraction of the potential at-risk areas across the state. One of the major goals of this project is to expand the reach and impact of that tool. We aim to build a flexible, user-friendly platform that allows cities, land managers, and community groups to upload their own tree inventory data and instantly generate customized, locally relevant risk maps. Whether users are managing city street trees, riparian zones, avocado groves, or parks, this tool will help them visualize real-time risk based on *their* data, filling critical information gaps, improving surveillance, and supporting informed decision-making on the ground.

But that's only part of the picture. FD–ISHB spreads across a wide range of landscapes, from dense urban corridors to patchy forests and avocado groves. To stay ahead of this threat, we also need to understand how landscape features such as habitat connectivity, urban development patterns, and barriers influence where and how fast the pest–pathogen complex can move. In addition, we must account for how infestations unfold over time, so we can act earlier, allocate resources more effectively, and prevent long-term ecological and economic damage. This project fills those critical gaps by developing next-generation models that simulate *both* the spatial spread and temporal dynamics of FD–ISHB outbreaks. These tools will allow us to identify new hotspots before infestations occur; forecast how infestations will grow and move over time; evaluate the effectiveness of different management strategies before deploying them on the ground; improve early detection and intervention efforts; and plan for future scenarios shaped by climate change and urban development. The recent spread of FD–ISHB into Northern California makes this work especially urgent. With time, budgets, and personnel stretched thin, California needs science-based decision tools that help land managers, city officials, and agencies prioritize action. This project delivers a practical, forward-looking approach to managing one of the most complex invasive pest problems facing the state today.

Objectives

1. **Expand the statewide monitoring network** by incorporating new infested and non-infested plots in Northern California to improve model accuracy across broader ecological and climatic gradients.
2. **Refine spatial susceptibility models** by integrating landscape structure and habitat connectivity to improve predictions of where FD–ISHB is most likely to establish.
3. **Develop a dynamic SEIR (Susceptible–Exposed–Infectious–Removed) epidemic model** to simulate the progression of FD–ISHB outbreaks over time and under varying ecological and management conditions.
4. **Forecast the spatial and temporal spread of FD–ISHB** under multiple future scenarios, including differing management responses, climate projections, and urban expansion patterns.
5. **Create an interactive, user-friendly map platform** that allows stakeholders to upload tree inventory data and receive real-time, localized risk assessments to guide surveillance and management decisions.
6. **Produce updated, statewide risk maps** that incorporate new field data, user-submitted inventories, and model refinements to support targeted monitoring and early intervention efforts.

Project Duration: 4 years
Total for 4 years: $1,161,582 + overhead

---

2. Assessment of ISHB dispersal risk through green waste handling and management

Leads:
Beatriz Nobua-Behrman: UC Cooperative Extension, Orange and LA Counties
Shannon Lynch: UC Davis, Plant Pathology Department
David Pegos: CDFA

Justification

The movement of green waste is a recognized pathway for the spread of invasive shothole borers (ISHB) and other tree pests in California. Recent regulatory shifts, such as the elimination of diversion credit for green waste used as alternative daily cover in landfills, have led to increased reliance on processing and composting facilities. These changes may inadvertently raise the risk of pest dispersal by increasing the transport distance of infested materials and the likelihood of beetles emerging from stored wood near susceptible trees.

This project aims to identify key points within the green waste stream where the risk of ISHB spread is highest. While our primary focus will be on Los Angeles and Orange counties, we may expand to other regions as appropriate. In collaboration with Local Enforcement Agencies (LEAs), we will engage green waste facilities and landscaping companies through a combination of surveys, site visits, and trapping to better understand current practices. We will identify risk hotspots and co-develop practical outreach and management strategies to mitigate that risk. Results will guide the development of best practices and educational materials, and help inform future funding and policy decisions aimed at minimizing pest spread through green waste

Objectives

1. **Identify high-risk stages within the green waste stream** that contribute the most to the spread of invasive shothole borers.
2. **Develop practical outreach materials and management recommendations** in collaboration with LEAs and industry partners to reduce pest dispersal through green waste handling.

Project Duration: 2 years
Total for 2 years: $93,210 + overhead

---

3. Strategic tree selection to slow FD-ISHB spread in California landscapes.

Leads:
Shannon Lynch: UC Davis, Plant Pathology Department

Justification

FD–ISHB attacks a wide range of tree species, but not all hosts contribute equally to the risk of establishment and spread. Research shows that disease dynamics are closely tied to local tree community composition, particularly the presence and relative abundance of reproductive hosts that support beetle colonization and the growth of its symbiotic pathogenic fungi (Lynch et al. 2025). This project translates that insight into actionable guidance by identifying combinations of tree species that minimize site susceptibility and slow the progression of FD–ISHB outbreaks. Our findings will directly support restoration, reforestation, and urban planting programs by providing science-based recommendations on tree palettes that enhance resilience, reduce long-term management costs, and limit the likelihood of future infestations. We will leverage the statewide risk model developed by Lynch et al. (2025), which used data from over 5.2 million individual trees representing 1,037 species across 170 California cities, the largest known inventory of urban trees in the U.S. This model identifies areas of both high and low establishment risk. By focusing on low-risk locations, we will analyze the composition and structure of local tree communities to identify species combinations associated with reduced FD–ISHB risk. The result will be a regional menu of recommended tree species combinations designed to fit California's diverse climate zones, management goals, and ecological conditions. These tools will empower land managers, city planners, and community groups to make informed planting decisions that serve climate adaptation and biodiversity goals and reduce vulnerability to one of California's most damaging invasive pests. By aligning strategic planting with pest ecology, this project offers a proactive, landscape-level approach to slowing FD–ISHB spread and building more resilient tree communities statewide.

Objectives:

1. Identify tree species combinations that reduce FD–ISHB establishment and spread, and develop region-specific planting guidelines to support resilient, low-risk landscapes across California.

Project Duration: 1 Year
Cost: $98,210 + overhead

Biology

4. Effects of nutrient and water availability on the severity of Fusarium dieback–invasive shothole borer (FD–ISHB) infestations in California

Leads:
Shannon Lynch: UC Davis, Plant Pathology Department

Justification
Field observations suggest that trees growing in areas with high water availability or excess nutrients such as floodplains, irrigated groves, or sites affected by wastewater suffer more severe infestations. This may be due to changes in wood density and moisture content that make trees easier for beetles to colonize and more favorable for their fungal symbionts. However, until now, these patterns have not been tested experimentally or evaluated at a statewide scale. This project will generate the first comprehensive evidence on how soil nutrients and water availability influence FD–ISHB development, colonization success, and outbreak severity. By identifying specific environmental factors that increase risk, we can give land managers, urban foresters, and restoration practitioners clear guidance on which sites are more vulnerable and should be prioritized for monitoring**,** which management practices (e.g., irrigation, fertilization, soil amendments) may increase or reduce risk, how to design future planting and restoration projects to avoid creating conditions that favor infestation.

Objectives

1. **Quantify how nitrogen availability affects ISHB reproduction and development** by measuring beetle emergence, fecundity, and growth rates in artificial sawdust media with varying nitrogen concentrations.
2. **Evaluate the effects of water and nutrient levels on beetle success in live host trees** through controlled greenhouse experiments across multiple tree species.
3. **Assess whether soil nutrients and proximity to water predict infestation severity** by analyzing field data from 15,000 trees across 260 long-term monitoring plots in Southern California.

Project Duration: 2 years
Cost: $244,212 + overhead

5. Are California's crops at risk? Determining the reproductive host potential of agricultural species for invasive shothole borers.

Leads:
Shannon Lynch: UC Davis, Plant Pathology Department
Akif Eskalen: UC Davis, Plant Pathology Department

Justification
While FD-ISHB are known to attack a wide range of native and ornamental tree species, it remains unclear whether key agricultural crops, including high-value fruit, nut, and vine crops, can serve as reproductive hosts that support beetle colonization and fungal development. Without this knowledge, growers, regulators, and pest managers are left without the information they need to proactively protect crops and prepare for potential outbreaks. This issue is particularly pressing in California's Central Valley, one of the most productive agricultural regions in the world and home to vast acreages of tree crops. Recent modeling (Lynch et al. 2025) shows that the Central Valley's climate is highly favorable to ISHB reproduction and spread. If these beetles can complete their life cycle on common agricultural species, the region could serve as a high-risk corridor that facilitates natural spread of the pest–pathogen complex throughout the state, posing a direct threat to forested, urban, and agricultural landscapes statewide. This project fills a critical knowledge gap by systematically evaluating the susceptibility of California's agricultural crops to ISHB infestation. Through a combination of fungal colonization trials, beetle host acceptance assays, and host preference experiments across multiple beetle generations, we will assess whether agricultural species can support the full reproductive cycle of these pests. By the end of this project, regulatory agencies and growers will have science-based risk assessments to guide monitoring, quarantine, and management strategies. Understanding whether agricultural crops are part of the reproductive host range is a foundational step in protecting California's agricultural economy from one of the state's most damaging invasive insect–pathogen complexes.

Objectives

1. Determine whether high-value California agricultural crops can serve as reproductive hosts for invasive shothole borers by assessing beetle colonization success and fungal symbiont establishment.

Project Duration: 4 Years
Cost: $372,880 + overhead

---

6. Investigating host preference plasticity in invasive shothole borers.

Leads:
Shannon Lynch: UC Davis Plant Pathology Department

Justification
Invasive shothole borers (ISHB) are known to attack a wide variety of tree species, yet field observations often reveal strong site-level preferences for certain hosts, even among tree species that are similarly susceptible. This discrepancy poses a significant challenge for monitoring and management: pest managers may overlook high-risk hosts if beetles appear to ignore them in the field, or conversely, overprioritize trees that are attacked more due to local beetle behavior rather than inherent vulnerability. One plausible explanation is that host preference in ISHB is not fixed, but instead shaped by previous experience, particularly during

larval development. Beetles reared for several generations on a single host species may develop a preference for that host, skewing host selection behavior in the field. This form of host-conditioning or preference plasticity could help explain why the same beetle population behaves differently across landscapes. To address this critical knowledge gap, we will experimentally rear ISHB on sawdust media from different host species across multiple generations, then switch the host media and test whether preferences shift accordingly. This will allow us to disentangle inherent host susceptibility from learned or induced host preferences. By understanding whether host choice is influenced by beetle rearing history, we can improve early detection by targeting likely preferred hosts based on local beetle conditioning; avoid underestimating risk to hosts that may not be preferred now but could become targets following a host shift; develop more resilient planting and restoration strategies by factoring in behavioral plasticity in pest dynamics; and provide scientifically grounded recommendations for risk assessment models that reflect both ecological and behavioral drivers of infestation. Ultimately, this work will help regulatory agencies, land managers, and growers make more accurate predictions about ISHB behavior in specific settings, allowing for more targeted, efficient, and cost-effective management strategies.

Objectives

1. Determine whether larval rearing history influences ISHB host preference and fecundity by rearing beetles on different host media and assessing performance after host switching.

Project Duration: 3 years
Cost: $228,779 + overhead

---

7. Uncovering bacterial–fungal interactions in the mycangia of invasive shothole borers

Leads:
Shannon Lynch: UC Davis Plant Pathology Department
Akif Eskalen: UC Davis Plant Pathology Department

Justification

ISHB rely on symbiotic relationships with mycangial fungi to colonize and reproduce within host trees. We have extensively characterized these beetle–fungal interactions, yet one critical component remains largely unexplored: the bacterial communities that coexist within the beetle's mycangia. Our preliminary work indicates that bacteria are consistently present in ISHB mycangial fungi, but their identities, functions, and ecological roles are unknown. This knowledge gap represents a significant blind spot in our understanding of ISHB biology. Given that bacteria in other insect–fungus symbioses are known to influence fungal growth, mediate pathogen suppression, or facilitate nutrient cycling, these bacteria may play key roles in fungal maintenance, vector success, or host-pathogen interactions. Understanding these bacterial–fungal relationships is crucial for improving management strategies, clarifying invasion mechanisms, and refining diagnostic tools. This project will initiate a foundational survey of bacterial taxa in mycangia isolated from ISHB, using culture- and sequence-based methods. The goal is to identify core bacterial taxa and evaluate their in vitro interactions with the mycangial symbionts *Fusarium*, *Graphium*, and *Paracremonium* to better understand their functional roles within the beetle–fungus complex. Gaining this baseline knowledge is essential to fully understand and effectively manage the complex microbiome that supports ISHB survival and spread.

Objectives

1. Characterize the bacterial communities associated with ISHB mycangial fungi.
2. Determine the in vitro interactions between isolated bacterial taxa and the key mycangial fungal symbionts (*Fusarium*, *Graphium*, and *Paracremonium*) to assess potential synergistic or antagonistic relationships.

Project Duration: 1 year
Cost: $76,260 + overhead

---

8. Defining the host range of *Euwallacea interjectus* to protect California's urban and natural forests

Leads:
Shannon Lynch: UC Davis Plant Pathology Department

Justification
The recent detection of *Euwallacea interjectus* (GSHB) in Santa Cruz County marks the first known introduction of this beetle–pathogen complex to the western U.S. Unlike PSHB and KSHB, the host range of GSHB in California remains largely unknown, limiting our ability to detect early infestations, assess risk to native and cultivated species, and prioritize monitoring efforts. Early detection, risk assessment, and mitigation depend on knowing which tree species GSHB can successfully colonize. Field surveillance is severely hampered without this information, risking delayed intervention and widespread establishment. Given GSHB's broad host use in other regions, including damage to *Populus* spp. and *Acer negundo*, a systematic evaluation of its host range is urgently needed to inform field surveillance and prevent widespread establishment in California's diverse landscapes. This project directly addresses this urgent need by conducting systematic no-choice bioassays to evaluate GSHB reproductive success on a representative panel of 50 tree species from across California's diverse ecosystems. By ranking species based on beetle colonization, reproduction, and fungal symbiont establishment, we will identify which native, ornamental, and cultivated trees are most vulnerable. This information is critical for guiding early detection and monitoring programs toward high-risk hosts; updating management protocols; informing restoration planting decisions to avoid future vulnerability; and prioritizing rapid response strategies to prevent widespread establishment. Without a foundational understanding of host susceptibility, California remains unprepared to contain this new pest–pathogen complex. This study will provide the science-based guidance needed to safeguard the state's forest and urban tree resources.

Objective
1. Determine the potential host range of GSHB using no-choice assays on a representative panel of 50 tree species in California.

Project Duration: 2 years
Cost: $218,379 + overhead

Control

Biocontrol

9. Prospecting and testing endophytic biocontrol agents for Fusarium dieback management
Leads:
Shannon Lynch, UC Davis Plant Pathology Department
Akif Eskalen, UC Davis Plant Pathology Department
Justification:
Long-term, sustainable management of FD–ISHB in California wildlands requires tools that go beyond chemical treatments and are feasible for large-scale restoration and revegetation efforts. Our previous greenhouse studies have shown that certain endophytes isolated from California native hosts can suppress ISHB-associated *Fusarium* spp. (Lynch et al., 2025). However, their effectiveness under field conditions remains untested. At the same time, the California hosts from which our microbes were isolated may not harbor the same evolutionary resistance or microbial defenses as native trees in the beetle's region of origin. This raises the possibility that more effective or co-adapted microbial antagonists exist in ISHB's native range. To address both near-term and long-term needs, this project takes a dual approach. First, we will conduct field trials in California to evaluate the efficacy of native microbial inoculants on both outplanted and mature native trees. Second, we will launch a foreign exploration program in Japan, Taiwan, Thailand, and Vietnam, where ISHB and its *Fusarium* symbionts co-evolved with native host trees. Our goal is to isolate novel endophytes from these native-range trees and conduct in vitro screening to identify those with strong antifungal activity against ISHB-associated *Fusarium* spp.
By combining local field validation with international bioprospecting and early-stage screening, this project aims to build a diverse and well-characterized pipeline of microbial biocontrol candidates for long-term restoration resilience and integrated pest management.
Objectives:

1. **California-Based Field Testing:**
    - Evaluate the efficacy of native endophytic microbial inoculants in suppressing *Fusarium* colonization on (a) outplanted native trees in restoration sites and (b) mature native trees in natural habitats.
2. **Foreign Exploration and In Vitro Screening:**
    - Isolate and identify endophytic microbes from ISHB-associated host trees in the beetle's native range (Japan, Taiwan, Thailand, and Vietnam).
    - Screen isolates in vitro for antifungal activity against *Fusarium* spp. associated with ISHB.

Project Duration: 4 years
Cost: $540,480 + overhead

---

10. Harnessing the rhizosphere for sustainable management of FD–ISHB

Leads:
Shannon Lynch UC Davis Plant Pathology Department

Akif Eskalen: UC Davis Plant Pathology Department

Justification
While our research has demonstrated clear differences in the wood microbiome between FD–ISHB-infested and non-infested trees (Lynch et al., 2025), studies in other plant disease systems suggest that rhizosphere microbial communities may also play a pivotal role in influencing host susceptibility and disease outcomes. Additionally, healthy trees may benefit from a protective belowground microbiome that suppresses *Fusarium* spp., promotes systemic resistance, or competes with beetle-associated fungi for colonization niches. Despite this potential, the composition and functional role of rhizosphere microbiota in FD–ISHB-impacted systems remain poorly understood. This represents a critical gap in our understanding of disease dynamics and limits our ability to harness soil health as part of an integrated management strategy.

This project aims to evaluate the role of rhizosphere microbial communities in modulating FD–ISHB disease severity by addressing the **following objectives**:

1. Collecting rhizosphere soil samples from diseased and non-diseased trees across long-term monitoring plots to characterize microbial community composition and identify potential protective taxa.
2. Testing the efficacy of microbial inoculants and soil amendments in suppressing fungal colonization and improving tree resilience in both greenhouse and field trials.

By identifying rhizosphere microbial profiles associated with disease suppression and evaluating strategies to manipulate soil microbial communities, this research will generate actionable insights into how soil health and microbial diversity contribute to aboveground disease resistance. Ultimately, the results will inform the development of ecologically based, long-term management strategies for FD–ISHB, reducing reliance on chemical treatments and enhancing the success of restoration plantings.

Objectives
See text above

Project duration: 4 years
Cost: $382,200 + overhead

---

11. Placeholder – this project was merged with # 9

---

12. Expanding foreign exploration for biological control agents of invasive shothole borers in Southeast Asia

Leads:
Paul Rugman-Jones: UC Riverside Entomology Department

Justification
Current foreign exploration has identified several parasitoid wasps that use ISHB as a host in Taiwan. A colony of one of these species, *Phymastichus nududraco*, has been successfully established in U.S. quarantine (USDA-APHIS-PPQ, Buzzards Bay, MA), and host-specificity testing is about to begin. That testing is being funded by a federal grant, and while a step in the

right direction, the suitability and approval of this species for release as a biological control agent is by no means guaranteed. Furthermore, ISHB has been deprioritized at the federal level and funding for continued foreign exploration has ended. This is unfortunate since it is unlikely that the fauna of Taiwan is fully representative of the natural enemies associated with a beetle complex that occurs across the whole of SE Asia.

In the last round of CISAC funding (2020), we (Richard Stouthamer, now retired) were awarded funding to expand the geographic scope of our foreign exploration efforts. However, we were unable to achieve much due to severe travel restrictions imposed during the COVID-19 pandemic, and that funding was returned, largely unspent. Eventually, in 2023 we were able to use federal funds to expand our foreign exploration effort to northern Thailand. Working in collaboration with a researcher at Chiang Mai University, we have completed two, short collecting trips and already identified that several potential biological control agents for ISHB are present. These again included *Phymastichus nudusdraco*, but also several additional parasitoids that we had not encountered in Taiwan. This is extremely encouraging and confirms that extending foreign exploration to other parts of the native range of ISHB can yield further natural enemies, thereby improving our chances of developing a successful classical biological control agent. The ultimate goal of this research is to identify additional natural enemies of ISHB (and now GSHB) within their native range, and to assess the potential of such enemies for use as classical biological control agents in California.

Objectives:

1. Conduct exploration for natural enemies of ISHB in Thailand and Japan. We already working in Thailand and have also identified a collaborator in Japan. The island of Okinawa is of particular interest since it is known to harbor both polyphagous- and Kuroshio shothole borers, with the former being a significant pest in mango.
2. Import natural enemies into quarantine at UCR and establish permanent colonies of each. The relevant import permit is already in place for Thailand.
3. Establish a permanent colony of *Phymastichus nudusdraco* from Taiwan, at UCR. Having two disparate colonies will provide a critical back-up should one be lost.
4. Test the acceptability of GSHB (*Euwallacea interjectus*) as a host for *P. nudusdraco*. This can be incorporated into the federally funded host specificity testing (at little to no cost) or can be conducted at UCR once we establish a *Phymastichus* colony.
5. Look for additional natural enemies of GSHB in Taiwan. We have previously encountered GSHB in wood infested by ISHB, so we have a head start on knowing where to begin looking.

Project duration: 3 years
Cost: $757,500 + overhead

Chemical Control

13. Locally systemic fungicides for the management of Fusarium dieback–ISHB

Leads
Akif Eskalen: UC Davis Plant Pathology Department

Justification

This project focuses on evaluating locally systemic fungicides as a practical tool to manage *Fusarium dieback* (FD), a serious tree disease caused by fungi carried by invasive shot hole borers (ISHB). While many current treatments are limited in effectiveness, this work builds on our earlier lab research that identified several promising fungicides capable of slowing fungal growth. We will expand our testing to include newly available conventional (synthetic) and biologically derived fungicides on the three main fungal species that cause FD: *Fusarium euwallaceae, F. kuroshium,* and now *F. floridanum*. Laboratory screening allows us to quickly and efficiently compare how well different products inhibit fungal growth. The most promising treatments will then be tested in greenhouse and field trials to evaluate how well they protect trees under more realistic conditions. In these trials, we'll apply fungicides to trees with and without simulated beetle damage to determine whether they can reduce fungal infection, beetle survival, and visible disease symptoms like lesions and wood staining. Our goal is to identify products that can be safely and effectively used to protect vulnerable tree species in both urban landscapes and wildland restoration areas. The results of this project will help guide best-use practices for fungicide application, and provide science-based recommendations for integrating chemical treatments with other tools in integrated pest management (IPM) programs for FD–ISHB.

Objectives

1. Evaluate the efficacy of locally systemic fungicides in suppressing *Fusarium* spp. through laboratory, greenhouse, and field trials.

Project duration: 3 years
Cost: $198,300 + overhead

---

14. Plant-based and biorational treatment strategies for managing FD-ISHB in water-sensitive landscapes

Leads:
Akif Eskalen: UC Davis Plant Pathology Department
Shannon Lynch: UC Davis Plant Pathology Department

Justification

This project explores plant-based and biorational treatment strategies for managing *Fusarium dieback* (FD) and invasive shot hole borers (ISHB), with a focus on water-sensitive landscapes such as riparian zones, public greenspaces, and ecological restoration sites where the use of conventional pesticides is limited. We will evaluate a range of botanical and biologically derived compounds, including entomopathogenic fungi, salicylic acid analogs, and other biofactors, that either activate host defense responses or directly impact beetle survival and fungal colonization.

Plant defense activators are environmentally friendly compounds, often produced naturally by plants, that stimulate internal resistance pathways. Compounds such as salicylic acid, oxalic acid, acibenzolar-S-methyl, and potassium phosphate have been shown to significantly reduce disease development in a range of crops, including citrus, rice, and cashew (Hu et al. 2018; Lopez & Lucas 2002; Sreeja 2014). In our pilot study on infested willows in semi-natural habitats at UC Irvine, these defense inducers reduced new ISHB attacks by 30% within a year (Eskalen), underscoring their potential as low-risk alternatives to chemical pesticides in restoration and wildland contexts. We will also build on previous work evaluating biopesticide delivery systems. Prior studies explored mixing entomopathogenic fungi with fire-retardant gels to improve residual efficacy on bark surfaces; more recently, we tested a novel chitin-based foam to hold fungal biopesticides in place. Although initial results were promising, field degradation of the foam limited its persistence. This project will optimize minimally invasive delivery methods, such as tree-inserted tablets, pelleted carriers, or slow-release formulations, which can be deployed without spray rigs or heavy equipment. In parallel, we will compare performance and environmental risk of these alternatives to conventional systemics (e.g., imidacloprid tablets). The goal is to identify practical, scalable, and water-safe treatment options that can be integrated into long-term management strategies for FD–ISHB, particularly in sensitive or hard-to-access landscapes.

Objectives

1. Evaluate the efficacy of plant defense activators and biologically derived treatments in reducing *Fusarium* infection in native tree hosts.

Project duration: 4 years
Cost: $340,600 + overhead

Mechanical Control

15. Push-pull trap strategies for ISHB-FD control

Leads:
Akif Eskalen: UC Davis Plant Pathology Department

Justification
This project will test how well "push-pull" strategies can help manage the *Fusarium dieback–polyphagous shot hole borer* (FD–ISHB) complex in California's landscapes. In a push-pull system, repellents are used to drive beetles away from high-value trees (push), while attractants draw them into traps (pull), reducing the number of beetles that successfully colonize host trees. We will test and compare different types of traps (sticky panels versus freshly cut logs) and arrange them in various layouts (grids and barriers) across multiple field sites. By using chemical lures that mimic beetle attractants, we'll measure how effectively each setup captures beetles and prevents damage to nearby trees throughout the year. Our approach is based on recent simulation models (Byers and Levi-Zada, 2022) and builds on our previous field work in avocado and sycamore systems. We'll combine field experiments with computer simulations to find the most effective and cost-efficient trap spacing and orientation. The end goal is to provide clear, practical guidelines for using push-pull methods as part of an integrated pest management (IPM) strategy for land managers, arborists, and restoration practitioners working to protect trees in both urban and wildland settings.

Project duration: 2 years
Cost: $186,000 + overhead

---

16. Assessing ISHB viability in composted mulch from infested plant material

Lead:
Beatriz Nobua-Behrman: UC Cooperative Extension, Orange and LA Counties

Justification
Composting is widely considered an effective method for producing pest-free green waste products. However, one common output, composted mulch, often contains relatively large wood chips that may not meet current ISHB mitigation guidelines, which recommend chipping infested wood to less than 1 inch in size. While the composting process involves heat and microbial

activity that could eliminate ISHB, it is unclear whether these conditions are consistently sufficient when larger wood pieces are present.

This project will compare composted mulch and uncomposted mulch derived from ISHB-infested material to evaluate whether viable beetles remain in either product. The goal is to determine whether composted mulch can be considered ISHB-free, and to inform science-based recommendations for mulch processing and use.

Objective

1. Assess whether composting ISHB-infested wood, including material with larger chip sizes, effectively eliminates viable beetles, and determine if composted mulch can be safely used without contributing to pest spread.

Project Duration: 1 year
Total for 1 year: $38,000 + overhead

Monitoring

17. AI-assisted identification and quantification of *Euwallacea* beetles from monitoring trap images

Leads
Jiri Hulcr: University of Florida Forest Entomology Department

Justification
Rapid and accurate identification of invasive *Euwallacea* beetles, including is critical for monitoring and responding to FD-ISHB outbreaks in California. Currently, species-level identification relies on highly trained personnel and time-consuming lab work, creating bottlenecks in trap processing and delaying management actions. This project will develop an AI-assisted image-based identification tool trained specifically on *Euwallacea* beetles captured in California surveys. Building on recent advances in machine learning for bark beetle identification (Marais et al. 2025), the tool will use deep learning to classify beetles from trap images, reducing reliance on expert taxonomists and enabling rapid, high-throughput screening. We will assemble a comprehensive training dataset using verified beetle specimens and apply state-of-the-art techniques (e.g., MaxViT architecture, out-of-class detection algorithms) to distinguish among key ISHB complex members, while flagging unknown or suspect specimens for expert review. This approach has already proven effective in separating morphologically similar bark beetle genera with >99% accuracy under controlled conditions. The outcome will be a deployable prototype to support both statewide CDFA-led monitoring and local detection efforts, improving identification speed, diagnostic accuracy, and resource efficiency across California.

Objectives

1. Develop an AI-based tool to identify and quantify *Euwallacea* beetles from California monitoring trap images to support rapid, large-scale detection and response efforts.

Project Duration: 2 years
Cost: $160,000 + overhead

---

18. A portable diagnostic tool for early detection of FD-associated *Fusarium* species and their beetle vectors

Leads:
Shannon Lynch: UC Davis Plant Pathology Department
Caterina Villari: University of Georgia, Warnell School of Forestry and Natural Resources

Justification
Land managers, regulators, and pest control professionals urgently need fast and reliable tools to identify invasive pests and their associated pathogens in the field. Currently, species-level identification of *Fusarium dieback* (FD) pathogens and their beetle vectors requires weeks of lab-based testing, which delays management responses and increases the risk of spread. This project will develop a portable, field-ready diagnostic tool using loop-mediated isothermal amplification (LAMP), a simple, rapid, and highly accurate molecular technique. Unlike traditional lab methods, LAMP assays can deliver results in under 30 minutes using basic equipment and minimal training, making them ideal for on-site use in forest, agricultural, and urban environments. Our goal is to create a LAMP-based test that can accurately detect and distinguish between the three main *Fusarium* species that cause FD (*F. euwallaceae*, *F. kuroshium*, and *F. floridanum*) as well as their invasive beetle vectors (PSHB, KSHB, and GSHB). We will first validate the test in the lab using known samples, then test it on real-world samples (infected plant tissues and beetles) collected from the field. Once developed, this tool will allow stakeholders to diagnose infections quickly and accurately, enabling timely decisions such as containment, eradication, or targeted treatment. This will be especially critical for detecting new introductions like GSHB and managing outbreaks of established pests in California's forests, farms, and urban landscapes.

Objectives

1. Develop and validate a rapid field-deployable LAMP assay for early and species-specific detection of *Fusarium euwallaceae*, *F. kuroshium*, and *F. floridanum.*

Project duration: 3 years
Cost: $323,000

---

19. Trap optimization for the greater shothole borer

Leads
Shannon Lynch: UC Davis Plant Pathology Department

Justification
Effective detection and monitoring are critical for managing invasive pests like the greater shothole borer (GSHB), a newly introduced species in California with limited biological and behavioral data. While monitoring strategies developed for PSHB and KSHB have relied on the semiochemical querciverol as an attractant, we currently assume that GSHB responds to querciverol in the same way. However, without species-specific validation and optimization, our current traps may underestimate GSHB presence and spread, leading to delayed detection and ineffective management responses. This project will fill that knowledge gap by optimizing semiochemical-based traps for accurate, efficient detection of GSHB. Through a series of four field experiments at Zayante Trail where GSHB was first detected in high numbers, we will test lure composition, concentration, and release rates to identify the most effective trap setup. These experiments will also evaluate whether combining querciverol with other known attractants (such as α-copaene and ultra-low release ethanol) improves beetle capture. In

addition to improving trap performance, we will assess daily and seasonal flight activity to better understand beetle behavior and refine the timing of survey and management efforts. Data on peak flight periods will enable more strategic deployment of traps, increasing the chances of early detection in new locations. Ultimately, this work will produce science-based guidelines for trapping and monitoring GSHB, providing land managers, regulatory agencies, and researchers with a reliable, field-tested tool to track and respond to this emerging pest threat. These insights are essential for protecting California's urban forests, riparian systems, and restoration plantings from the potential impacts of GSHB.

Objectives
1. Optimize greater shothole borer monitoring traps.

Project Duration: 2 years
Cost: $196,500 + overhead

IPM

20. Evaluating treatment thresholds for ISHB-FD management in urban trees

Lead:
Beatriz Nobua-Behrman: UC Cooperative Extension, Orange and LA Counties

Justification
Integrated management strategies for invasive shothole borers and Fusarium dieback (ISHB-FD) in Southern California have proven fairly effective, combining tree removal, pruning, and targeted chemical treatments. However, chemical control remains costly and pesticide-intensive, especially when treating significant numbers of infested trees across urban landscapes. Notably, most infested trees (roughly 80%) are only lightly infested, and field observations suggest that many of these trees can recover naturally when the surrounding reinfestation pressure is reduced through removal and treatment of more severely affected trees.

This project will evaluate whether lightly infested trees can be excluded from chemical treatment without compromising overall management outcomes. At a site where severely infested trees will be removed and moderately to heavily infested trees managed using current best practices, lightly infested trees will be divided into treated and untreated groups. By tracking the progression or recovery of these trees over time, we aim to refine treatment thresholds, reduce unnecessary pesticide use, and maintain effective ISHB-FD control at the landscape level.

Objectives:
1. Assess whether excluding lightly infested trees from chemical treatment affects overall ISHB-FD management effectiveness in a controlled field setting.
2. Identify a practical treatment threshold within the 'lightly infested' category based on observed tree recovery or infestation progression.

Project Duration: 2 years
Total for 2 years: $277,700 + overhead

Social

21. Bioeconomic modeling of ISHB control

Leads:
Karen Jetter: University of California Agriculture and Natural Resources
Shannon Lynch: UC Davis Plant Pathology Department
Beatriz Nobua-Behrmann: UCCE Orange and Los Angeles Counties

Justification
This project will build on prior work estimating the economic benefits of public monitoring programs for the ISHB. Monitoring of invasive pests is key to early detection and management to slow the spread, and the economics costs, of invasive pests. The benefits of these programs are then in the costs avoided between the spread of an invasive pest with no monitoring and management, and their cost when monitoring and management slows their spread. In the prior study the costs of monitoring for ISHB were compared to the benefits of slowing the spread of ISHB throughout a region in California. The model used a sensitivity analysis that assumed the public monitoring program would slow the spread of ISHB over a 10 year period by a low of 10% to a high of 60%. The model was applied to seven agro-climatic regions in California. The results show that in all regions, under all scenarios, the benefits of minimizing the costs of ISHB spread are greater than the monitoring and management costs except for California's desert region when the spread of the pest is only slowed by 10% to 20%. In this region there are relatively fewer host trees, so the benefits are lower. However, if the pest is not controlled in the desert regions it will spread into the remaining areas in California, causing economic damages. Consequently, when all of California is considered the benefits of public monitoring programs are always greater than the costs under all scenarios.

The previous model incorporated generic monitoring and management costs by just considering county budgets, rather than specific costs related to specific activities. The next step in developing a bioeconomic model would be to incorporate physical characteristics into it such as different management options and a dispersion function of the pest over time, both with and without specific monitoring and management programs. The dispersion function would need to take into account both the characteristics of the pest and how it influences spread, and the environment/phenology of the area it can potentially spread into. There are three distinct regions where this will focus: Southern California, San Jose and Santa Cruz. There is a large and well-established population of ISHB in Southern California and this represents a large edge in which to complete the analysis. Both the infestation in San Jose and Santa Cruz are recent, more contained infestations. This will provide an interesting case study of different dynamics in which to complete the economic analysis.

Objectives
1. Develop an integrated bioeconomic model of ISHB spread and control that accounts for pest biology, environmental factors, and spatial variation across key infested and at-risk regions in California.
2. Quantify the economic benefits of public monitoring and management strategies by comparing avoided costs under various control scenarios and levels of intervention.
3. Generate region-specific, cost-effective recommendations to support strategic decision-making by land managers and policymakers in managing ISHB across different infestation contexts.

Project Duration: 3 years
Cost: $318,987 + overhead

---

22. Identifying barriers to local firewood use: A behavioral analysis to inform outreach and policy

Leads:
Amanda Crump: University of California Agricultural and Natural Resources

Justification
Encouraging people to buy firewood locally, rather than transporting it from other areas, is an important way to prevent the spread of invasive pests and diseases. However, getting people to change their behavior can be challenging. Many different factors influence whether someone adopts a new practice, including convenience, cost, social norms, and policies. To better understand why some people choose to buy firewood where they burn it, and why others do not, we will conduct a barrier analysis. This is a proven method used to identify the specific obstacles that prevent people from changing their behavior. We will interview 45 people who follow this best practice (adopters) and 45 who don't (non-adopters). By comparing their responses, we can identify common reasons for resistance and develop practical recommendations to help overcome those barriers. The results of this study will provide valuable insights for designing more effective outreach campaigns, educational materials, and policy strategies that support local firewood use and help protect California's forests from invasive threats.

Objectives
1. Identify key behavioral, social, and practical barriers that prevent individuals from buying firewood locally rather than transporting it from other locations.
2. Compare perspectives of adopters and non-adopters of local firewood use to understand the motivators and obstacles influencing their decisions.
3. Generate actionable recommendations for outreach, education, and policy interventions that encourage local firewood purchasing and reduce the spread of invasive pests.

Duration: 2 years
Estimated Cost: $70,000 + overhead
