ZONE OF INFESTATION PROPOSAL:

INVASIVE SHOT HOLE BORERS - SOUTHERN CALIFORNIA COUNTIES

Los Angeles

Orange

Riverside

San Bernardino

San Diego

San Luis Obispo

Santa Barbara

Ventura

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INTRODUCTION

Stands of native and ornamental tree species in Southern California are being severely damaged by the invasive ambrosia beetles, polyphagous shot hole borer (PSHB), *Euwallacea fornicatus*, and Kuroshio shot hole borer (KSHB), *Euwallacea kuroshio,* collectively known as the invasive shot hole borers (ISHB) (Gomez et al., 2018, Smith et al., 2019)). The invasive shot hole borers (ISHB) have become confirmed in eight counties in Southern California: Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara and Ventura. Of these, San Diego and Orange are counties most severely affected by these invasive insects. Both species of ISHB have wide host ranges of 65 reproductive hosts, including 18 native to California that have varying levels of susceptibility to invasion and mortality (Eskalen et al., 2013). Another 260+ tree species, representing 64 plant families are capable of being attacked but do not support beetle reproduction (Boland, 2016). Many of ISHBs host species grow in riparian habitat and are used as ornamental plantings in the urban forest. Native riparian habitats are being impacted and lost along with hundreds of thousands of trees in the urban landscape costing millions of dollars in remediation and loss of property value. Over the last 8 years, a coordinated multiagency approach involving all levels of government, universities and the tree care industry has worked to slow the spread of this beetle. Although this coordination has been effective, the threat of ISHB moving to additional counties throughout California is significant and requires more proactive steps to be taken. Establishing a Zone of Infestation (ZOI) would allow state and local officials to take immediate action to mitigate new infestations and bolster the effort against ISHB. It will also increase awareness of the threat these insects pose to infested and non-infested counties throughout the state.

BACKGROUND INFORMATION FOR THE CREATION OF THE ZONE OF INFESTATION

The beetle was initially found in 2003 but was originally identified as the tea shot hole borer (TSHB). It was later determined through genetic analyses that this was a unique species and given the common name, polyphagous shot hole borer (PSHB) (Eskalen et al., 2013). Since 2012, PSHB was found to be invading Los Angeles and Orange Counties, and into certain areas of Riverside, San Bernardino and Ventura Counties. In 2014, a separate invasion by the genetically distinct but morphologically indistinguishable Kuroshio shot hole borer was found in San Diego and Orange Counties (Rios, 2015; Univeristy of California Agriculture and Natural Resources (UC ANR), 2017). In 2016, KSHB was found in San Luis Obispo County. These ambrosia beetles carry three genera of fungi for food, *Fusarium* spp*., Graphium* spp*.,* and *Paracremonium pembeum* (Carrillo et al. 2019). The *Fusarium* fungi are the beetle's main source of food and are also plant pathogens that

cause Fusarium Dieback (Eskalen et al., 2013). Trees that are susceptible to *Fusarium* experience several symptoms including branch dieback, leaf wilting and discoloration on the branches, gumming, oozing, sugar volcanoes (in avocados), light – colored powdery exudate and death. While ISHB can infest and reproduce in 65 reproductive hosts, 15 of those hosts (Table 1) seem more susceptible to tree death by the disease-pest complex. These susceptible hosts are largely riparian species and the number of susceptible reproductive hosts keeps increasing as new hosts are discovered. The less susceptible hosts experience branch dieback and/or beetle colonization at canker margins occurs.

Table 1: Reproductive Hosts of the ISHB (as of June 2020).

* indicates California native

Susceptibility to ISHB-FD	**Common Name**	**Scientific Name**
Susceptible	Trident maple	*Acer buergerianum*
Susceptible	Big Leaf maple*	*Acer macrophyllum*
Susceptible	Box elder*	*Acer negundo*
Susceptible	Palo verde	*Parkinsonia aculeata*
Susceptible	California sycamore*	*Platanus racemosa*
Susceptible	London plane	*Platanus x hispanica*
Susceptible	Fremont cottonwood*	*Populus fremontii*
Susceptible	Black poplar*	*Populus nigra*
Susceptible	Black cottonwood*	*Populus trichocarpa*
Susceptible	Valley oak*	*Quercus lobata*
Susceptible	English oak	*Quercus robur*
Susceptible	Castor bean	*Ricinus communis*
Susceptible	Black willow*	*Salix gooddingii*
Susceptible	Red willow*	*Salix laevigata*
Susceptible	Arroyo willow*	*Salix lasiolepis*
Less Susceptible	Australian blackwood	*Acacia melanoxylon*
Less Susceptible	Acacia	*Acacia spp.*
Less Susceptible	Evergreen maple	*Acer paxii*
Less Susceptible	California buckeye*	*Aesculus californica*
Less Susceptible	Tree of heaven	*Alianthus altissima*
Less Susceptible	Mimosa	*Albizia julibrissin*
Less Susceptible	Titoki	*Alectryon excelsus*
Less Susceptible	White alder*	*Alnus rhombifolia*
Less Susceptible	King palm	*Archontophoenix cunninghamiana*
Less Susceptible	Mule fat*	*Baccharis salicifolia*
Less Susceptible	Purple orchid tree	*Bauhinia variegata*
Less Susceptible	Kurrajong	*Brachychiton populneus*
Less Susceptible	Camellia	*Camellia semiserrata*

Less Susceptible	Moreton Bay chestnut	*Castanospermum australe*
Less Susceptible	Australian pine tree	*Casuarina equisetifolia*
Less Susceptible	Blue palo verde*	*Parkinsonia florida*
Less Susceptible	Sonoran palo verde	*Parkinsonia x sonorae*
Less Susceptible	Laurel leaf snailseed tree	*Cocculus laurifolius*
Less Susceptible	Carrotwood	*Cupaniopsis anacardioides*
Less Susceptible	Strawberry tree	*Dombeya cacuminum*
Less Susceptible	Coast coral tree	*Erythrina caffra*
Less Susceptible	Coral tree	*Erythrina coralloides*
Less Susceptible	Brazilian coral tree	*Erythrina falcata*
Less Susceptible	Red flowering gum	*Corymbia ficifolia*
Less Susceptible	Japanese beech	*Fagus crenata*
Less Susceptible	Council tree	*Ficus altissima*
Less Susceptible	Black mission fig	*Ficus carica*
Less Susceptible	Honey locust	*Gleiditsia triacanthos*
Less Susceptible	Tulip wood	*Harpullia pendula*
Less Susceptible	Kentia palm	*Howea forsteriana*
Less Susceptible	Chinese holly	*Ilex cornuta*
Less Susceptible	Jacaranda	*Jacaranda mimosifolia*
Less Susceptible	Japanese maple	*Acer palmatum*
Less Susceptible	Chinese flame tree	*Koelreuteria bipinnata*
Less Susceptible	American sweet gum	*Liquidambar styriciflua*
Less Susceptible	Southern magnolia	*Magnolia grandifloria*
Less Susceptible	Sweet bay	*Magnolia virginiana*
Less Susceptible	Avocado	*Persea americana*
Less Susceptible	Mexican sycamore	*Platanus mexicana*
Less Susceptible	Mesquite*	*Prosopis articulata*
Less Susceptible	Chinese wingnut	*Pterocarya stenoptera*
Less Susceptible	Coast live oak*	*Quercus agrifolia*
Less Susceptible	Canyon live oak*	*Quercus chrysolepis*
Less Susceptible	Englemann oak*	*Quercus englemannii*
Less Susceptible	Cork oak	*Quercus suber*
Less Susceptible	Weeping willow	*Salix babylonica*
Less Susceptible	African tulip tree	*Spathodea campanulata*
Less Susceptible	Tamarisk	*Tamarix ramosissima*
Less Susceptible	Japanese wisteria	*Wisteria floribunda*
Less Susceptible	Dense logwood/Shiny *Xlyosma*	*Xylosma congesta*

Since 2012 & 2015 when the PSHB & KSHB were identified respectively, hundreds of thousands of trees have been infested in the urban and forest settings in Southern California (Boland, 2020;

Parks, 2018). ISHB are native to Southeast Asia and were believed to be brought to the US through untreated wood packaging material or plant material (Eskalen personal communication, Wingfield et al, 2010). Since their introduction these insects have spread both by natural and human mediated movement of infested firewood and greenwaste. All ownerships – federal, state, tribal, county, city and private property have been impacted by ISHB. Recognizing that these are new pests to California and our forest systems do not have natural defense mechanisms, there is significant concern that these pests will continue to impact and spread within forested areas throughout California.

ISHB has already caused significant economic, ecological, cultural and aesthetic losses to the region. One example of this is within the Tijuana River Valley, where more than 375,000 trees over 597 acres of primary riparian forest have been infested by KSHB (Boland, 2020). This stretch of river serves as a vital breeding ground for the state and federally endangered least Bell's vireo (*Vireo bellii pusillus*). Further damage of critical native habitat can be expected in the future if methods to control ISHB are not taken. Due to the extensive list of suitable reproductive host plants and the survivability of the fungus and beetles in a wide range of temperatures (Eskalen, 2016), these pests have the potential to establish throughout the state and other parts of the county (personal communication from Colin Umeda, UCR).

In 2014, federal, state, county, city agencies, universities and the tree care industry in Southern California recognized that the impacts of ISHB were significant and would continue without intervention. In an effort to provide the public with a coordinated response to address ISHB, a Polyphagous shot hole borer – Research, Management and Outreach Collaborative Tools Group was formed by the University of California to provide guidance and establish a collective place for ISHB information to be housed. Additionally, the Emerging Tree Pest Education and Outreach Committee was formed by a grassroots collective and was used as a connection for information sharing and distribution of published materials to the public (Appendix A), including providing information through the website, www.ISHB.org, which is managed by the University of California Agriculture and Natural Resources.

Realizing that these groups were not enough to limit the impact and spread of ISHB within the state, the California Invasive Species Council (CISAC) convened in January 2018, to initiate a statewide summit. The goal of this summit was to develop a regional approach to the ISHB response that involved collaboration between stakeholder groups, policymakers and researchers. Out of the summit came suggestions that were incorporated into Assembly Bill No. 2470 which was co-authored by Assembly Members Lorena Gonzalez Fletcher and Timothy Grayson representing the 80th and 14th Assembly Districts (Appendix B). The bill authorized CISAC to build a consensus and develop a plan "…for the cure or suppression of diseases associated with the spread of Invasive Shot Hole Borers, including, but not limited to the Polyphagous and Kuroshio shot hole borers". The California Legislature passed AB 2470 in fall of 2018 and Governor Brown approved the allocation of $5 million for the execution of the plan. To develop the statewide Fusarium Dieback – Invasive Shot Hole Borers (FD-ISHB) management plan under

AB 2470, an Executive Committee and four subcommittees were created. The subcommittees consisted of Research and Technology Development; Survey, Detection and Rapid Response; Greenwaste and Firewood as Pathways; and Outreach and Education. Each subcommittee facilitated a public-consensus building process to prioritize the appropriation of funds within each respective section of the plan.

To date each subcommittee have finished their prioritization plans and have started their implementation.

- The research and technology development subcommittee have developed 28 priority research projects (which have been rated from highest to lowest priorities) with associated budgets for each and are working on securing funds for those projects.
- The survey, detection and rapid response subcommittee have determined a statewide monitoring program, rapid response measures and laboratory identification procedures.
    - The monitoring program have established a trapping protocol, purchased trapping supplies and are currently distributing them to counties and have hired a visual survey and data coordinator.
    - Rapid response matrix has been determined which includes treatment and removal protocols and management options depending on ISHB infestation level, and a ISHB Zone of Infestation is currently under consideration.
    - Laboratory identification procedures have been established. The Plant Disease Diagnostics Laboratory at California Department of Food and Agriculture (CDFA) or the Eskalen lab at UC Davis have been diagnosing the fungal pathogens and the Stouthamer lab at UC Riverside have been performing molecular identification of the beetles.
- Outreach and education subcommittee have created handouts on ISHB including identification cards, bookmarks and 8 x 10 handout describing ISHB. An ISHB communications coordinator has been hired to help coordinate conferences, maintaining the ISHB website and creating training courses.
- Greenwaste and Firewood subcommittee have determined the best way to address the role of plant material processing and movement. The group has established collaboration between local enforcement agencies (LEA) and county agricultural commissioners to help track the movement of greenwaste to determine low risk sites to store the waste and what mitigation measures to be used. Regulatory gaps in the movement of firewood have been determined and a strategy for California is being developed.

The invasive shot hole borers impacts continue to cause substantial tree mortality in many of Southern California counties. In partnership with and support from MVU, BDU, RRU and SLU CALFIRE unit foresters, and Orange and Los Angeles contract counties forestry and fire staff, the Southern Regional Forest Pest Specialist is requesting the Director of the California Department of Forestry and Fire Protection (Department) and the California Board of Forestry and Fire Protection (Board) to consider declaring a Zone of Infestation (ZOI) for ISHB. A Zone of Infestation

would represent an official and formal action to recognize ISHB as a threat to California's forest and woodland resources, will allow state and local officials to take immediate action to mitigate new infestation sites as well as continue to bolster the effort against ISHB and elevate the level of awareness of its potential threat to the state.

VALUES FOR CREATING A ZONE OF INFESTATION FOR ISHB

The value of establishing a Zone of Infestation for the invasive shot hole borers are linked to:

- Fostering collaborative efforts with both current and potential private, local, state, federal, and tribal agency partners working on ISHB prevention, containment, control and remediation.
- Communicating the concern of both the Department and the Board for the ISHB issue and its current potential impact in California to the public.
- Showing support from both the Department and the Board for efforts to seek funding, research, education outreach, best management practices for control, management efforts in managing ISHB-infested wood, and other ISHB related activities.
- Creating a directive that ISHB suppression and control measures be addressed, where feasible, in Timber Harvest Plans within the ZOI (applicable only in mixed conifer stands where host trees are being harvested incidentally along with commercial species of conifers and a THP would be required).
- Establishing an official mapped boundary of the known ISHB infestation which can serve to notify communities within the current infested area and to alert communities in neighboring non-infested areas of proximity, spread and threat of ISHB.
- Expressing the continued concern to the state legislature and Governor's office about the potential impact and harm ISHB could have statewide.
- Partnering with local governments in efforts to help stop the spread.
- Supporting the use of California Conservation Camp and California Conservation Corps crews in control and management projects for ISHB on private and state lands.

DESCRIPTION OF THE PROPOSED ZONE

Mapping criteria were developed to determine the proposed ZOI boundary. The mapping criteria are defined as: known locations of ISHB; flight range of ISHB; location of host species from CALFIRE FRAP FVEG data; reproductive host ranges from Elbert Little Jr's tree range maps that were digitized by USGS Geosciences and Environmental Change Science Center's and mapped in ArcMap; Landscape Ecology, Modeling, Mapping and Analysis (LEMMA) and the public land survey system.

Analysis of the mapping criteria determined reproductive hosts are present within most areas of the affected counties. The spread of these insects is accelerated by human-mediated movement of greenwaste, wood products and firewood and all areas with susceptible vegetation were included in the proposed ZOI. The combined areas total 15,775,396 acres. The acres for each respective county are listed in Table 2. The description of the boundaries for each county are described in Table 3 and the maps for the proposed ISHB Zone of Infestation and for each individual county are shown in Appendices C – S.

Table 2: Number of Acres for each County in the ISHB Zone of Infestation.

County	Number of Acres
Los Angeles	2,529,514
Orange	509,466
Riverside	1,989,419
San Bernardino Section A Section B Section C Section D	 2,631,873 83,542 269,276 118,232
San Diego	2,712,195
San Luis Obispo	2,124,278
Santa Barbara	1,633,621
Ventura	1,173,980
Total	**15,775,396**

Table 3: Boundary Description of the Zone of Infestation for ISHB by county.

County	Boundary	Description
Los Angeles	Entire County	The entire county of Los Angeles
Orange	Entire County	The entire county of Orange
Santa Barbara	Entire County	The entire county of Santa Barbara
San Diego	Entire County	The entire county of San Diego
San Luis Obispo	Entire County	The entire county of San Luis Obispo
Ventura	Entire County	The entire county of Ventura
Riverside	Western	The entire county border east
	Southern	The county border from the SW corner to north of Section 32, T.08S. R.09E. SBM, then north of Section 04, T.08S. R09E. SBM, then north of Section 03, T.08S. R.09E. SBM, then north of

		Section 02, T.08S. R.09E. SBM, then north of Section 01, T.08S. R.09E. SBM, then north of Section 06, T.08S. R.10E. SBM, then north of Section 05, T.08S. R.10E. SBM, then north of Section 04, T.08S. R.10E. SBM, then north of Section 03, T.08S. R.10E. SBM, then north of Section 02, T.08S. R.10E. SBM.
	Eastern	Lands west of Section 32, T.08S. R09E. SBM, then west of Section 29, T.08S. R.09E. SBM, then west of Section 20, T.08S. R.09E. SBM, then west of Section 17, T.08S. R.09E. SBM, then west of Section 08, T.08S. R.09E. SBM, then west of Section 02, T.08S. R.10E. SBM, then west of Section 35, T.07S. R10E. SBM, then west of Section 26, T.07S. R.10E. SBM, then west of Section 23, T.07S. R.10E. SBM, then west of Section 14, T.07S. R.10E. SBM, then west of Section 09, T.07S. R.09E. SBM, then west of Section 04, T.07S. R09E. SBM, then west of Section 33, T.06S. R.09E. SBM, then west of Section 25, T.06S. R.08E. SBM, then west of Section 24, T.06S. R.08E. SBM, then west of Section 13, T.06S. R.08E. SBM, then west of Section 10, T.06S. R.08E. SBM, then west of Section 03, T.06S. R.08E. SBM, then west of Section 33, T.05S. R.08E. SBM, then west of Section 28, T.05S. R.08E. SBM, then west of Section 21, T.05S. R.08E. SBM, then west of Section 17, T.05S. R.08E. SBM, then west of Section 08, T.05S. R.08E. SBM, then west of Section 05, T.05S. R.08E. SBM, then west of Section 34, T.04S. R.07E. SBM, then west of Section 29, T.04S. R.07E. SBM, then west of Section 20, T.04S. R.07E. SBM, then west of Section 16, T.04S. R.06E. SBM, then west of Section 09, T.04S. R.06E. SBM, then west of Section 01, T.04S. R.05E. SBM, then west of Section 36, T.03S. R.05E. SBM, then west of Section 25, T.03S. R.05E. SBM, then west of Section 24, T.03S. R.05E. SBM, then west of Section 13, T.03S. R.05E. SBM, then west of Section 12, T.03S. R.05E. SBM, then west of Section 01, T.03S. R.05E. SBM, then west of Section 36, T.02S. R.05E. SBM,

		then west of Section 28, T.02S. R.05E. SBM, then west of Section 21, T.02S. R05E. SBM, then west of Section 18, T.02S. R.05E. SBM, then west of Section 10, T.02S. R.04E. SBM, and then west of Section 03, T.02S. R.04E. SBM.
	Northern	The county border from the NW corner to south of Section 03, T.02S. R.04E. SBM, then south of Section 14, T.02S. R.04E. SBM, then south of Section 13, T.02S. R.04E. SBM, then south of Section 18, T.02S. R.05E. SBM, then south of Section 20, T.02S. R.05E. SBM, then south of Section 21, T.02S. R.05E. SBM, then south of Section 34, T.02S. R.05E. SBM, then south of Section 35, T.02S. R.05E. SBM, then south of Section 36, T.02S. R.05E. SBM, then south of Section 07, T.04S. R.06E. SBM, then south of Section 08, T.04S. R.06E. SBM, then south of Section 09, T.04S. R.06E. SBM, then south of Section 22, T.04S. R.06E. SBM, then south of Section 23, T.04S. R.06E. SBM, then south of Section 24, T.04S. R.06E. SBM, then south of Section 19, T.04S. R.07E. SBM, then south of Section 20, T.04S. R.07E. SBM, then south of Section 33, T.04S. R.07E. SBM, then south of Section 34, T.04S. R.07E. SBM, then south of Section 02, T.05S. R.07E. SBM, then south of Section 01, T.05S. R.07E. SBM, then south of Section 06, T.05S. R.08E. SBM, then south of Section 05, T.05S. R.08E. SBM, then south of Section 21, T.05S. R08E. SBM, then south of Section 03, T.06S. R.08E. SBM, then south of Section 14, T.06S. R.08E. SBM, then south of Section 13, T.06S. R.08E. SBM, then south of Section 31, T.06S. R.09E. SBM, then south of Section 32, T.06S. R.09E. SBM, then south of Section 33, T.06S. R.09E. SBM, then south of Section 15, T.07S. R.09E. SBM, then south of Section 14, T.07S. R.09E. SBM, then south of Section 13, T.07S. R.09E. SBM, then south of Section 18, T.07S. R.19E. SBM, then south of Section 17, T.07S. R.10E. SBM, then south of Section 16, T.07S. R.10E. SBM, then south of Section 15, T.07S. R.10E. SBM, and then south of Section 14, T.07S. R.10E. SBM.

San Bernardino – Section A	Western	The county border from the SW corner north to Section 31, T.05N. R07W. SBM, then lands east of Section 25, T.05N. R.06W. SBM, then east of Section 24, T.05N. R.06W. SBM, then east of Section 13, T.05N. R.06W. SBM, then east of Section 12, T.05N. R.06W. SBM, then east of Section 01, T.05N. R.06W. SBM, then east of Section 36, T.06N. R.06W. SBM, then east of Section 25, T.06N. R.06W. SBM, then east of Section 24, T.06N. R.06W. SBM, then east of Section 13, T.06N. R.06W. SBM, then east of Section 12, T.06N. R.06W. SBM, then east of Section 02, T.06N. R.05W. SBM, then east of Section 35, T.07N. R.05W. SBM, then east of Section 26, T.07N. R.05W. SBM, then east of Section 23, T.07N. R.05W. SBM, then east of Section 14, T.07N. R.05W. SBM, then east of Section 11, T.07N. R.05W. SBM, then east of Section 02, T.07N. R.05W. SBM, then east of Section 35, T.08N. R.05W. SBM, then east of Section 26, T.08N. R.05W. SBM, then east of Section 23, T.08N. R.05W. SBM, then east of Section 17, T.08N. R.04W. SBM, then east of Section 08, T.08N. R.04W. SBM, then east of Section 05, T.08N. R.04W. SBM, then east of Section 32, T.09N. R.04W. SBM, then east of Section 29, T.09N. R.04W. SBM, then east of Section 20, T.09N. R.04W. SBM, then east of Section 17, T.09N. R.04W. SBM, then east of Section 08, T.09N. R.04W. SBM, then east of Section 05, T.10N. R.04W. SBM, then east of Section 32, T.11N. R.04W. SBM, then east of Section 29, T.11N. R.04W. SBM, then east of Section 20, T.11N. R.04W. SBM and lands east of Section 17, T.11N. R.04W. SBM.
	Southern	Lands north from the county border from the SW corner east to Section 35, T.01S. R09E.
	Eastern	Lands west of Section 24, T.10N. R.03E. SBM, then west of Section 25, T.10N. R.03E. SBM, then west of Section 36, T.10N. R.03E. SBM, then west of Section 01, T.09N. R.03E. SBM, then west of Section 12, T.09N. R.03E. SBM, then west of Section 13, T.09N. R.03E. SBM,

		then west of Section 24, T.09N. R.03E. SBM, then west of Section 25, T.09N. R.03E. SBM, then west of Section 31, T.09N. R.04E. SBM, then west of Section 06, T.08N. R.04E. SBM, then west of Section 07, T.08N. R.04E. SBM, then west of Section 18, T.08N. R.04E. SBM, then west of Section 19, T.08N. R.04E. SBM, then west of Section 30, T.08N. R.04E. SBM, then west of Section 31, T.08N. R.04E. SBM, then west of Section 06, T.07N. R.04E. SBM, then west of Section 07, T.07N. R.04E. SBM, then west of Section 18, T.07N. R.04E. SBM, then west of Section 19, T.07N. R.04E. SBM, then west of Section 30, T.07N. R.04E. SBM, then west of Section 31, T.07N. R.04E. SBM, then west of Section 06, T.06N. R.04E. SBM, then west of Section 09, T.06N. R.04E. SBM, then west of Section 16, T.06N. R.04E. SBM, then west of Section 21, T.06N. R.04E. SBM, then west of Section 28, T.06N. R.04E. SBM, then west of Section 33, T.06N. R.04E. SBM, then west of Section 04, T.05N. R.04E. SBM, then west of Section 09, T.05N. R.04E. SBM, then west of Section 16, T.05N. R.04E. SBM, then west of Section 21, T.05N. R.04E. SBM, then west of Section 28, T.05N. R.04E. SBM, then west of Section 33, T.05N. R.04E. SBM, then west of Section 04, T.04N. R.04E. SBM, then west of Section 09, T.04N. R.04E. SBM, then west of Section 13, T.04N. R.04E. SBM, then west of Section 24, T.04N. R.04E. SBM, then west of Section 25, T.04N. R.04E. SBM, then west of Section 36, T.04N. R.04E. SBM, then west of Section 01, T.03N. R.04E. SBM, then west of Section 12, T.03N. R.04E. SBM, then west of Section 13, T.03N. R.04E. SBM, then west of Section 24, T.03N. R.04E. SBM, then west of Section 25, T.03N. R.04E. SBM, then west of Section 36, T.03N. R.04E. SBM, then west of Section 01, T.02N. R.04E. SBM, then west of Section 12, T.02N. R.04E. SBM, then west of Section 14, T.02N. R.09E. SBM, then west of Section 23, T.02N. R.09E. SBM,

		then west of Section 26, T.02N. R.09E. SBM, then west of Section 35, T.02N. R.09E. SBM, then west of Section 02, T.01N. R.09E. SBM, then west of Section 11, T.01N. R.09E. SBM, then west of Section 14, T.01N. R.09E. SBM, then west of Section 23, T.01N. R.09E. SBM, then west of Section 26, T.01N. R.09E. SBM, then west of Section 35, T.01N. R.09E. SBM, then west of Section 02, T.01S. R.09E. SBM, then west of Section 11, T.01S. R.09E. SBM, then west of Section 14, T.01S. R.09E. SBM, then west of Section 23, T.01S. R.09E. SBM, then west of Section 26, T.01S. R.09E. SBM, and lands west of Section 35, T.01S. R.09E. SBM.
	Northern	Lands south of Section 17, T.11N. R.04W. SBM, then south of Section 16, T.11N. R.04W. SBM, then south of Section 27, T.11N. R.04W. SBM, then south of Section 26, T.11N. R.04W. SBM, then south of Section 25, T.11N. R.04W. SBM, then south of Section 11, T.11N. R.04W. SBM, then south of Section 30, T.11N. R.03W. SBM, then south of Section 29, T.11N. R.03W. SBM, then south of Section 09, T.09N. R.03W. SBM, then south of Section 10, T.09N. R.03W. SBM, then south of Section 02, T.09N. R.03W. SBM, then south of Section 01, T.09N. R.03W. SBM, then south of Section 30, T.10N. R.02W. SBM, then south of Section 29, T.10N. R.02W. SBM, then south of Section 28, T.10N. R.02W. SBM, then south of Section 27, T.10N. R.02W. SBM, then south of Section 26, T.10N. R.02W. SBM, then south of Section 25, T.10N. R.02W. SBM, then south of Section 30, T.10N. R.01W. SBM, then south of Section 29, T.10N. R.01W. SBM, then south of Section 28, T.10N. R.01W. SBM, then south of Section 27, T.10N. R.01W. SBM, then south of Section 26, T.10N. R.01W. SBM, then south of Section 25, T.10N. R.01W. SBM, then south of Section 07, T.09N. R.01E. SBM, then south of Section 08, T.09N. R.01E. SBM, then south of Section 09, T.09N. R.01E. SBM, then south of Section 10, T.09N. R.01E.

		SBM, then south of Section 02, T.09N. R.01E. SBM, then south of Section 01, T.09N. R.01E. SBM, then south of Section 06, T.09N. R.02E. SBM, then south of Section 05, T.09N. R.02E. SBM, then south of Section 33, T.10N. R.02E. SBM, then south of Section 34, T.10N. R.02E. SBM, then south of Section 26, T.10N. R.02E. SBM, then south of Section 25, T.10N. R.02E. SBM, then south of Section 30, T.10N. R.03E. SBM, then south of Section 29, T.10N. R.03E. SBM, then south of Section 21, T.10N. R.03E. SBM, then south of Section 22, T.10N. R.03E. SBM, then south of Section 23, T.10N. R.03E. SBM, and then lands south of Section 24, T.10N. R.03E. SBM.
San Bernardino – Section B	Western	Land east of Section 35, T.15N. R.01E. SBM, then east of Section 02, T.14N. R.01E. SBM, then east of Section 11, T.14N. R.01E. SBM, then east of Section 14, T.14N. R.01E. SBM, then east of Section 23, T.14N. R.01E. SBM, then east of Section 26, T.14N. R.01E. SBM, then east of Section 35, T.14N. R.01E. SBM, then east of Section 02, T.13N. R.01E. SBM, then east of Section 11, T.13N. R.01E. SBM, then east of Section 14, T.13N. R.01E. SBM, then east of Section 23, T.13N. R.01E. SBM, then east of Section 26, T.13N. R.01E. SBM, then east of Section 35, T.13N. R.01E. SBM, then east of Section 02, T.12N. R.01E. SBM, then east of Section 11, T.12N. R.01E. SBM, and lands east of Section 14, T.12N. R.01E. SBM.
	Southern	Lands north of Section 14, T.12N. R.01E. SBM, then north of Section 13, T.12N. R.01E. SBM, then north of Section 18, T.12N. R.02E. SBM, then north of Section 17, T.12N. R.02E. SBM, then north of Section 16, T.12N. R.02E. SBM, and lands north of Section 15, T.12N. R.02E. SBM.
	Eastern	Lands west of Section 15, T.12N. R.02E. SBM, then west of Section 10, T.12N. R.02E. SBM, then west of Section 03, T.12N. R.02E. SBM, then west of Section 34, T.13N. R.02E. SBM,

		then west of Section 27, T.13N. R.02E. SBM, then west of Section 22, T.13N. R.02E. SBM, then west of Section 15, T.13N. R.02E. SBM, then west of Section 10, T.13N. R.03E. SBM, then west of Section 03, T.13N. R.03E. SBM, then west of Section 34, T.14N. R.03E. SBM, then west of Section 27, T.14N. R.03E. SBM, then west of Section 22, T.14N. R.03E. SBM, then west of Section 15, T.14N. R.03E. SBM, then west of Section 10, T.14N. R.02E. SBM, then west of Section 03, T.14N. R.02E. SBM, and lands west of Section 31, T.15N. R.02E. SBM.
	Northern	Lands south of Section 35, T.15N. R.01E. SBM, then south of Section 36, T.15N. R.01E. SBM, then south of Section 31, T.15N. R.02E. SBM, then south of Section 05, T.14N. R.02E. SBM, then south of Section 04, T.14N. R.02E. SBM, then south of Section 03, T.14N. R.02E. SBM, then south of Section 14, T.14N. R.02E. SBM, then south of Section 13, T.14N. R.02E. SBM, then south of Section 18, T.14N. R.03E. SBM, then south of Section 17, T.14N. R.03E. SBM, then south of Section 16, T.14N. R.03E. SBM, and lands south of Section 15, T.14N. R.03E. SBM.
San Bernardino – Section C	Western	Lands east of Section 13, T.01S. R.16E. SBM, then east of Section 12, T.01S. R.16E. SBM, then east of Section 06, T.01S. R.17E. SBM, then east of Section 36, T.01N. R.17E. SBM, then east of Section 25, T.01N. R.16E. SBM, then east of Section 24, T.01N. R.16E. SBM, then east of Section 13, T.01N. R.16E. SBM, then east of Section 12, T.01N. R.16E. SBM, then east of Section 01, T.01N. R.16E. SBM, then east of Section 36, T.02N. R.16E. SBM, then east of Section 25, T.02N. R.16E. SBM, then east of Section 13, T.02N. R.16E. SBM, then east of Section 18, T.02N. R.17E. SBM, then east of Section 07, T.02N. R.17E. SBM, then east of Section 06, T.02N. R.17E. SBM, then east of Section 31, T.03N. R.17E. SBM, then east of Section 30, T.03N. R.17E. SBM,

		then east of Section 19, T.03N. R.17E. SBM, then east of Section 18, T.03N. R.17E. SBM, then east of Section 07, T.03N. R.17E. SBM, then east of Section 06, T.03N. R.17E. SBM, then east of Section 31, T.04N. R.17E. SBM, then east of Section 30, T.04N. R.17E. SBM, then east of Section 19, T.04N. R.17E. SBM, then east of Section 18, T.04N. R.17E. SBM, then east of Section 12, T.04N. R.16E. SBM, then east of Section 01, T.04N. R.16E. SBM, then east of Section 36, T.05N. R.16E. SBM, then east of Section 30, T.05N. R.17E. SBM, then east of Section 19, T.05N. R.17E. SBM, then east of Section 18, T.05N. R.17E. SBM, then east of Section 07, T.05N. R.17E. SBM, then east of Section 01, T.05N. R.16E. SBM, then east of Section 36, T.06N. R.16E. SBM, then east of Section 25, T.06N. R.16E. SBM, then east of Section 24, T.06N. R.16E. SBM, then east of Section 13, T.06N. R.16E. SBM, then east of Section 08, T.06N. R.17E. SBM, then east of Section 05, T.06N. R.16E. SBM, then east of Section 32, T.07N. R.17E. SBM, then east of Section 29, T.07N. R.17E. SBM, then east of Section 20, T.07N. R.17E. SBM, then east of Section 17, T.07N. R.17E. SBM, then east of Section 08, T.07N. R.17E. SBM, then east of Section 01, T.07N. R.16E. SBM, then east of Section 36, T.08N. R.16E. SBM, and lands east of Section 25, T.08N. R.16E. SBM,
	Southern	Lands north of Section 13, T.01S. R.16E. SBM, then north of Section 18, T.01S. R.17E. SBM, then north of Section 17, T.01S. R.17E. SBM, then north of Section 16, T.01S. R.17E. SBM, then north of Section 15, T.01S. R.17E. SBM, then north of Section 14, T.01S. R.17E. SBM, and lands north of Section 13, T.01S. R.17E. SBM.
	Eastern	Lands west of Section 30, T.08N. R.19E. SBM, then west of Section 31, T.08N. R.19E. SBM, then west of Section 06, T.07N. R.19E. SBM, then west of Section 06, T.07N. R.19E. SBM,

		then west of Section 06, T.07N. R.19E. SBM, then west of Section 07, T.07N. R.19E. SBM, then west of Section 18, T.07N. R.19E. SBM, then west of Section 19, T.07N. R.19E. SBM, then west of Section 30, T.07N. R.19E. SBM, then west of Section 31, T.07N. R.19E. SBM, then west of Section 06, T.06N. R.19E. SBM, then west of Section 07, T.06N. R.19E. SBM, then west of Section 18, T.06N. R.19E. SBM, then west of Section 19, T.06N. R.19E. SBM, then west of Section 28, T.06N. R.18E. SBM, then west of Section 09, T.05N. R.18E. SBM, then west of Section 16, T.05N. R.18E. SBM, then west of Section 21, T.05N. R.18E. SBM, then west of Section 28, T.05N. R.18E. SBM, then west of Section 33, T.05N. R.18E. SBM, then west of Section 04, T.04N. R.18E. SBM, then west of Section 07, T.04N. R.18E. SBM, then west of Section 18, T.04N. R.18E. SBM, then west of Section 19, T.04N. R.18E. SBM, then west of Section 30, T.04N. R.18E. SBM, then west of Section 31, T.04N. R.18E. SBM, then west of Section 06, T.03N. R.18E. SBM, then west of Section 12, T.03N. R.17E. SBM, then west of Section 13, T.03N. R.17E. SBM, then west of Section 24, T.03N. R.17E. SBM, then west of Section 25, T.03N. R.17E. SBM, then west of Section 36, T.03N. R.17E. SBM, then west of Section 01, T.02N. R.17E. SBM, then west of Section 12, T.02N. R.17E. SBM, then west of Section 13, T.02N. R.17E. SBM, then west of Section 24, T.02N. R.17E. SBM, then west of Section 25, T.02N. R.17E. SBM, then west of Section 36, T.02N. R.17E. SBM, then west of Section 01, T.01N. R.17E. SBM, then west of Section 12, T.01N. R.17E. SBM, then west of Section 13, T.01N. R.17E. SBM, then west of Section 24, T.01N. R.17E. SBM, then west of Section 25, T.01N. R.17E. SBM, then west of Section 36, T.01N. R.17E. SBM, then west of Section 01, T.01S. R.17E. SBM, then west of Section 12, T.01S. R.17E. SBM,

		and lands west of Section 13, T.01S. R.17E. SBM.
	Northern	Lands south of Section 25, T.08N. R.16E. SBM, then south of Section 30, T.08N. R.17E. SBM, then south of Section 29, T.08N. R.17E. SBM, then south of Section 28, T.08N. R.17E. SBM, then south of Section 27, T.08N. R.17E. SBM, then south of Section 26, T.08N. R.17E. SBM, then south of Section 30, T.08N. R.18E. SBM, then south of Section 29, T.08N. R.18E. SBM, then south of Section 28, T.08N. R.18E. SBM, then south of Section 27, T.08N. R.18E. SBM, then south of Section 26, T.08N. R.18E. SBM, and lands south of Section 30, T.08N. R.19E. SBM.
San Bernardino – Section D	Western	Lands east of Section 13, T.13N. R.19E. SBM, then east of Section 24, T.13N. R.19E. SBM, then east of Section 25, T.13N. R.19E. SBM, then east of Section 36, T.13N. R.19E. SBM, then east of Section 01, T.12N. R.19E. SBM, then east of Section 12, T.12N. R.19E. SBM, then east of Section 13, T.12N. R.19E. SBM, then east of Section 24, T.12N. R.19E. SBM, then east of Section 25, T.12N. R.19E. SBM, then east of Section 36, T.12N. R.19E. SBM, then east of Section 01, T.11N. R.19E. SBM, then east of Section 12, T.11N. R.19E. SBM, then east of Section 13, T.11N. R.19E. SBM, then east of Section 24, T.11N. R.19E. SBM, then east of Section 25, T.11N. R.19E. SBM, then east of Section 36, T.11N. R.19E. SBM, then east of Section 10, T.10N. R.20E. SBM, then east of Section 15, T.10N. R.20E. SBM, then east of Section 22, T.10N. R.22E. SBM, then east of Section 27, T.10N. R.22E. SBM, then east of Section 34, T.10N. R.22E. SBM, then east of Section 03, T.09N. R.22E. SBM, then east of Section 10, T.09N. R.22E. SBM, then east of Section 15, T.09N. R.22E. SBM, then east of Section 22, T.09N. R.22E. SBM, then east of Section 27, T.09N. R.22E. SBM, then east of Section 34, T.09N. R.22E. SBM,

		and lands east of Section 03, T.08N. R.22E. SBM.
	Eastern	Lands west of the county boarder from Section 13, T.13N. R.19E. SBM south to Section 04, T.08N. R.23E. SBM.
	Southern	Lands north of Section 15, T.10N. R.20E. SBM, then north of Section 14, T.10N. R.20E. SBM, then north of Section 13, T.10N. R.20E. SBM, then north of Section 18, T.10N. R.21E. SBM, then north of Section 17, T.10N. R.21E. SBM, then north of Section 16, T.10N. R.21E. SBM, then north of Section 15, T.10N. R.21E. SBM, then north of Section 14, T.10N. R.21E. SBM, then north of Section 13, T.10N. R.21E. SBM, then north of Section 18, T.10N. R.22E. SBM, then north of Section 17, T.10N. R.22E. SBM, then north of Section 16, T.10N. R.22E. SBM, then north of Section 03, T.08N. R.22E. SBM, then north of Section 02, T.08N. R.22E. SBM, then north of Section 01, T.08N. R.22E. SBM, then north of Section 06, T.08N. R.23E. SBM, then north of Section 05, T.08N. R.23E. SBM, and lands north of Section 04, T.08N. R.23E. SBM.

The distribution of ownership within the proposed ZOI reflects a wide variety of land owners, Table 4. While many public lands managers have acted to minimize spreading ISHB on their lands, currently there are no policies or regulations at the county, state or federal level that restricts the movement of ISHB infested wood from private property and other non-federal lands.

Table 4: Distribution of Land Ownership – Private and Public Lands

Ownership	**Acres**
Bureau of Indian Affairs	225,210
CAL FIRE	2,364
California Department of Fish and Game	187,878
California Department of Parks and Recreation	757,611
California State Lands Commission	261,026
Local Government	482,044
Non-Profit Conservancies and Trusts	84,103
Other Federal Lands	2,465

Other State Lands	31,487
Private	9,860,151
State Conservancies	11,291
US Bureau of Land Management	8,075,615
US Bureau of Reclamation	28,796
US Department of Defense	2,526,360
US Fish and Wildlife Service	25,209
US Forest Service	3,147,182
US National Park Service	2,517,729
TOTAL	**28,226,471**

PEST BIOLOGY, SIGN AND SYMPTOMS, AND STATUS OF OUTBREAK

Pest Biology

Ambrosia beetles in the *Euwallacea fornicatus* species complex are native to SE Asia and are considered pests of economic importance in many areas they have invaded. This species complex consists of several species, all of which are nearly identical, which makes this species complex the most challenging. The morphology-defined species boundaries have been ambiguous until recently when molecular data has been used to determine 4 distinct species by morphological and phylogenetic analyses (Smith et al., 2019). Two of the species in this complex are found in Southern California – PSHB & KSHB.

The PSHB cause damage to host plants and carries several fungal pathogens that cause disease within susceptible hosts in California, Israel, and South Africa. The closely related KSHB similarly affects host plants in California and Mexico.

Female ISHB are 0.07 – 0.1 inches (1.8-2.5 mm) in length and range from brown to black in color. Males are 0.05 – 0.06 inches (1.3-1.5 mm) in length, light brown to black in color and lack wings. Long distance spread and gallery formation is strictly limited to females. Males are only able to disperse by walking (Umeda et al., 2016). Females create galleries which are only as wide as their bodies and bore into the tree to a depth of about 0.60 inches (15 mm) in the initial stages of colonization. Because ambrosia beetles do not feed on the wood, as they chew the wood they push the fine particles of wood, resembling sawdust, out of their galleries as they are created. Sawdust may be found on the outside of the bark or at the base of the tree. The female beetle carries fungal symbionts in specialized structures known as mycangia. The fungal symbionts are deposited on the gallery walls as the female beetle chews through the wood in gallery construction. Each species of invasive shot hole borer carries unique fungal symbionts. *Fusarium euwallaceae* and *Graphium euwallaceae* are specific to PSHB, and *F. kuroshium* and *G. kuroshium* are specific to KSHB. Both species share symbioses with *Paracremonium pembeum* (Carrillo et al., 2019; Freeman et al., 2013; Shannon Colleen Lynch et al., 2016; Na et al., 2018). The two species of *Fusarium* are the causal agents of Fusarium dieback in the invaded susceptible hosts.

Once fungal growth is sufficient to provide a food source, the female will lay eggs at the end of the gallery. ISHB reproduce by haplodiploidy, an unfertilized haploid egg develops into males and fertilized diploid eggs develop into females. This produces a collection of progeny that is female-biased (Cooperband et al., 2016). The female adult will lay about 50 eggs in niches along the walls of the galleries. Most of the eggs will be fertilized eggs (female) and a few will be non-fertilized eggs (male). While in the gallery, beetles will mate with their siblings and continue to feed on the fungi growing on the gallery walls (Umeda et al, 2016). Because of this feeding and sibling mating, female ISHB disperse already mated and carrying the *Fusarium* spores in their mycangia.

Larvae emerge after approximately 13-16 days, become pupae after 7-11 days and adults 2-3 days later (Cooperband et al., 2016), for a total development/maturation period of 22-30 days. Development is temperature dependent with optimal development occurring at 80˚F (27˚C). As temperatures increase from 64˚F (18˚C) to 90˚F (32˚C), the time it takes for the beetle to complete its lifecycle decreases. It is important to note that though PSHB was unable to have offspring develop into adults at 59˚F (15˚C), they could survive for over 200 days at that temperature. At that temperature (15˚C), the fungal growth may not be able to grow fast enough to support the development of the beetle and its offspring but just fast enough to support a single adult (Lynch et al. 2015). The number of degree days for the beetle to complete its development from egg stage to adult stage is 398 ± 52 degree days. The average number of generations per year will be between 3-6 depending on temperatures in California (Umeda, 2017). Degree days are used to predict insect life cycles and where no development occurs when temperatures are below a specific threshold temperature. The threshold temperature for ISHB is 59˚F (15˚C), (Lynch et al., 2016). Degree days are calculated by taking the average temperature for the day and subtracting from the threshold temperature. For example, if the average temperature was 64.4˚F (18˚C), then 5.4˚F degree days would have accumulated in the number needed for the beetle to complete development. Population buildup for ISHB is exponential. For examples assuming an attack is initiated by a single female and 5 daughters survive from each subsequent brood (10-20%), after 8 generations one tree will have almost 100,000 beetles producing mated female beetles able to spread and start a new population. The mated dispersing females may either fly from their natal host to search for a new suitable host tree or they may re-colonize the same host tree. The stimuli associated with the decision to disperse or re-colonize are poorly understood but maybe associated with densities of occupied galleries and condition of the host (Umeda, 2017). There are two peak flight periods that occur: one in the spring and one in the fall (Dr. Christine Dodge personal communication, Calnaido et al, 1966). The flying capacity of ISHB can be related to TSHB beetles, in the *Euwallacea fornicatus* species complex, which consists of several species including the TSHB and ISHB. The TSHB beetle can fly to a distance of 0.25 – 0.50 miles (430 – 860m) and at a height ranging from of 4 - 250 feet (1.2 – 76.2 m) depending on the time of day. That distance was covered in a single flight without assistance from the wind (Calnaido et al, 1966). Long distance dispersal TSHB only occurred with the help of air currents (James, 2007). Based on studies of flight activity in TSHB and Dr. Richard Stouthamer's (University of California, Riverside)

observations of flight activity in both PSHB and KSHB, a conservative estimate for natural population spread in Southern California is 10-15 miles per year (Stouthamer personal communication).

Symptoms and Signs of Infestation

Entrance and Exit holes: The entrance and exit holes of both species of ISHB are approximately 0.03 inches (0.85mm) in diameter and can be located beneath or near the visible response symptoms produced by the tree. ISHB entrance and exit holes are most commonly seen on the trunk of the tree but they can attack branches as small as 2cm in diameter (Mendel et al., 2012). The diameter of the holes are about the same size as a medium ball point pen tip, a helpful diagnostic tool for distinguishing ISHB holes from the entrance or exit holes of other beetle species.

Staining: The presence of staining or discoloration of the bark associated with a medium ballpoint-pen tip sized entrance hole is a good indicator of ISHB infestation. Each host tree has a unique visible response to the damage caused by the insect-disease complex. Some hosts respond to the infestation by producing long streams of sap oozing down the trunk, while other hosts produce distinct stain spots around the entry/exit holes. Sugary exudate, gumming and frass (excrement of insects and insect larvae) are other symptoms that may be noticeable even before ISHB entry holes are detected. If the staining is caused by ISHB it will not be associated with cavities along the stem or mechanical wounds. When the outer bark is removed from the stained areas, the entrance hole for the ISHB gallery should still be visible and the gallery should extend down into the wood.

Galleries: Unlike bark beetles, ambrosia beetles don't feed on the phloem or the cambial tissue. They instead bore into the wood of the tree, where the female will construct her galleries that are 0.85mm in diameter. The galleries are clean and not packed with sawdust (also known as frass) and the walls are inoculated with the fungi carried in her mycangia, which colonize the gallery walls and serve as the food source for the developing larvae. The female ISHB act as farmers for their symbiotic fungi and keep the galleries clean from any contaminants such as frass, bacteria or other fungi.

Crown thinning: Fusarium euwallaceae or F. kuroshium colonizes the trees vascular system which blocks water and nutrient transport. The tree may exhibit symptoms of Fusarium dieback, wilting branches, discolored leaves and breaking of heavy branches (Umeda er al, 2016). These symptoms will typically be observed on the primary branches, however, ISHB also infests young, small branches as small as 0.78 inches (Mendel et al., 2012). Advanced or high levels of infestations can cause severe branch and crown dieback; epicormic growth along the stem and the base of the tree; stem or branch failure; and eventual tree death (Coleman et al., 2019). This is usually seen after more than one year of infestation.

Status of Outbreak

The first documentation of PSHB in California was in 2003 on black locust (*Robinia* pseudoacacia) (Rabaglia et al., 2006; Umeda, 2017). The species went unnoticed until 2012 when it was found damaging a backyard avocado tree and urban forest trees in Los Angeles basin. Once that discovery was made, a rapid monitoring response uncovered the broad host range of the pest-pathogen complex (Eskalen et al, 2013). The earliest mapping of PSHB infestations started in 2012. Since 2012, the PSHB beetle-fungus complex spread throughout Los Angeles and Orange Counties, and into certain areas of Riverside, San Bernardino and Ventura Counties. A separate invasion by KSHB occurred in San Diego County in early 2014, and this species has since been detected in Orange, Santa Barbara and San Luis Obispo Counties (UC ANR, 2020).

The effects of ISHB on many California urban and riparian species are likely to be severe. As ISHB population expands and the resulting supply of infested wood increases, the risk of accidental transport of infested firewood and green waste to other parts of California and beyond will be high. The spread of ISHB into currently uninfested areas is of additional concern because reproductive host species can be found through California and the United States. Remediation costs, property values and ecosystem services losses will vary based upon the location and value of the species affected, but, for the most part these costs and losses will be substantial.

TREE SPECIES DISTRIBUTION

The reproductive host ranges from the Fire and Resource Assessment Program (FRAP) vegetation layer and Elbert Little Jr's digitized tree range maps were used for the tree species distribution analysis. The distribution of the reproductive hosts covered most of the state of California. Areas that lacked hosts were mostly desert areas and areas where significant urbanization has taken place, such as the inner part of the central valley (Umeda, 2017). Though in areas where significant urbanization has taken place in Southern California, susceptible hosts are planted and significantly irrigated, so urbanized areas in Southern California were not left out of the analysis (personal communication with David Erickson).

DAMAGE TO AFFECTED STANDS AND TREES

Damage caused by the invasive shot hole borers includes branch and crown dieback, discolored and wilting leaves, gumming and oozing, epicormic growth along the stem and the base of the tree, stem or branch failure, and eventual tree death (Coleman et al., 2019; Akif Eskalen et al., 2013). This is usually seen after more than one year of infestation resulting in a decline/loss of

preferred reproductive species within riparian, oak woodlands, and mixed evergreen communities.

Mortality Levels

Mortality levels associated with the ISHB have been determined in a few areas. In a recent study by Coleman et al, it was determined that tree mortality rates across all hardwood species were low (KSHB, 7.8%; PSHB, 5.6%) and just above background (2%). However, within certain species of maples and willows, mortality rates ranged from nearly 10% (KSHB) to over 25%(PSHB) (Coleman et al., 2019).

Another study by University of California Cooperative Extension (UCCE) in 2016 of Orange County Parks found rates of infestation are >50% in several hardwood species (e.g., California sycamore/*Platanus racemosa*, willow/*Salix* sp., cottonwood/*Populus* sp., and London plane/a hybrid species in the *Platanus* genus) (CFPC, 2016).

Boland estimated that during the first two years of the KSHB infestation in the Tijuana River Valley in south San Diego County, mortality levels of native willows were 30% or 120,000 trees (Boland er al, 2019).

Most mortality levels are a snap shot in time, one exception being the Tijuana River Valley, and since the newly emerged females have been observed to re-attack the same tree if the host is still suitable substrate for the symbiotic fungi mortality levels could increase (Coleman et al., 2019).

Infestation Rates

Coleman et al determined that overall infestation rates for PSHB and KSHB species were, > 59% and >65%, respectively across all native and ornamental trees surveyed. It was also found that infestation rates on native trees were significantly greater than infestation rate on ornamental trees. Infestation levels by both beetles were exceptionally high for certain tree species; arroyo willow (83% & 72%), western sycamore (80% & 79%), Goodding's black willow (77% & 81%) and castor bean (71% & 60%) (Coleman et al., 2019).

In the Tijuana River Valley, infestation rates peaked in the willow species in 2015-2016 at 75% and 80 % respectively, whereas in 2019 the overall infestation rate was only 9%. These infestation rates varied and are patchy among the different forest types but was the highest in the wet forest units, with an overall infestation rate over 5 years of 99%, Appendix Q (Boland, 2020). One important finding by Boland was that the re-sprouting willows were infested by KSHB in 2016, all survived and were growing strongly and all the re-sprouts in 2019 were not infested by KSHB.

Outbreaks of other ambrosia beetles have sometimes also declined unexpectedly. Outbreaks of the Tea Shot Hole Borer, *Euwallacea fornicatus* in Java "*often come to a sudden end for unknown reasons*" (Boland, 2020, Smith et al., 2019). This cycle of rapid growth and sudden collapse seems

to have occurred with KSHB in the Tijuana River Valley and could occur in other areas as well. An important note is the idea that all trajectories of infestation are similar from site to site is not true with this insect and that must be taken into consideration when new infestations are found and management recommendations are made.

Economic, Ecosystem, Cultural and Aesthetic Losses

An estimate of trees vulnerable to the ISHB FD complex in urban areas in Southern California and the magnitude of loss if those trees died was conducted in 2017 by McPherson (McPherson et al., 2017). The estimate included only urban areas in three climate zones where ISHB is found – Inland Empire, Coast Southern California and Southwest Desert which comprises 4,244 square miles and 20.5 million residents. Approximately 23.2 million trees or 32.8% of the Southern California region's 70.8 million trees were susceptible to the ISHB-FD complex. Should 50% (11.6 million) of the 23.2 million vulnerable trees die by 2031, the estimated annual value of ecosystem services lost would be $616.8 million. The approximate cost for removing and replacing the trees with similar species and size would be $15.9 billion. If 80% (18.6 million) of the vulnerable trees died, these losses are estimated to increase to $987 million and $25.4 billion respectively (McPherson et al., 2017). This estimate was for the 49 reproductive host species known at the time of the analysis. There are now 65 reproductive host species which would increase the estimate of millions and billions of dollars of ecosystem services lost and the costs needed to remove and replace those trees.

An understanding of the economic impacts of the current tree losses is lacking due to the limited investment in research. One example of the economic impacts associated with ISHB in the urban forests can be seen by the financial burden on Orange County Parks. Orange County Parks have inventoried 40,000 trees valued at $184 million. Between 2016-2019 Orange County has removed 3,922 infested trees and treated 2,228 trees with preventative insecticide and fungicides in the parks alone. Cumulative costs of treatments and removals for 2013-2019 total $1.8 million dollars. The value of the ISHB-infested trees removed from 2013-2019 total $11.8 million dollars (CPFC, 2019).

Concerns have been raised by Coleman and others, that, due to preliminary host range tests of English walnut (*Juglans regia* L.) suggest that multiple cultivars of walnut could potentially serve as hosts for PSHB (Chen et al., 2014; Coleman et al., 2019). Other fruit and nut tree crops grown in California's Central Valley, e.g., almond (*Prunus dulcis* (Mill.) D. A. Webb), persimmon (*Diospyros* spp. L.), pistachio (*Pistacia vera* L.), pomegranate (*Punica grantum* L.), and other *Prunus*, may also be vulnerable to PSHB and KSHB should their distributions expand (Coleman et al., 2019). If even some of those fruit and nut tree crops are susceptible, there is potential for significant loss to a multi-billion-dollar industry.

Many wildlife species are dependent on native host species that are attacked by ISHB – oaks, willow, sycamores, cottonwoods and maples. Loss of hardwood canopy cover, basal area, and stem density from PSHB and KSHB may affect habitat for some threatened and endangered

wildlife species, such as the least Bell's vireo (*Vireo bellii puillus*), previously mentioned that is being affected by the mortality in the Tijuana River Valley. One study by Howell, has shown that KSHB does influence the population of the least Bell's vireo, but this influence is variable. What they found was relative to 2004, the proportion of vireos decreased significantly in the high infestation units and increased significantly in the low infestation units after colonization by KSHB/FD (Howell et al., 2018). Other threatened and endangered wildlife species that could be affected could include the arroyo toad (*Anaxyrus californicus* (Camp)) and southwestern willow flycatcher (*Empidonax traillii extimius* (Audubon)), in native riparian stands of Southern California (Hatten and Paradzick 2003; Mitrovich et al. 2011). Thus, management options for PSHB and KSHB may be limited in these riparian corridors (e.g., because of the presence of endangered wildlife species or because of restrictions on insecticide applications near open water) (Coleman et al., 2019).

Native species are also valuable ornamentals providing deep shade and aesthetic appeal, which makes them highly desirable landscaping tree. Dead and dying trees create fiscal and physical liability to landowners and persons using and living in the forest and woodland areas. High levels of crown dieback and mortality in community areas, which are highly visible, likely will increase the public concerns regarding hazard trees. The loss of these trees is correlated to reduction in property values and lessens scenic values (Kovacs et al., 2011). Dead and dying trees create a more dangerous wildfire situation, especially in wildland riparian areas by affecting fire behavior and intensity parameters. Adding combustible fuels and increasing dead fuels within overstocked forested areas alters fuel compaction, horizontal continuity, vertical arrangement of vegetation among many other fire parameters. Research on stand level fire behavior associated with bark beetle mortality found that bark beetle induced tree mortality increases flammability or stands by changing the canopy and forest floor fuels (Hart et al., 2015). This alteration of fire behavior will most likely occur within ISHB infested forests while also increasing safety hazards along evacuation routes.

TERRAIN AND COVER IN RESPECT TO CONTROL

The terrain of the area of infestation varies in slope and elevation. Slopes range from flat to steep and include all aspects. The infested areas where ISHB have been discovered are on relatively flat ground in urban areas. Although in riparian areas where the most susceptible hosts exist, steep canyons also exist. ISHB have been found slightly above sea level (13 feet) to elevations nearing 1600 feet in mountainous areas. Access and terrain conditions will likely influence the range of the feasible treatment areas. Most private homes and campgrounds are on relatively flat terrain and easily accessible. Moderately steep sites may be treated but treatments may be limited due to sensitive species habitat along riparian areas as well as and equipment limitations.

PROPOSED CONTROL METHODS INTENT

1) Protect forest, riparian, oak woodlands, mixed evergreen from the tree killing pests known as the Invasive Shot Hole Borers (ISHB), *Euwallacea fornicatus* and *Euwallacea kuroshio.*
2) Contain ISHB within the ZOI boundary in the eight infested Counties and prevent further spread into un-infested counties.
    a. Limit the spread and severity of ISHB infestations within the ZOI by implementing Integrated Pest Management (IPM) strategies, expanding trapping efforts to document hot spots, implementing Best Management Practices (BMPs) for avoiding spread, providing education and outreach and utilizing CAL FIRE resources where appropriate, including resource management personnel, conservation camp crews, other personnel and/or equipment.
        i. Minimize the fiscal hardship caused by ISHB infestation on private and publicly-owned lands.
        ii. Protect natural and cultural resources threatened by ISHB infestation.
    b. Direct Timber Harvest Plans that harvest ISHB susceptible plant species within the ZOI to comply with the Forest Practice Rules (14 CCR 957.9 Prevention Practices) and utilize feasible measures guided by IPM.
        i. Prepare for and coordinate a rapid response should ISHB spread outside the ZOI, including conducting an assessment and implementing mitigation measures with partner agencies, in order to contain the spread and limit the severity of the new ISHB population.
        ii. Network with the appropriate agencies, counties and communities at risk and encourage them to develop ISHB preparedness plans.
        iii. Evaluate the need to change the ZOI boundary for any new infestations occurring outside the current boundary.
3) Improve knowledge and understanding of the ISHB pest by supporting and guiding studies and research efforts in order to develop effective Integrated Pest Management and Best Management Practices for ISHB.
4) Minimize public hazards created by ISHB-killed trees and resulting fuel build-up through coordinated abatement.
5) Foster wood product utilization that minimizes the chance of spreading ISHB.
6) Seek funding, whenever grant or other funds become available, to assist with activities associated with containing the spread of the ISHB pest, mitigating its impact in infested areas and restoration/reforestation of impacted areas.
7) Keep local/state/federal elected representatives, other state agencies, local/federal agencies, interest groups and the public apprised of the status and threat posed by ISHB and updated on containment and management efforts.
8) Setting up memorandums of understanding (MOUs) or joint power agreements (JPAs) with local permitting agencies to provide a programmatic level environmental review associated with treatment and removal of protected species.

PROPOSED CONTROL METHODS

Best Management Practices

Transporting ISHB-infested logs or firewood can introduce ISHB into uninfested areas (Force, 2019). ISHB adults may emerge from their galleries any time during their flight season (January through September or October) (Coleman, personal communication) if the tree retains enough moisture to support fungal growth and development. Therefore, prioritization of management efforts and methods for handling infested materials have been developed to help landowners, saw or lumber mills (ex. portable sawmills) and the firewood industries safely utilize wood from known infestation areas (Appendix R).

Monitoring by ground surveys is the most effective strategy for detecting ISHB infestation and severity in live plant hosts. There are certain host species that ISHB prefer to colonize over other hosts, such as box elder and sycamore. These hosts should be the prioritized in ground surveys to determine if an area is infested. ISHB do not have a known sex or aggregation pheromone to aid in detection, however, they do respond to quercivorol, a semiochemical found in volatiles from boring frass of the oak ambrosia beetle and odors from *Fusarium euwallaceae*, which make it possible to trap beetles in a localized area.

Mechanical Treatment Options:

Chipping – chipping ISHB-infested material is an effective strategy to eliminate live beetles. Infested logs and branches can be chipped in a commercial chipper to a size of ≤ 1 inches (2.5 cm) to kill 99.9% of live beetles (Jones and Paine, 2015). Chipped material should then be composted, solarized or delivered to a landfill for disposal to effectively kill the fungi. These treatments can be used year-round. When composting infested chipped material, it is recommended that the chipped material be taken to a composting facility that has earned the US Composting Council's Seal of Testing Assurance (STA), https://www.compostingcouncil.org/page/participants.

Solarization – Solarization is a suitable method for handling either infested chips or logs. When done properly, solar energy will heat plant material until both the beetle and fungi are killed. This is most effective during the peak of the summer, when temperatures are higher and days are longer, but may be used during the rest of the year if time and space can be committed. To ensure solarization is done properly use clear polyethylene plastic sheeting that is UV resistant and at least 6-mil thick (Jones and Paine, 2015). The edges of the sheeting must be buried in the soil or secured tightly and checked routinely for integrity. It is essential to check the integrity of the plastic sheeting periodically for any holes that may have formed to prevent any adults from escaping.

- July – August: cover chips/logs with 6-mil, UV resistant, clear polyethylene plastic sheeting for at least 6 weeks. Temperatures during these months should be regularly above 95°F.
- September – June: cover chips/logs with 6-mil, UV resistant, clear polyethylene plastic sheeting for at least 6 months.
- Infested logs stacked to only 2 logs deep maximum should be used to ensure even heating throughout the pile.
- Infested chips should be kept as thin as possible to ensure even heating throughout.

Pruning – Pruning of infested branches is another viable option. This technique can be used and is most effective for trees that only have infested branches. Be careful to follow proper pruning guidelines when removing the infested branch. Once the infested branch or branches are removed, they must be chipped and either properly disposed of or solarized. The pruning saw must also be surface sterilized to prevent the spread of the Fusarium pathogen to a healthy tree. Cleaning solutions containing at least 70% ethanol can be used to surface sterilize pruning saws.

Cultural Control - Avoid moving infested wood and chipped material out of infested areas unless the material is covered or contained during transport to locations where it will be solarized, chipped or composted. This is the most effective method for reducing long distance spread of this insect. Firewood is easily moved and is one of the primary ways insects and diseases are transported by humans. Limiting firewood movement to local transport is the best management approach for limiting the spread of ISHB and other invasive pests. For more information on the impact of firewood movement and to reduce the spread of invasive insects and diseases visit, www.firewood.ca.gov.

Individual Tree Protection – Systemic and Contact Insecticides:

It may be possible to use direct control with insecticides and fungicides to reduce the risk of infestation of individual high value trees. An insecticide plus fungicide combination should be used because control of the insect as well as the *Fusarium* pathogen is needed. Pesticides should only be applied to trees with low to moderate levels of infestation. For heavily infested trees it is advised that they be removed because they become "amplifier trees" contributing significantly to the local beetle population and are a potential hazard. Tree stumps should be ground, removed or treated with a pesticide and covered with soil. Topical and systemic insecticides should only be applied after evidence of ISHB has been found in the immediate area.

Low, moderate and high level of infestation are defined by the Orange County Decision Matrix, Appendix S:

- Low infestation level: < 50 beetle entry holes and no branch dieback
- Moderate I infestation level: ≥ 50 and <150 beetle entry holes and no branch dieback
- Moderate II infestation level: ≥ 150 beetle entry holes and no branch dieback

- Heavy infestation level: ≥ 150 + beetle entry holes and branch dieback

The current statewide criteria for removal of trees infested with ISHB is if there are ≥ 150 active galleries combined with canopy or branch dieback (Lynch, 2019).

Contact Treatments - A topical spray insecticide applied by a certified pesticide applicator to the trunk and the larger branches of a high-value potential host tree is the best option for preventing ISHB injury. Treating the entire crown is not necessary and would increase the impacts to non-target arthropods. Topical spray applications should occur in the spring before temperatures reach 68°F and before the fall flight to protect the trees before the beetles start to fly. Preventive synthetic pyrethroid contact sprays with insecticides, such as bifenthrin in combination with a fungicide, have been demonstrated to be effective at reducing the number of ISHB attacks and the densities of the galleries in both a lab and field setting. Bifenthrin is effective at establishing a barrier to beetles attempting to penetrate through the bark during colonization and leaving the galleries to disperse for low to moderately infested trees (Eatough Jones & Paine, 2018; Mayorquin et al., 2018). Field studies have shown that bifenthrin applied as a trunk spray was effective at reducing the number of beetle attacks on PSHB infested castor bean, *Ricinus communis*, and California sycamore trees (Jones and Paine, 2018; Jones et al., 2017). Though this is effective at reducing the number of beetles, the *Fusarium* fungus is not controlled by insecticides.

For an alternative to contact pesticide treatments, the bacteria *Bacillus subtilis* has been shown to provide short term control (1 month) when sprayed onto the trunk of the tree up to 8 feet. Having a biopesticide option is an important option for areas where chemical sprays are undesirable (Jones et al., 2017).

Systemic Treatment - Systemic insecticides and fungicides applied by a certified pesticide applicator as a trunk injection, trunk spray or soil drench may reduce the beetle population and slow the spread of the fungal pathogen in individual trees. In field studies, it has been shown that systemic insecticides and fungicides applied to trees with low to moderate infestation with ISHB can significantly reduce the number of beetle attacks. Systemic treatments applied as trunk or soil (imidacloprid) injections to trees should be applied in the spring and fall when the trees are actively taking up water and nutrients to allow for the translocation of the active ingredient into the vascular system. Care must be taken when injecting systemic insectides or fungicides as injection sites have been colonized by *Botryosphaeria* canker which can cause significant cankers in those areas and affect the health of the tree.

To control both the insect and the pathogen a combination of fungicides and insecticides have been studied. A combination of traizole fungicides, including tebuconazole, metconazole (not registered for ornamental trees in California), or propiconazole, with an insecticide (emamectin benzoate, imidacloprid, or bifenthrin) were found to significantly reduce the number of beetle attacks on treated California sycamore trees (Grosman et al., 2019; Jones et al., 2017; Mayorquin et al., 2018).

Suggested Management Summary:

- Careful monitoring of trees of interest, including surrounding trees, is always recommended.
- Treatments should only be applied to trees with low to moderate levels of infestation.
- Applications should not be made to noninfested trees because ISHB typically colonize only a few trees in an area and do not disperse to other host trees until beetle populations have increased enough to cause branch dieback or tree death. Once trees are severely infested and suffering branch dieback or severe tree decline, pesticide applications will not "save" those trees.
- After pesticide/fungicide application, treatment effectiveness needs to be assessed and trees need to be monitored regularly for ISHB activity.
- Heavily infested trees serve as amplifier trees of ISHB and contribute significantly to the local beetle population. Those trees may also pose a physical hazard; therefore, they should be removed and infested wood sanitized appropriately.
- Tree stumps should be ground, removed or treated with a pesticide and covered with soil.
- For up-to-date information regarding the management of ISHB please visit www.ishb.org.

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Appendix A: ISHB Education and Outreach Materials to High Priority Target Audiences (Lynch, 2019)

Target Audience	Title	Format	Language	Purpose	Source	Date Published
Arborists, general public	Sycamore assessment	Handout	English	How to assess infestation in sycamores	Eskalen Lab	Jun-17
Arborists, general public, monitoring crews	ISHB/FD: Identifying symptoms and look-alike pests	Handout	English	ID information	pshb.org	Sep-17
Arborists, land managers, monitoring crews	Identifying Signs of ISHB attack and Fusarium Dieback (FD) in Trees	Printed and online field guide	English	ID symptoms in many tree species	pshb.org	Apr-17
Arborists, monitoring crews	Identifying symptoms and look-alike pests in willows	Handout	English	ID symptoms in willow	Eskalen Lab	Jun-17
Arborists, monitoring crews	ISHB/FD: How to sample a suspect tree	Handout	English	How to take wood samples for fungal ID	pshb.org	Dec-14
Arborists, land managers	Invasive Shot Hole Borers Threatening Trees in Southern California	Article	English	Description and BMPs	Eskalen lab UC IPM	Dec-16
Arborists, land managers	Managing Invasive Shot Hole Borers in Southern California	Article	English	Description and BMPs	UCCE UC IPM	Oct-18
Avocado growers	Best Management Practices for ISHB/FD in avocado	Handout	English	ID symptoms and BMP in avocado	Eskalen Lab	Unknown
Avocado growers, general public	A pest disease complex on Avocado in CA	Handout	English	ID symptoms and BMP in avocado	pshb.org	Jul-18
Avocado growers, general public	Una compleja plaga-enfermedad en los Aguacates de CA	Handout	Spanish	ID symptoms and BMP in avocado	pshb.org	Dec-14
Avocado growers, general public	Alerta de plaga. PSHB en Aguacate	Handout	Spanish	ID symptoms in avocado	Eskalen Lab	Unknown
General public	Urban trees are under attack!	Handout	English	General information	California Urban Forests Conference	Apr-18

Target Audience	Title	Format	Language	Purpose	Source	Date Published
Arborists, general public	Sycamore assessment	Handout	English	How to assess infestation in sycamores	Eskalen Lab	Jun-17
Arborists, general public, monitoring crews	ISHB/FD: Identifying symptoms and look-alike pests	Handout	English	ID information	pshb.org	Sep-17
Arborists, land managers, monitoring crews	Identifying Signs of ISHB attack and Fusarium Dieback (FD) in Trees	Printed and online field guide	English	ID symptoms in many tree species	pshb.org	Apr-17
Arborists, monitoring crews	Identifying symptoms and look-alike pests in willows	Handout	English	ID symptoms in willow	Eskalen Lab	Jun-17
Arborists, monitoring crews	ISHB/FD: How to sample a suspect tree	Handout	English	How to take wood samples for fungal ID	pshb.org	Dec-14
Arborists, land managers	Invasive Shot Hole Borers Threatening Trees in Southern California	Article	English	Description and BMPs	Eskalen lab UC IPM	Dec-16
Arborists, land managers	Managing Invasive Shot Hole Borers in Southern California	Article	English	Description and BMPs	UCCE UC IPM	Oct-18
Avocado growers	Best Management Practices for ISHB/FD in avocado	Handout	English	ID symptoms and BMP in avocado	Eskalen Lab	Unknown
Avocado growers, general public	A pest disease complex on Avocado in CA	Handout	English	ID symptoms and BMP in avocado	pshb.org	Jul-18
Avocado growers, general public	Una compleja plaga-enfermedad en los Aguacates de CA	Handout	Spanish	ID symptoms and BMP in avocado	pshb.org	Dec-14
Avocado growers, general public	Alerta de plaga. PSHB en Aguacate	Handout	Spanish	ID symptoms in avocado	Eskalen Lab	Unknown
General public	Urban trees are under attack!	Handout	English	General information	California Urban Forests Conference	Apr-18

Target Audience	Title	Format	Language	Purpose	Source	Date Publishe
General public	Hiring a Landscape Contractor: What you should know before you start	Handout	English	Guidelines to hire a landscape contractor	UCCE San Diego	Unknown
General public	Que necesita saber si va a contratar una compania de jardineria	Handout	Spanish	Guidelines to hire a landscape contractor	UCCE San Diego	Unknown
General public	Help stop the spread of invasive species (2)	Poster	English	Firewood: buy it where you burn it	Firewood Task Force	Unknown
General public	Help stop the spread of invasive species	Poster	English	Firewood: buy it where you burn it	Firewood Task Force	Unknown
General public	Ayuda a detener la diseminacion de especies exoticas invasivas	Poster	Spanish	Firewood: buy it where you burn it	Firewood Task Force	Unknown
General public	Buy it where you burn it	Poster	English	Firewood: buy it where you burn it	Firewood Task Force	Unknown
General public	Compre la lena donde se va a usar	Poster	Spanish	Firewood: buy it where you burn it	Firewood Task Force	Unknown
General public	Invasive pests killing our trees in california	Video	English	General information	California ReLeaf	Unknown
General public - Spanish speakers	Los arboles urbanos bajo ataque!	Handout	Spanish	General information	California Urban Forests Conference	Apr-18
General public - Spanish speakers	Compre la lena donde se va a usar	Poster Handout	Spanish	Buy it where you burn it; firewood awareness	Firewood Task Force	Unknown
General public, arborists, greenwaste facilities	FD-ISHB: How to handle infested material	Handout	English	Greenwaste handling	pshb.org	Apr-17
General public, arborists, greenwaste facilities	FD-ISHB Que hacer con los restos de planta infectados?	Handout	Spanish	Greenwaste handling	pshb.org	Apr-16

Target Audience	Title	Format	Language	Purpose	Source	Date Publishe
General public	Hiring a Landscape Contractor: What you should know before you start	Handout	English	Guidelines to hire a landscape contractor	UCCE San Diego	Unknown
General public	Que necesita saber si va a contratar una compania de jardineria	Handout	Spanish	Guidelines to hire a landscape contractor	UCCE San Diego	Unknown
General public	Help stop the spread of invasive species (2)	Poster	English	Firewood: buy it where you burn it	Firewood Task Force	Unknown
General public	Help stop the spread of invasive species	Poster	English	Firewood: buy it where you burn it	Firewood Task Force	Unknown
General public	Ayuda a detener la diseminacion de especies exoticas invasivas	Poster	Spanish	Firewood: buy it where you burn it	Firewood Task Force	Unknown
General public	Buy it where you burn it	Poster	English	Firewood: buy it where you burn it	Firewood Task Force	Unknown
General public	Compre la lena donde se va a usar	Poster	Spanish	Firewood: buy it where you burn it	Firewood Task Force	Unknown
General public	Invasive pests killing our trees in california	Video	English	General information	California ReLeaf	Unknown
General public - Spanish speakers	Los arboles urbanos bajo ataque!	Handout	Spanish	General information	California Urban Forests Conference	Apr-18
General public - Spanish speakers	Compre la lena donde se va a usar	Poster Handout	Spanish	Buy it where you burn it; firewood awareness	Firewood Task Force	Unknown
General public, arborists, greenwaste facilities	FD-ISHB: How to handle infested material	Handout	English	Greenwaste handling	pshb.org	Apr-17
General public, arborists, greenwaste facilities	FD-ISHB Que hacer con los restos de planta infectados?	Handout	Spanish	Greenwaste handling	pshb.org	Apr-16

Target Audience	Title	Format	Language	Purpose	Source	Date Published
General public, land managers	FD-ISHB: Prioritizing management efforts	Handout	English	BMPs	pshb.org	Apr-17
General public, land managers	FD-ISHB Como priorizar los esfuerzos de manejo?	Handout	Spanish	BMPs	pshb.org	Apr-16
General public, land managers	ISHB detection assessment tool	Online interactive tool	English	BMPs	pshb.org	Unknown
General public, politicians	ISHB/FD: A devastating threat to California trees	Handout	English	General information	pshb.org	Apr-17
General public, politicians, Spanish speakers	FD-ISHB: Una devastadora amenasa para los arboles de California	Handout	Spanish	General information	pshb.org	Apr-16
Homeowners	Fusarium dieback disease and the Polyphagous Shot Hole Borer: A serious pest/disease complex of avocados and landscape trees	Handout	English & Spanish	ID and BMPs in avocados and other trees	Eskalen Lab	Unknown
K-12	Polyphagous Shot Hole Borer Activity Book - Advanced	Activity book for kids	English	General information Games and activities	American Public Garden Association	Unknown
K-12	Polyphagous Shot Hole Borer Activity Book - Beginner	Activity book for kids	English	General information Games and activities	American Public Garden Association	Unknown
K-12	Polyphagous shot hole borer Field Guide	Field Guide for kids	English	General information	American Public Garden	Unknown
Land managers	Monitoring trap guidelines	Handout	English	Trapping options	pshb.org	Sep-17
Land managers, monitoring crews	Polyphagous Shot Hole Borer and Fusarium Dieback Disease on Palms	Article	English	ID symptoms in palm trees	Donald Hodel	2017

Target Audience	Title	Format	Language	Purpose	Source	Date Published
Land managers, survey crews	Kuroshio and Polyphagous Shot Hole Borer in Southern California Wildlands Associated Host Identification Guide	Handout	English	ID symptoms in many tree species	CA Dept. Fish and Wildlife	Jan-07
Spanish speaking land managers	ESCARABAJO BARRENADOR POLÍFAGO Euwallacea sp.	Article	Spanish	Description and BMPs	Mexican Secretariat of Agriculture and Rural Development	Mar-16
Spanish speaking land managers	FICHA TÉCNICA Euwallacea sp.	Fact sheet/article	Spanish	Description, distribution in Mexico and management	Mexican Secretariat of Agriculture and Rural Development	Sep-14

Assembly Bill No. 2470

CHAPTER 870

An act to amend Sections 5260 and 7271 of, and to add Part 4.5 (commencing with Section 7700) to Division 4 of, the Food and Agricultural Code, relating to invasive species.

[Approved by Governor September 28, 2018. Filed with Secretary of State September 28, 2018.]

LEGISLATIVE COUNSEL'S DIGEST

AB 2470, Grayson. Invasive Species Council of California.

(1) Existing law generally provides for the eradication of pests that threaten this state's agriculture and imposes various duties on the Department of Food and Agriculture in that regard. Under existing law, the department is designated as the lead department in noxious weed management, and requires the department, in cooperation with the Secretary of the Natural Resources Agency, to implement provisions relating to noxious weed management.

This bill would establish the Invasive Species Council of California, with a prescribed membership, to help coordinate a comprehensive effort to prevent the introduction of invasive species in the state and to advise state agencies how to facilitate coordinated, complementary, and cost-effective control or eradication of invasive species that have entered or are already established in the state, as specified.

The bill would authorize the council to establish advisory committees and ad hoc working groups, including the California Invasive Species Advisory Committee, with a prescribed membership, to advise the council on a broad array of issues related to preventing the introduction of invasive species and providing for their control or eradication, as well as minimizing the economic, ecological, and human health impacts that invasive species cause, as specified.

The bill would require the council to coordinate with state and local public agencies, publicly funded educational institutions, and stakeholder groups to develop a plan for the cure or suppression of diseases associated with the spread of invasive shot hole borers.

The bill would establish the Invasive Species Account in the Department of Food and Agriculture Fund and moneys in the account would be available, upon appropriation, to the Secretary of Food and Agriculture for the purposes of funding invasive species projects and activities recommended by the council.

(2) Existing law creates the Noxious Weed Management Account in the Department of Food and Agriculture Fund, and provides for the allocation of those moneys, by percentage, for specified purposes, including control

and abatement and research, and to the department for the purposes of carrying out those provisions relating to noxious weed management.

This bill would revise the purposes for which 20% of the moneys in the Noxious Weed Management Account are to be allocated for research to instead be made available through a grant program administered by the department for proposals evaluated in consultation with the Range Management Advisory Committee, with an emphasis placed on the funding of needs-based, applied, and practical research, as specified.

The people of the State of California do enact as follows:

SECTION 1. Section 5260 of the Food and Agricultural Code is amended to read:

5260. The Legislature hereby finds and declares all of the following:

(a) California is home to more species of plants and animals in the world and the highest number of species found nowhere else in the world.

(b) The state's plants and animals coexist to create the complex ecosystems upon which so much of the state's people and economy depend.

(c) Global travel, global trade, and climate change are introducing invasive animals, plants, insects, and plant and animal diseases to California.

(d) Global warming is changing ecosystems at an unprecedented pace. These changes bring invasive species and pests that pose direct threats to the state's native and agricultural biodiversity.

(e) The State of California should undertake advance planning on whether and how to address those invasive animals, plants, insects, and plant and animal diseases that are a threat to the state's agriculture, environment, or economy.

(f) The Legislature fully recognizes that any prediction of which invasive pests will enter California cannot be precise because of the many entry mechanisms.

SEC. 2. Section 7271 of the Food and Agricultural Code is amended to read:

7271. (a) The Legislature designates the department as the lead department in noxious weed management and the department is responsible for the implementation of this article in cooperation with the Secretary of the Natural Resources Agency.

(b) There is hereby created in the Department of Food and Agriculture Fund the Noxious Weed Management Account.

(c) Moneys appropriated for expenditure by the secretary for the purposes of this article may be spent without regard to fiscal year and shall be allocated as follows:

(1) Sixty percent of the moneys in the account shall be made available to eligible weed management areas or county agricultural commissioners for the control and abatement of noxious and invasive weeds according to an approved integrated weed management plan. These control moneys shall be made available through a grant program administered by the department.

and abatement and research, and to the department for the purposes of carrying out those provisions relating to noxious weed management.

This bill would revise the purposes for which 20% of the moneys in the Noxious Weed Management Account are to be allocated for research to instead be made available through a grant program administered by the department for proposals evaluated in consultation with the Range Management Advisory Committee, with an emphasis placed on the funding of needs-based, applied, and practical research, as specified.

The people of the State of California do enact as follows:

SECTION 1. Section 5260 of the Food and Agricultural Code is amended to read:

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(b) The state's plants and animals coexist to create the complex ecosystems upon which so much of the state's people and economy depend.

(c) Global travel, global trade, and climate change are introducing invasive animals, plants, insects, and plant and animal diseases to California.

(d) Global warming is changing ecosystems at an unprecedented pace. These changes bring invasive species and pests that pose direct threats to the state's native and agricultural biodiversity.

(e) The State of California should undertake advance planning on whether and how to address those invasive animals, plants, insects, and plant and animal diseases that are a threat to the state's agriculture, environment, or economy.

(f) The Legislature fully recognizes that any prediction of which invasive pests will enter California cannot be precise because of the many entry mechanisms.

SEC. 2. Section 7271 of the Food and Agricultural Code is amended to read:

7271. (a) The Legislature designates the department as the lead department in noxious weed management and the department is responsible for the implementation of this article in cooperation with the Secretary of the Natural Resources Agency.

(b) There is hereby created in the Department of Food and Agriculture Fund the Noxious Weed Management Account.

(c) Moneys appropriated for expenditure by the secretary for the purposes of this article may be spent without regard to fiscal year and shall be allocated as follows:

(1) Sixty percent of the moneys in the account shall be made available to eligible weed management areas or county agricultural commissioners for the control and abatement of noxious and invasive weeds according to an approved integrated weed management plan. These control moneys shall be made available through a grant program administered by the department.

Proposals shall be evaluated based on the strategic importance for local and regional eradication of high priority noxious and invasive weeds.

(2) (A) Twenty percent shall be made available toward research on the biology, ecology, or management of noxious and invasive weeds; the mapping, risk assessment, and prioritization of weeds; the prevention of weed introduction and spread; and education and outreach activities. These moneys shall be made available to qualified applicants through a grant program administered by the department. Proposals shall be evaluated in consultation with the Range Management Advisory Committee, established pursuant to Section 741 of the Public Resources Code, with an emphasis placed on funding of needs-based, applied, and practical research.

(B) For purposes of this paragraph, a qualified applicant includes nonprofits, publicly funded educational institutions, state and local agencies, and California Native American tribes.

(3) Twenty percent shall be made available to the department, and shall only be used for the following purposes:

(A) Carrying out the provisions of this article.

(B) Developing noxious weed control strategies.

(C) Seeking new, effective biological control agents for the long-term control of noxious weeds.

(D) Conducting private and public workshops as needed to discuss and plan weed management strategies with all interested and affected local, state, and federal agencies, private landowners, educational institutions, interest groups, and county agricultural commissioners.

(E) Appointing a noxious weed coordinator and weed mapping specialist to assist in weed inventory, mapping, and control strategies.

SEC. 3. Part 4.5 (commencing with Section 7700) is added to Division 4 of the Food and Agricultural Code, to read:

PART 4.5. INVASIVE SPECIES COUNCIL OF CALIFORNIA

7700. (a) (1) There is in state government the Invasive Species Council of California. The purpose of the council is to help coordinate a comprehensive effort to prevent the introduction of invasive species in the state and to advise state agencies, including, but not limited to, the department and the Natural Resources Agency, within their respective authorities how to facilitate coordinated, complementary, and cost-effective control or eradication of invasive species that have entered or are already established in the state. The council may address nonnative organisms that cause economic or environmental harm. Invasive species within the scope of the council's advisory duties do not include humans, domestic livestock, domestic or domesticated species exempted pursuant to Section 2118 of the Fish and Game Code, or nonharmful exotic organisms.

(2) This part shall not prohibit the department from serving as the state's governing authority in invasive pest and plant management, as specified in this division.

(b) The Invasive Species Council of California shall consist of the following six members:

(1) The secretary or his or her designated representative.

(2) The Secretary of the Natural Resources Agency or his or her designated representative.

(3) The Secretary for Environmental Protection or his or her designated representative.

(4) The Secretary of Transportation or his or her designated representative.

(5) The Secretary of California Health and Human Services or his or her designated representative.

(6) The Director of Emergency Services or his or her designated representative.

(c) The Secretary of the Natural Resources Agency or his or her designated representative and the secretary or his or her designee shall serve as cochairs of the council.

(d) The Invasive Species Council of California shall meet annually and as needed as determined by the cochairs.

(e) The secretary may designate a staff liaison to further the purposes of this part.

(f) (1) The Invasive Species Council of California may establish advisory committees and ad hoc working groups, as necessary, to advise on a broad array of issues related to preventing the introduction of invasive species and providing for their control or eradication, as well as minimizing the economic, ecological, and human health impacts that invasive species cause.

(2) The advisory committees and working groups may consist of representatives from state agencies, federal agencies, county agricultural commissioners, academia, nonprofit organizations, tribal nations, industry representatives, and members of the public.

7702. Upon the appropriation or transfer of adequate moneys to the Invasive Species Account, created pursuant to Section 7706, the Invasive Species Council of California may make recommendations on invasive species projects and activities, including, but not limited to, any of the following:

(a) To assist state, federal, and local agencies to prevent the introduction of invasive species.

(b) To relevant state agencies and departments regarding any of the following:

(1) Detection, control, and eradication of invasive species, including emergency and nonemergency detection and rapid response.

(2) Development and maintenance of statewide surveys and mapping of high-risk areas.

(3) Improvement of inspections at state and national boundaries to prevent the introduction of invasive species.

(c) To develop comprehensive reports on the ecological, agricultural, and economic impacts of invasive species.

(d) To develop statewide education, outreach, and branding of invasive species.

(e) To increase coordination and collaboration among invasive species partners.

(f) To develop statewide invasive species action plans, including the plan required pursuant to Section 7708.

(g) To host an annual California Invasive Species Summit to develop new recommendations and to coordinate invasive species activities.

(h) (1) To develop a report containing activities of the Invasive Species Council of California and recommendations to improve invasive species management.

(2) The council shall submit the report developed pursuant to this subdivision to the Legislature and the Governor.

(3) A report to be submitted to the Legislature pursuant to this subdivision shall be submitted in compliance with Section 9795 of the Government Code.

7704. The Invasive Species Council of California may establish the California Invasive Species Advisory Committee, which shall consist of the following 19 members:

(a) Four members designated by the secretary.

(b) Four members designated by the Secretary of the Natural Resources Agency or his or her designated representative.

(c) One member appointed by the Secretary for Environmental Protection or his or her designated representative.

(d) One member appointed by the Secretary of Transportation or his or her designated representative.

(e) One member appointed by the Secretary of California Health and Human Services or his or her designated representative.

(f) One member appointed by the Director of Emergency Services or his or her designated representative.

(g) Six members appointed by the cochairs of the Invasive Species Council of California to create a diverse makeup of federal, nonprofit organization, tribal, industry, and other representatives.

(h) One member appointed by the California Agricultural Commissioners and Sealers Association.

7706. (a) The Invasive Species Account is hereby established in the Department of Food and Agriculture Fund. Moneys in the account are available, upon appropriation by the Legislature, to the secretary for the purposes of funding invasive species projects and activities recommended by the Invasive Species Council of California.

(b) Moneys in the Invasive Species Account appropriated by the Legislature for allocation by the secretary for the purposes of this part may be allocated without regard to fiscal year.

7708. (a) The Invasive Species Council of California shall coordinate with state and local public agencies, publicly funded educational institutions, and stakeholder groups to develop a plan for the cure or suppression of

diseases associated with the spread of invasive shot hole borers, including, but not limited to, the Polyphagous and Kuroshio shot hole borers.

(b) (1) Upon the completion of the plan required pursuant to subdivision (a), the department, subject to the availability of appropriations for those specified purposes, shall support the efforts of state and local agencies, California Native American tribes, and nonprofits to cure or suppress the diseases affiliated with the invasive shot hole borer infestation as provided in paragraph (2).

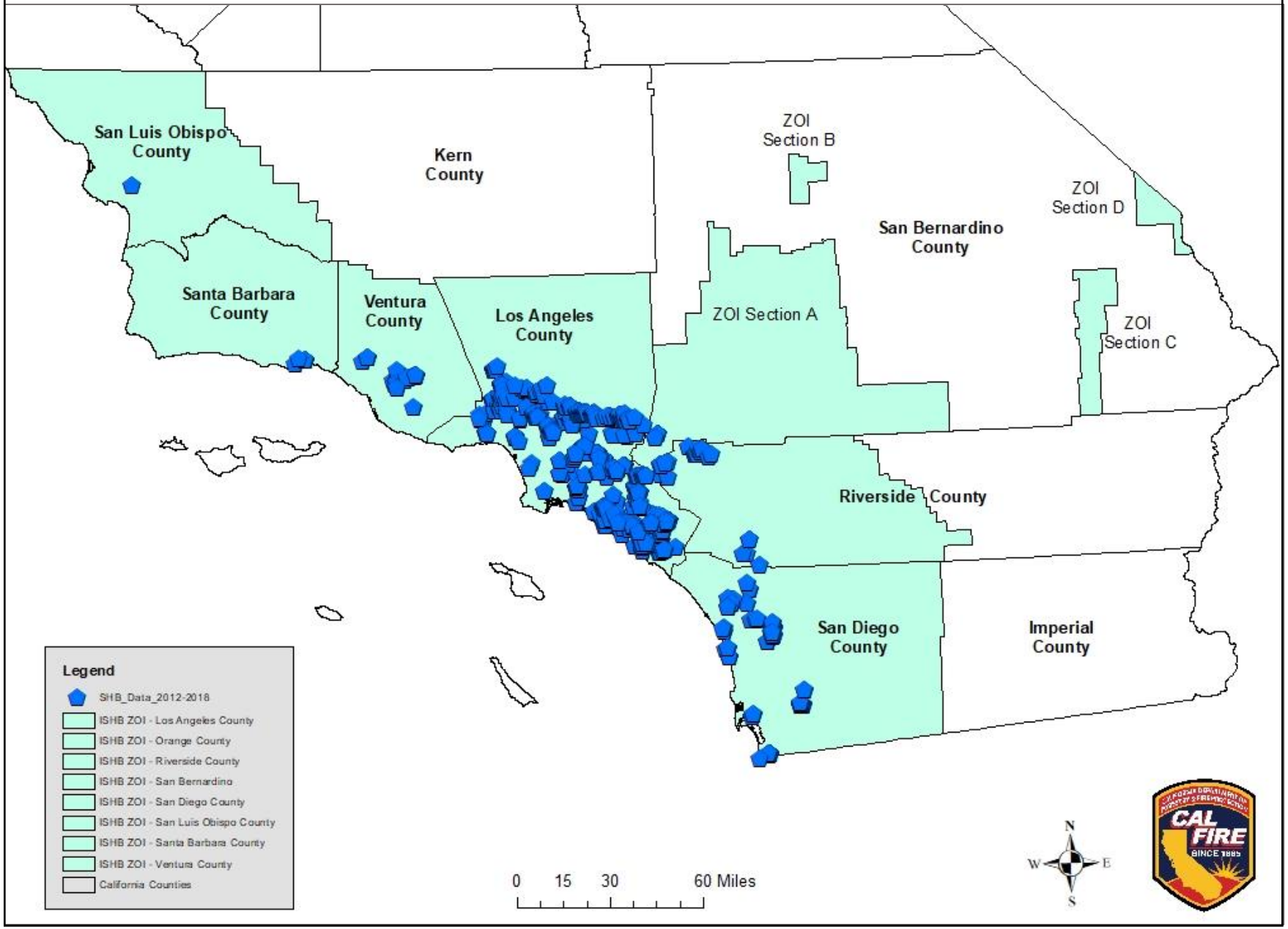
(2) Support provided by the department pursuant to this section may include, but is not limited to, the following:

(A) Grants to support research related to the identification of infected trees and methods to prevent further infestation.

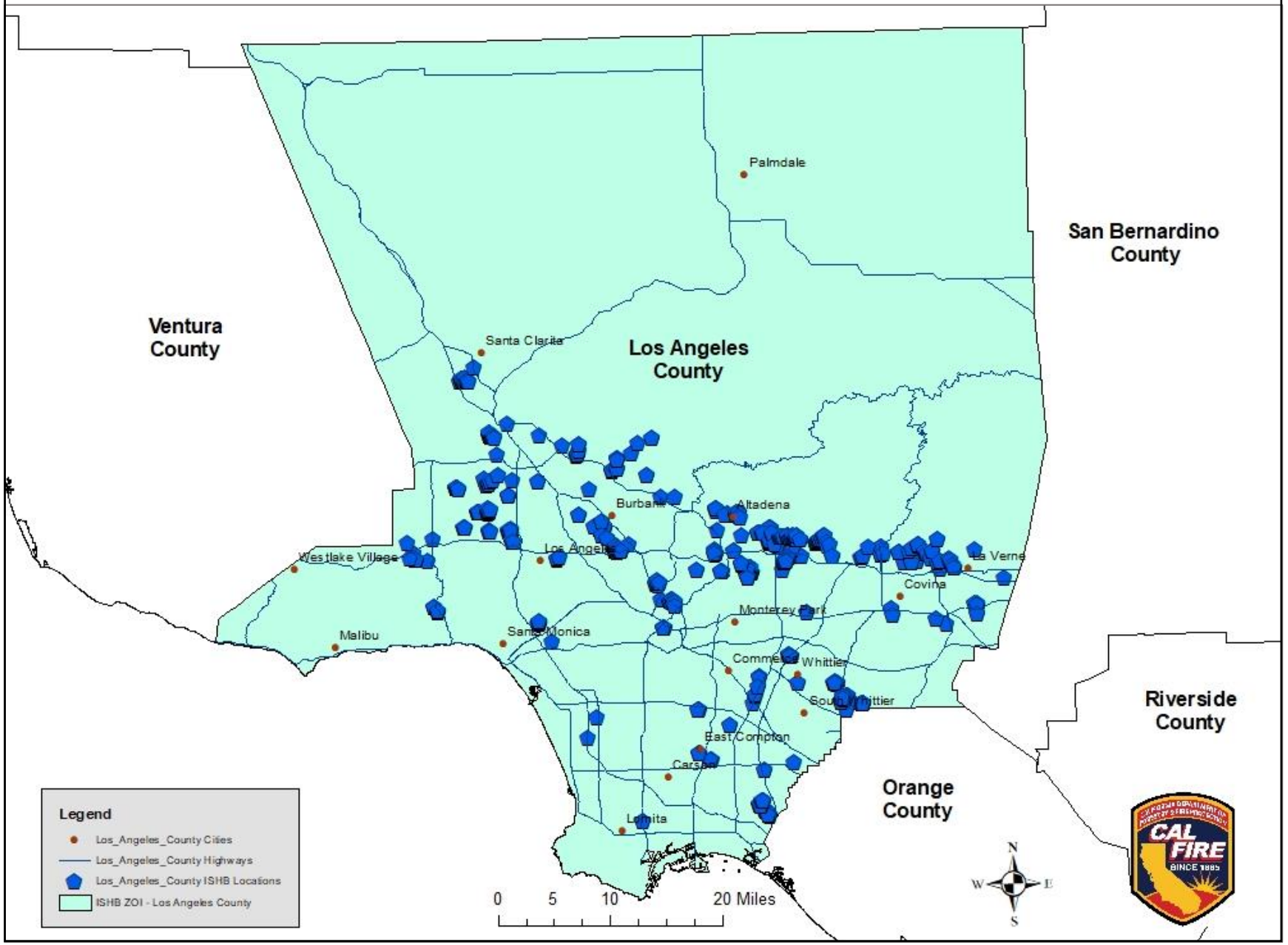
(B) Grants to state and local agencies, California Native American tribes, and nonprofits to support suppression or cure efforts.

(c) No state moneys shall be awarded to a local agency pursuant to subdivision (b) unless the local agency has contributed from local resources a dollar amount that is equal to the dollar amount of state moneys to be awarded or the local agency is located in a disadvantaged community, as identified pursuant to Section 39711 of the Health and Safety Code.

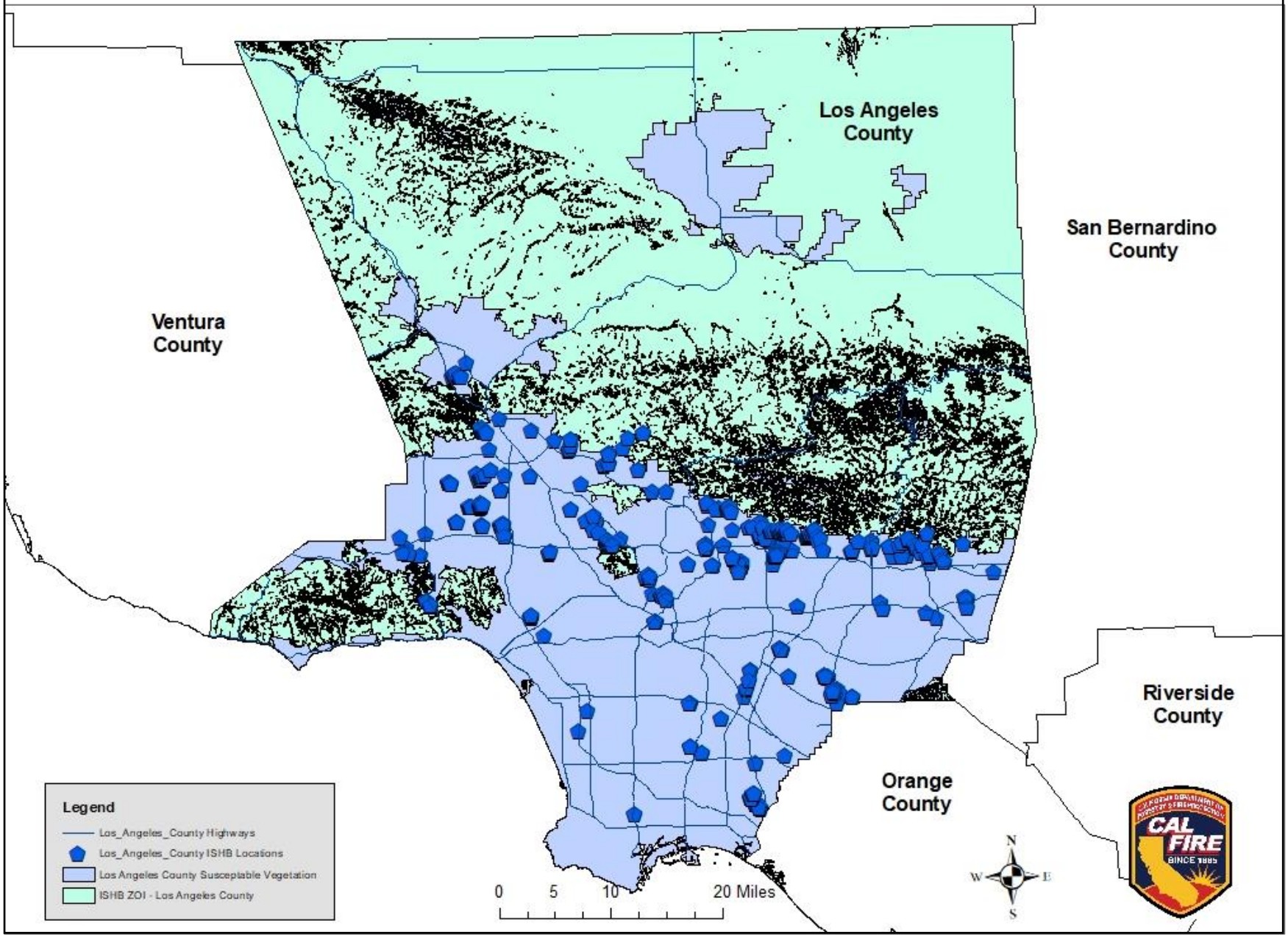
Appendix C: Proposed Map for the ISHB Zone of Infestation



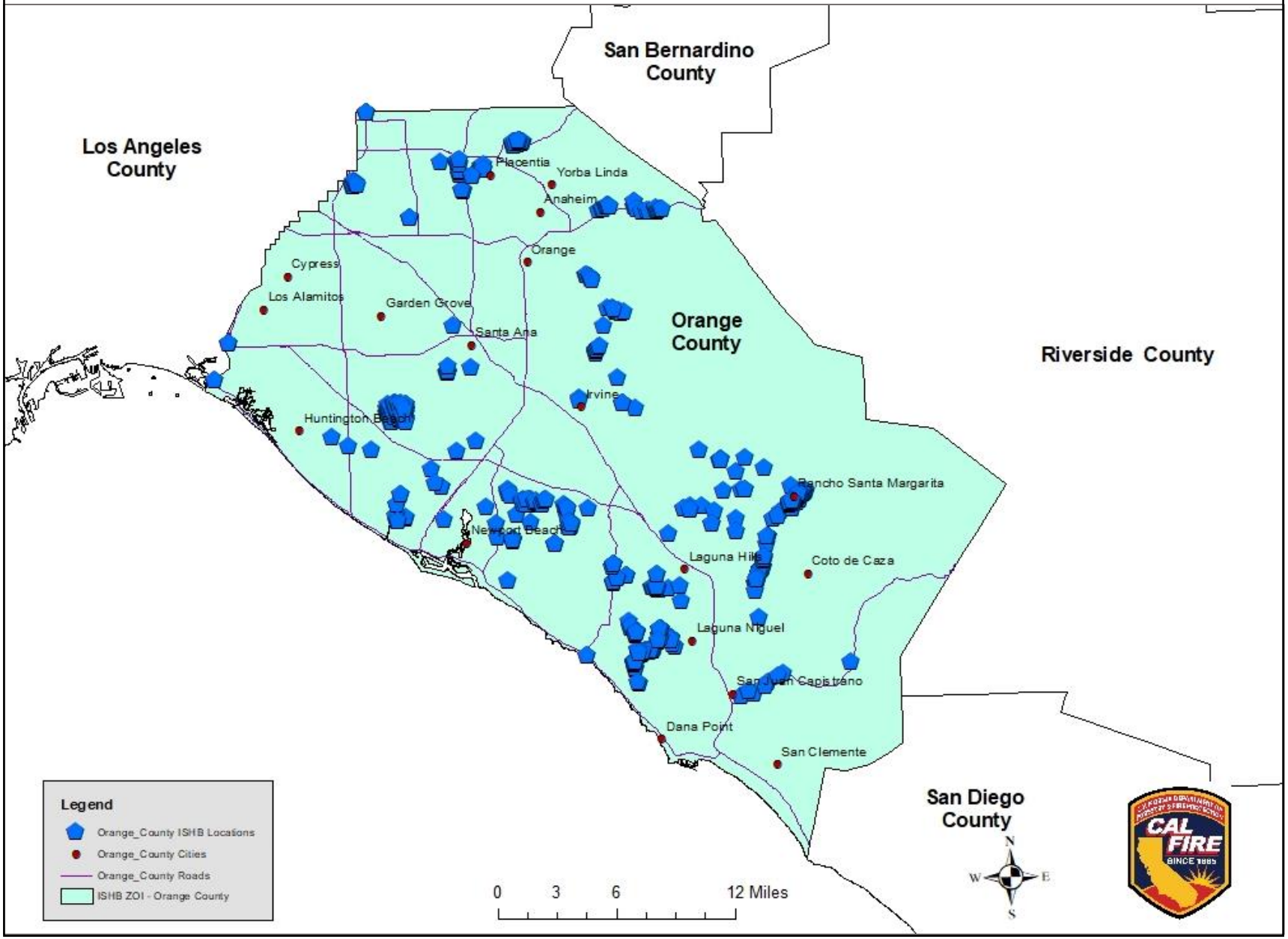
Appendix D: Proposed Map for the ISHB Zone of Infestation for Los Angeles County



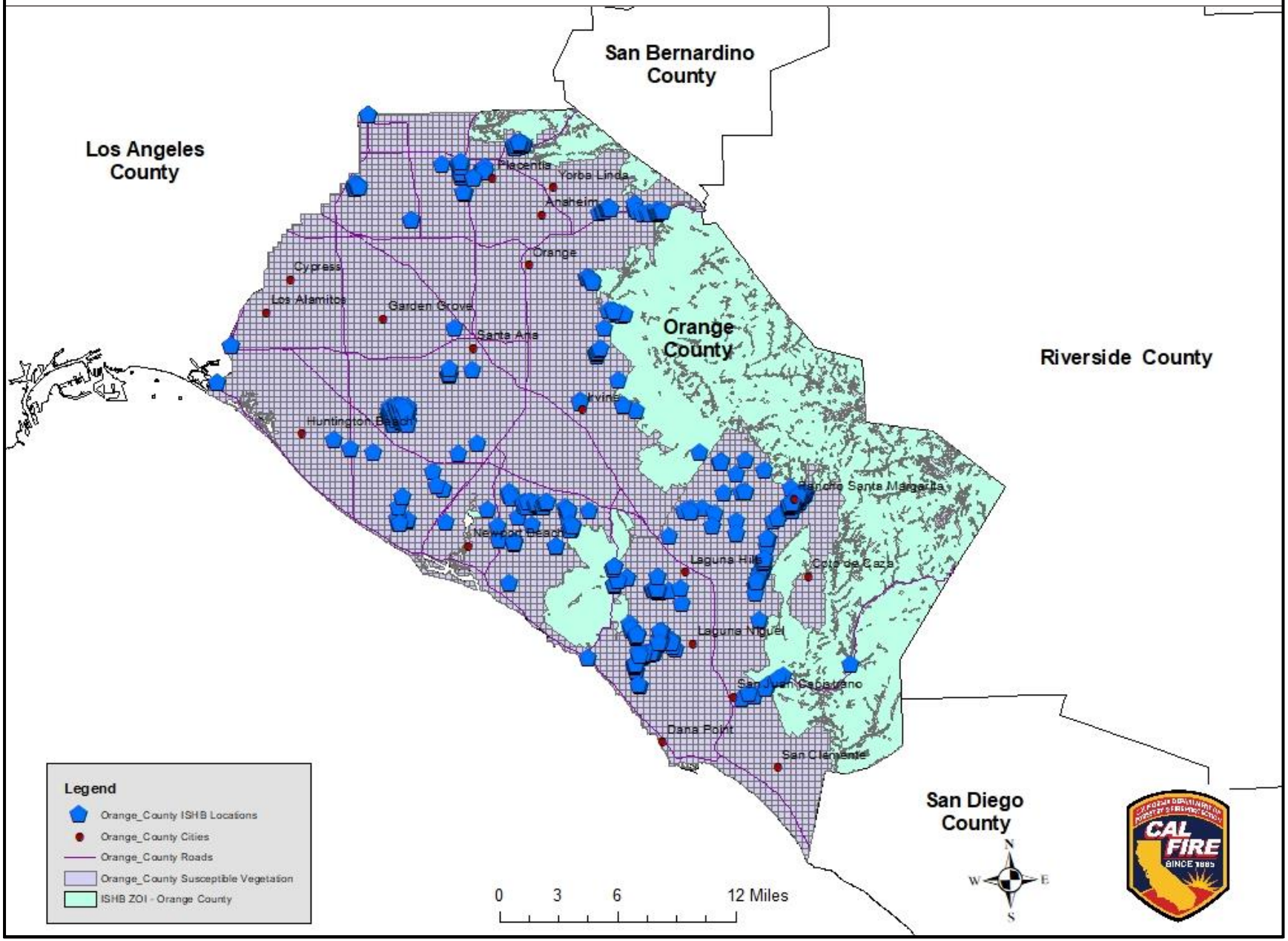
Appendix E: Proposed Map for the ISHB Zone of Infestation for Los Angeles County with Susceptible Vegetation



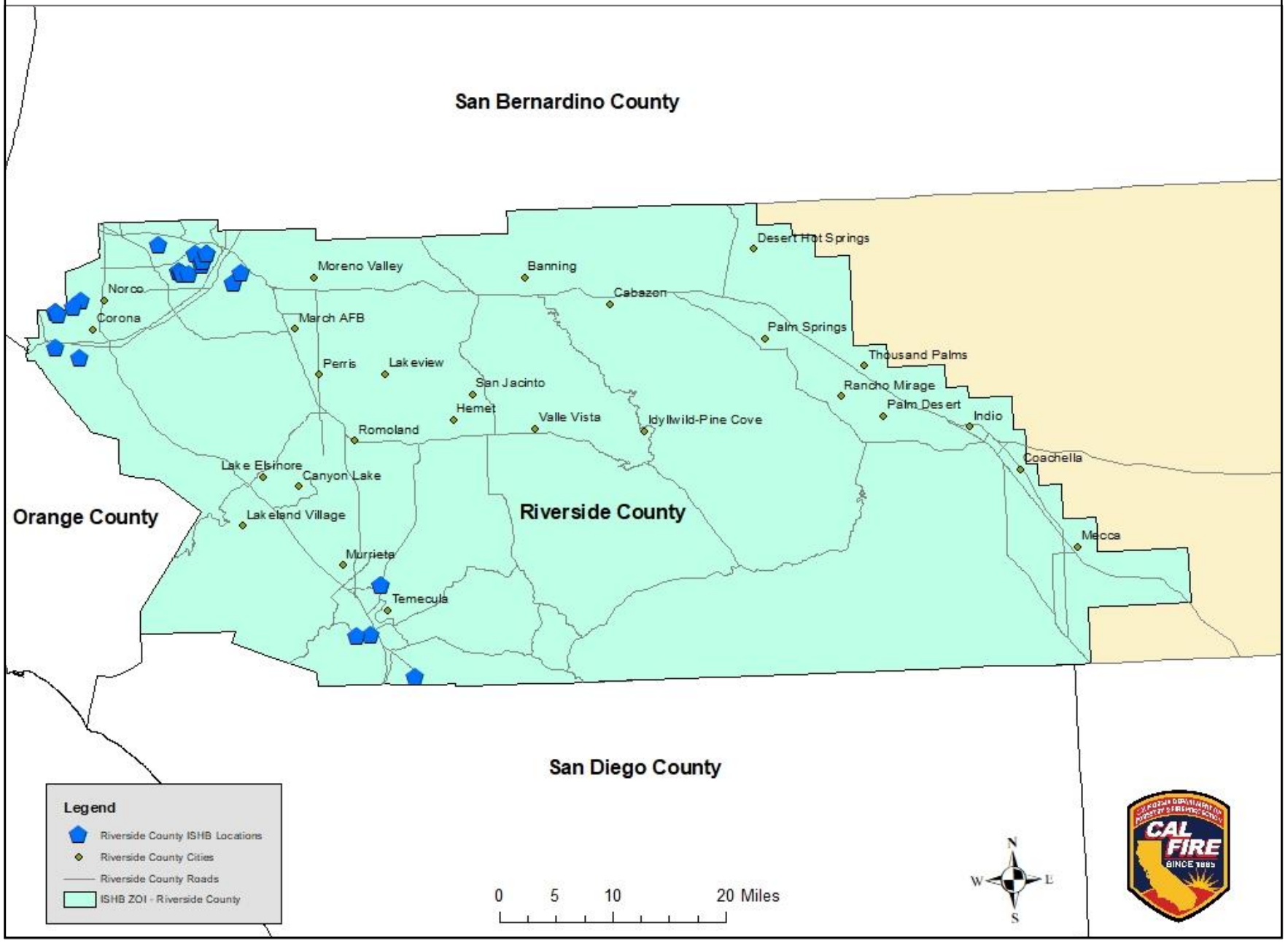
Appendix F: Proposed Map for the ISHB Zone of Infestation for Orange County



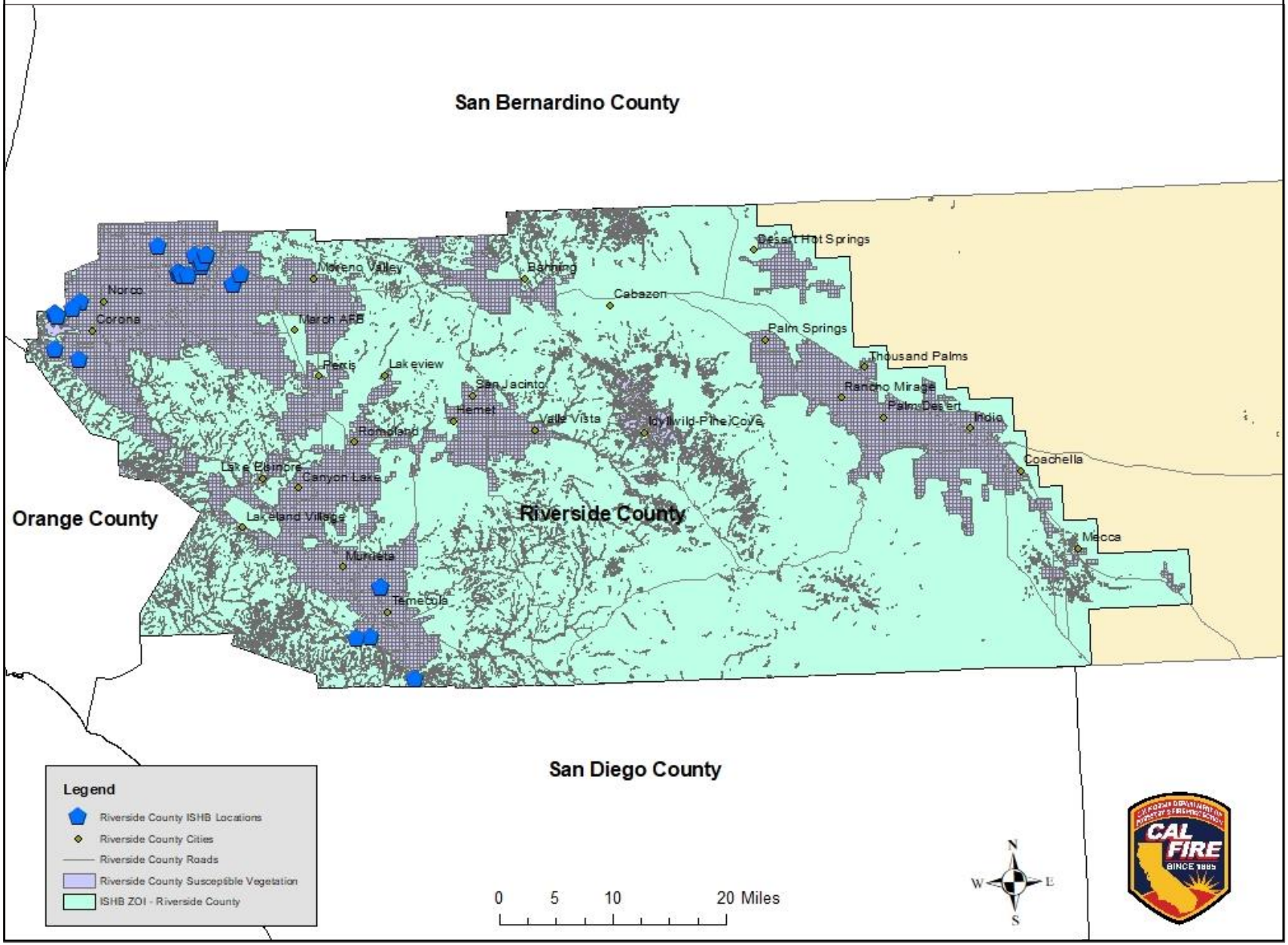
Appendix G: Proposed Map for the ISHB Zone of Infestation for Orange County with Susceptible Vegetation



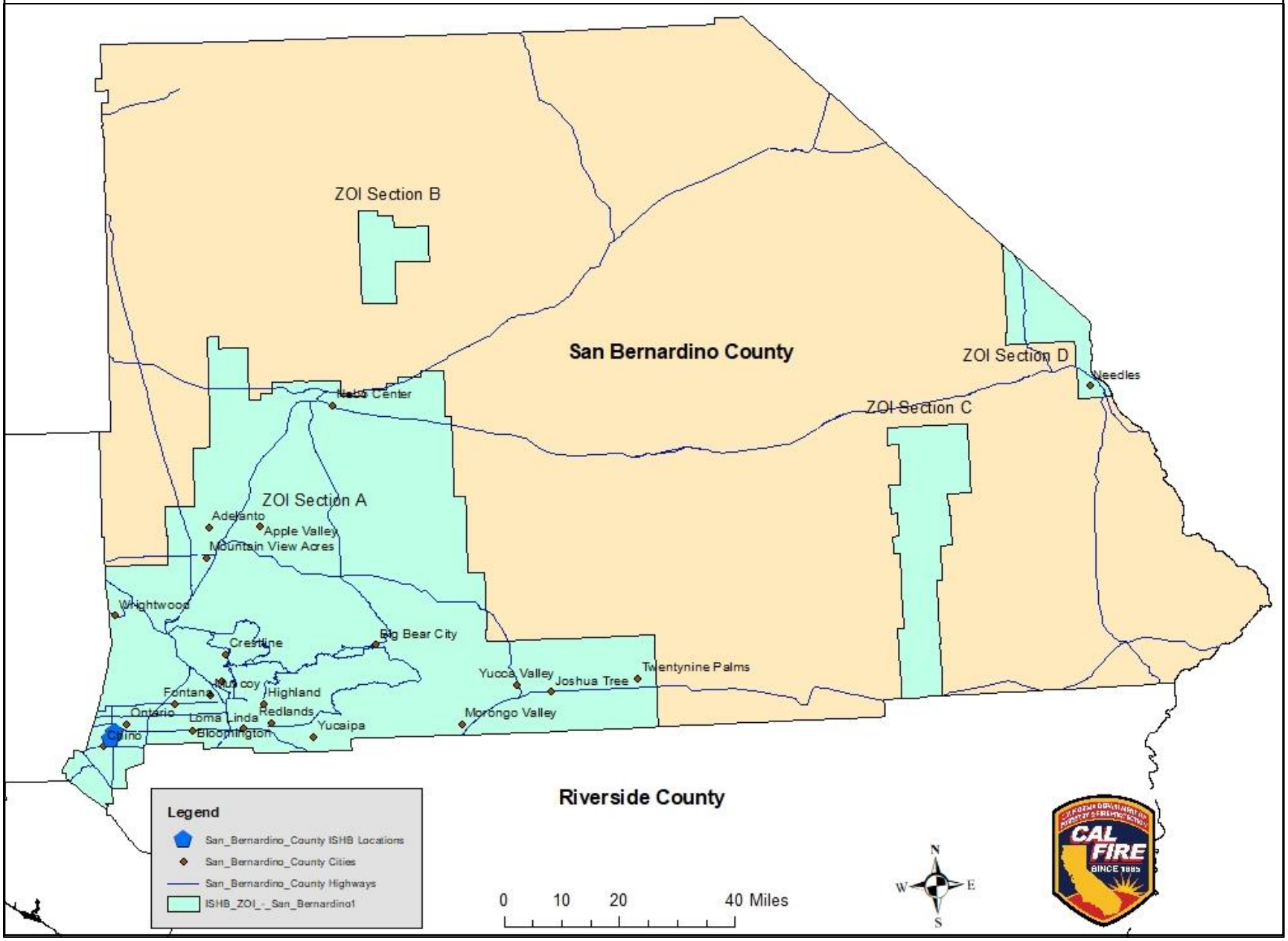
Appendix H: Proposed Map for the ISHB Zone of Infestation for Riverside County



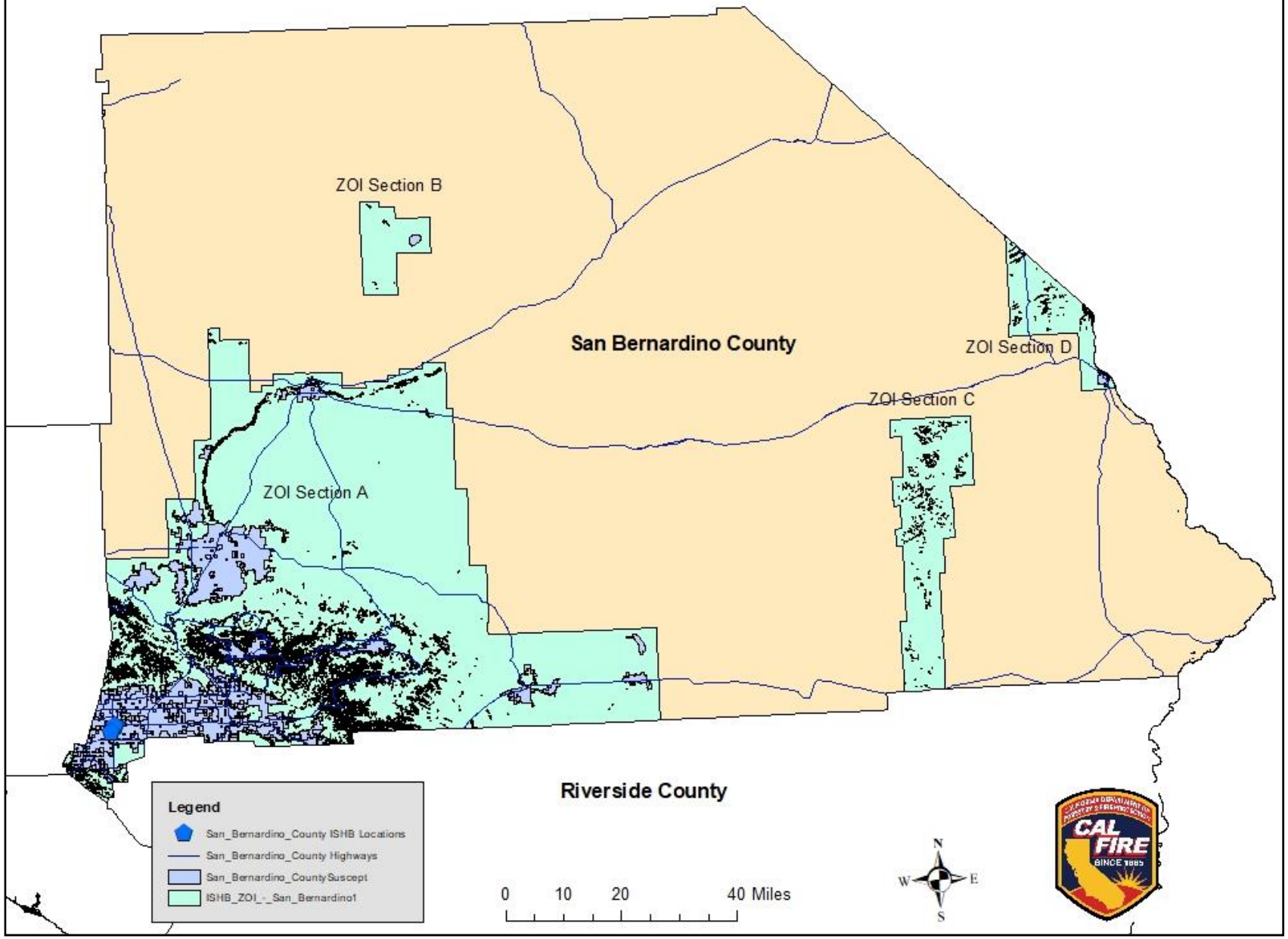
Appendix I: Proposed Map for the ISHB Zone of Infestation for Riverside County with Susceptible Vegetation



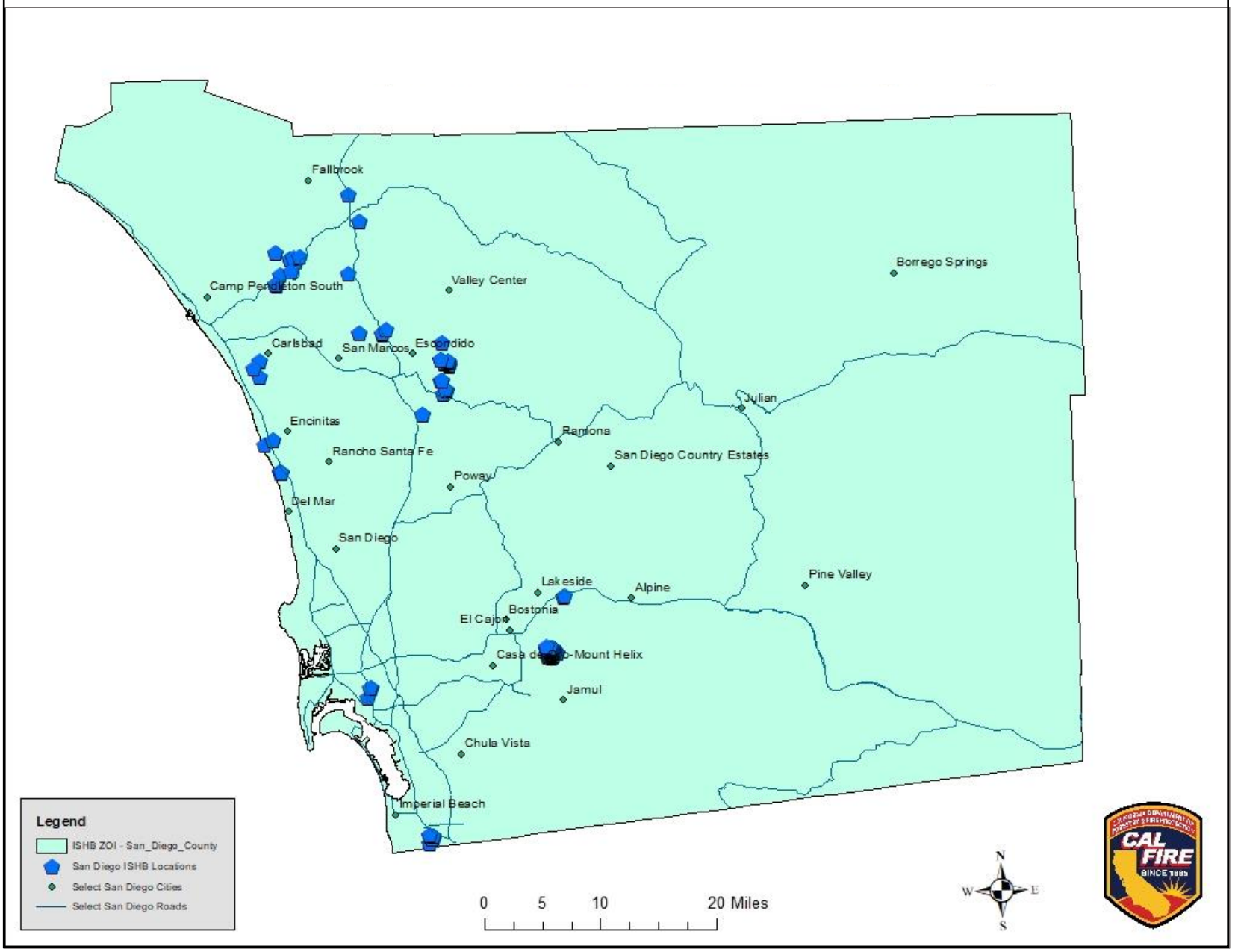
Appendix J: Proposed Map for the ISHB Zone of Infestation for San Bernardino County



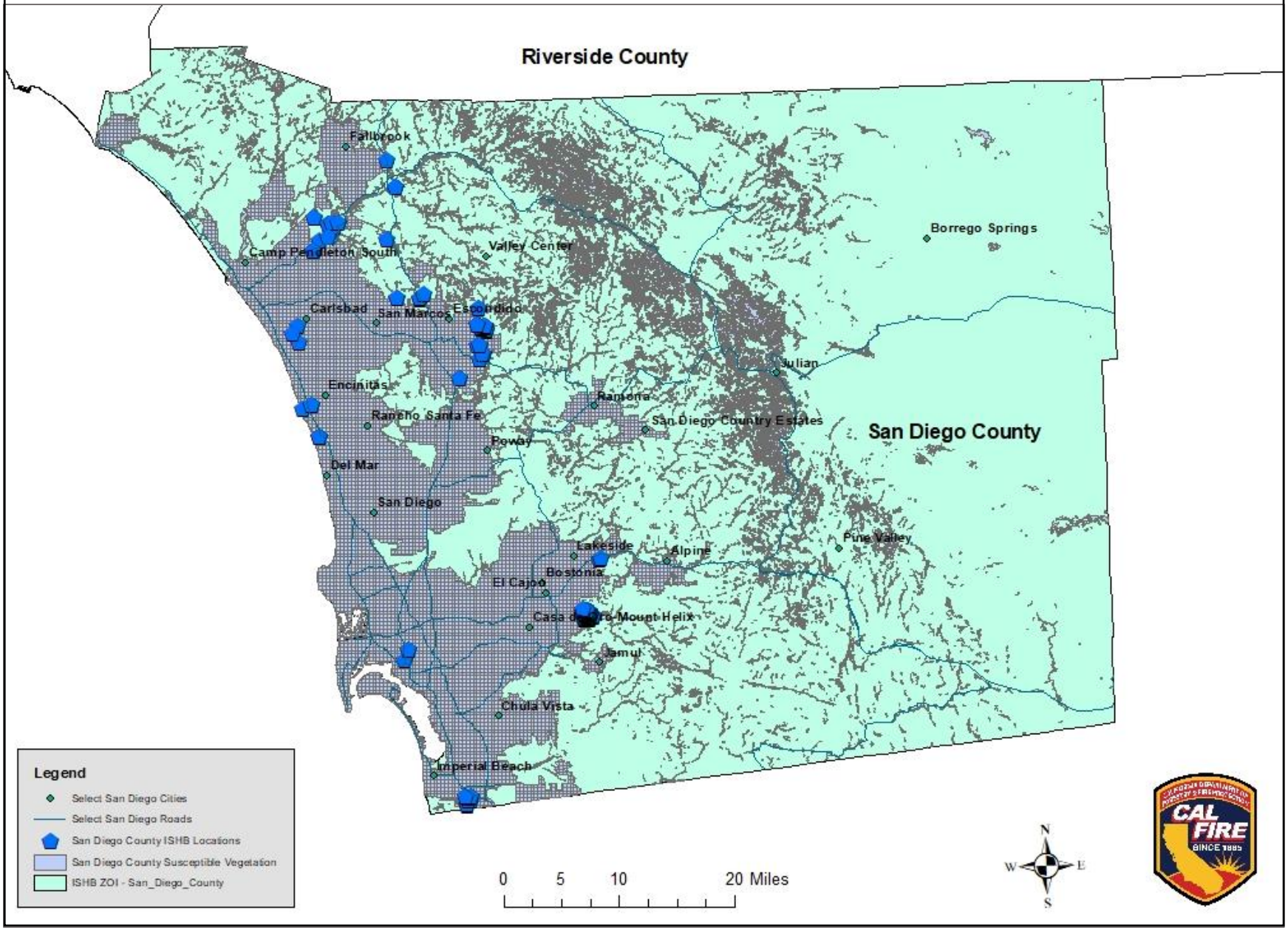
Appendix K: Proposed Map for the ISHB Zone of Infestation for San Bernardino County with Susceptible Vegetation



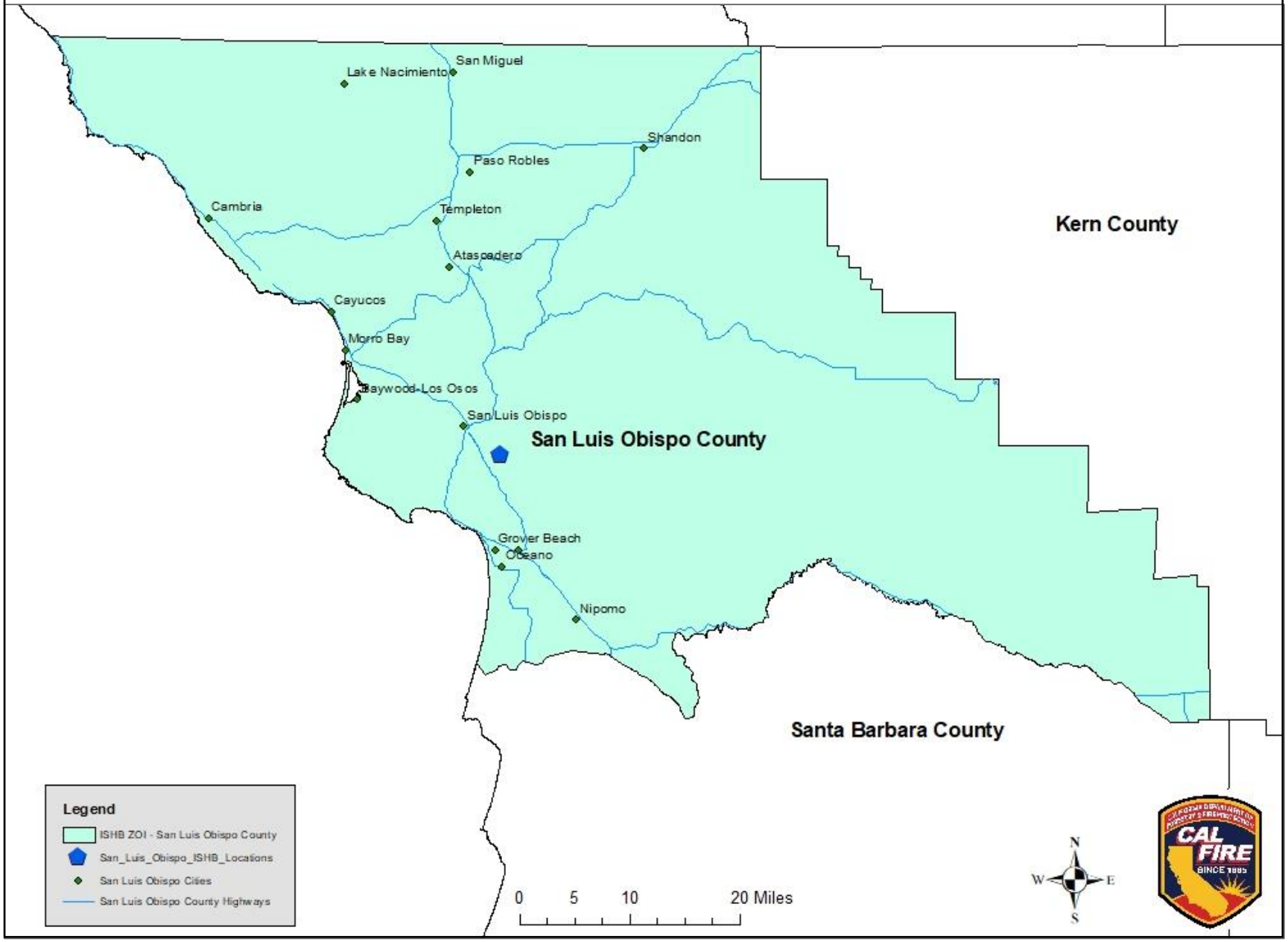
Appendix L: Proposed Map for the ISHB Zone of Infestation for San Diego County



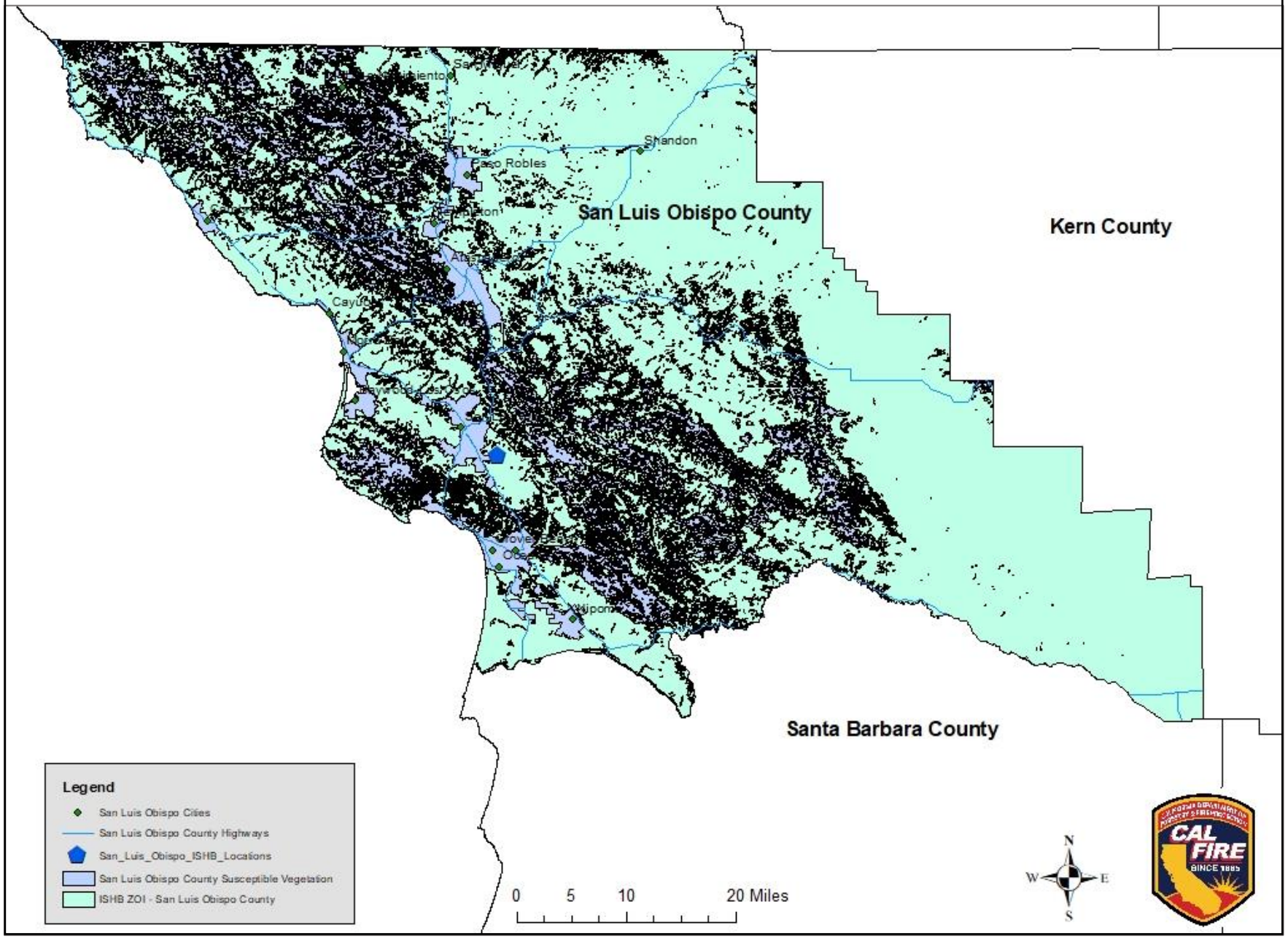
Appendix M: Proposed Map for the ISHB Zone of Infestation for San Diego County with Susceptible Vegetation



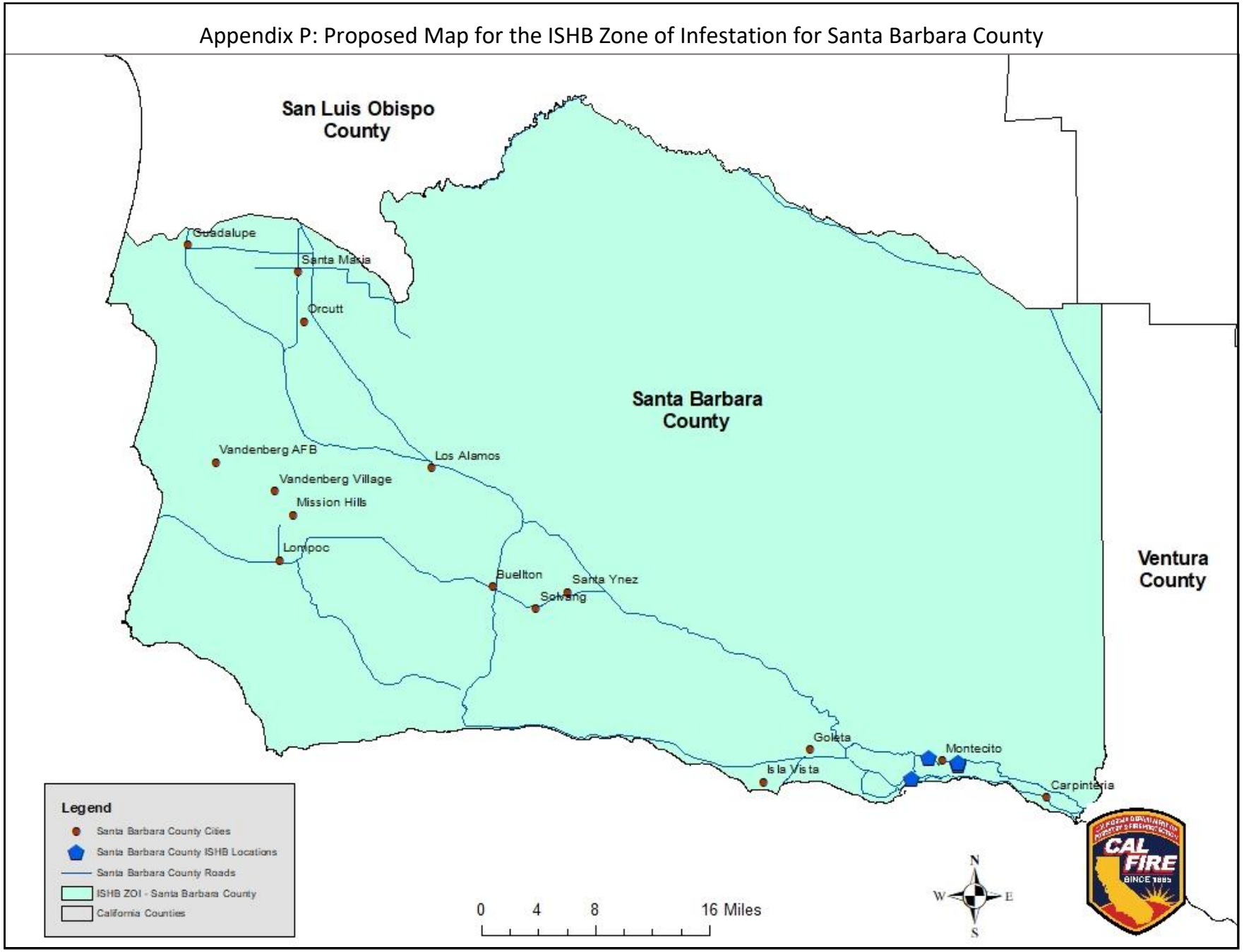
Appendix N: Proposed Map for the ISHB Zone of Infestation for San Luis Obispo County



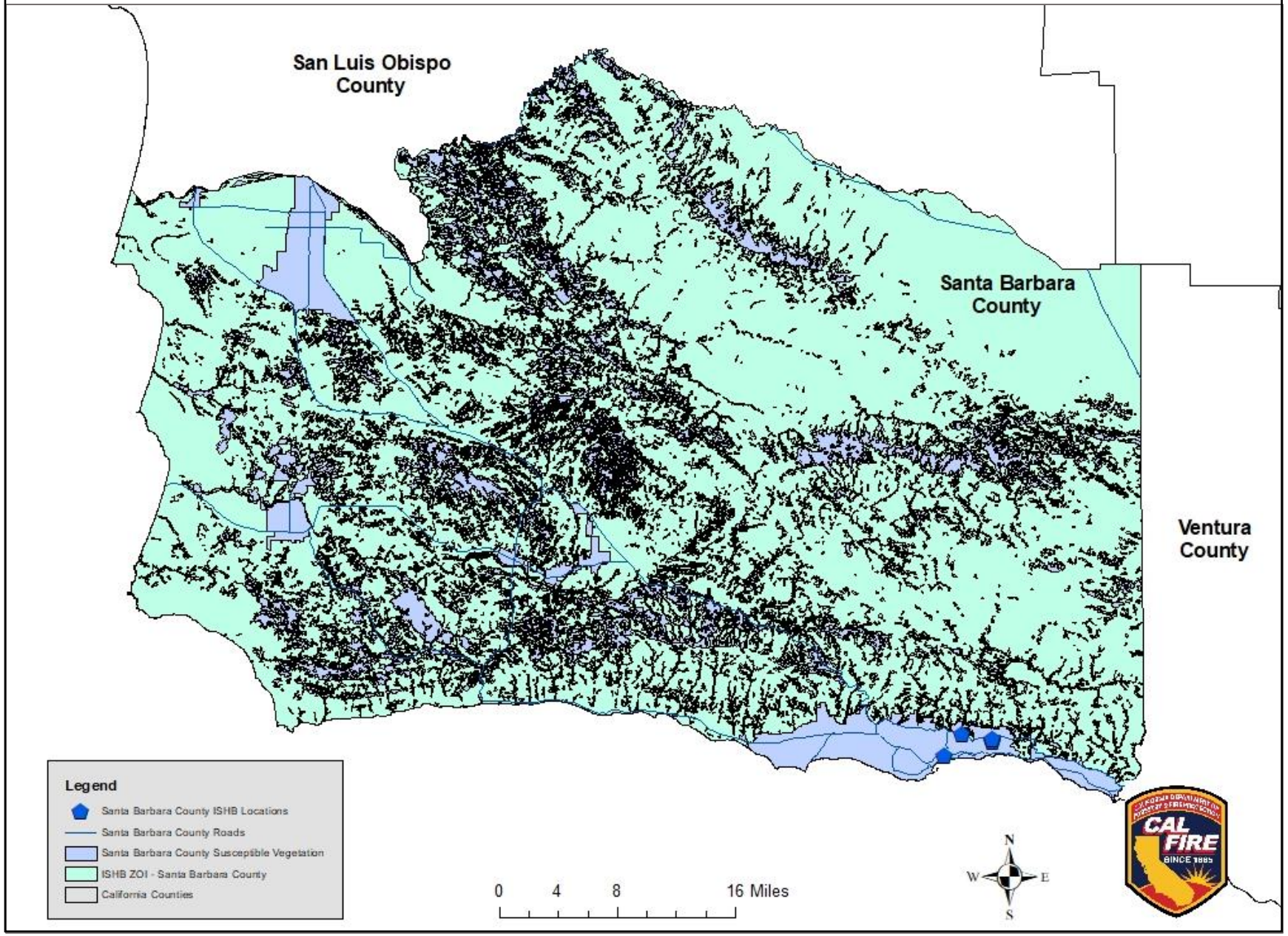
Appendix O: Proposed Map for the ISHB Zone of Infestation for San Luis Obispo County with Susceptible Vegetation



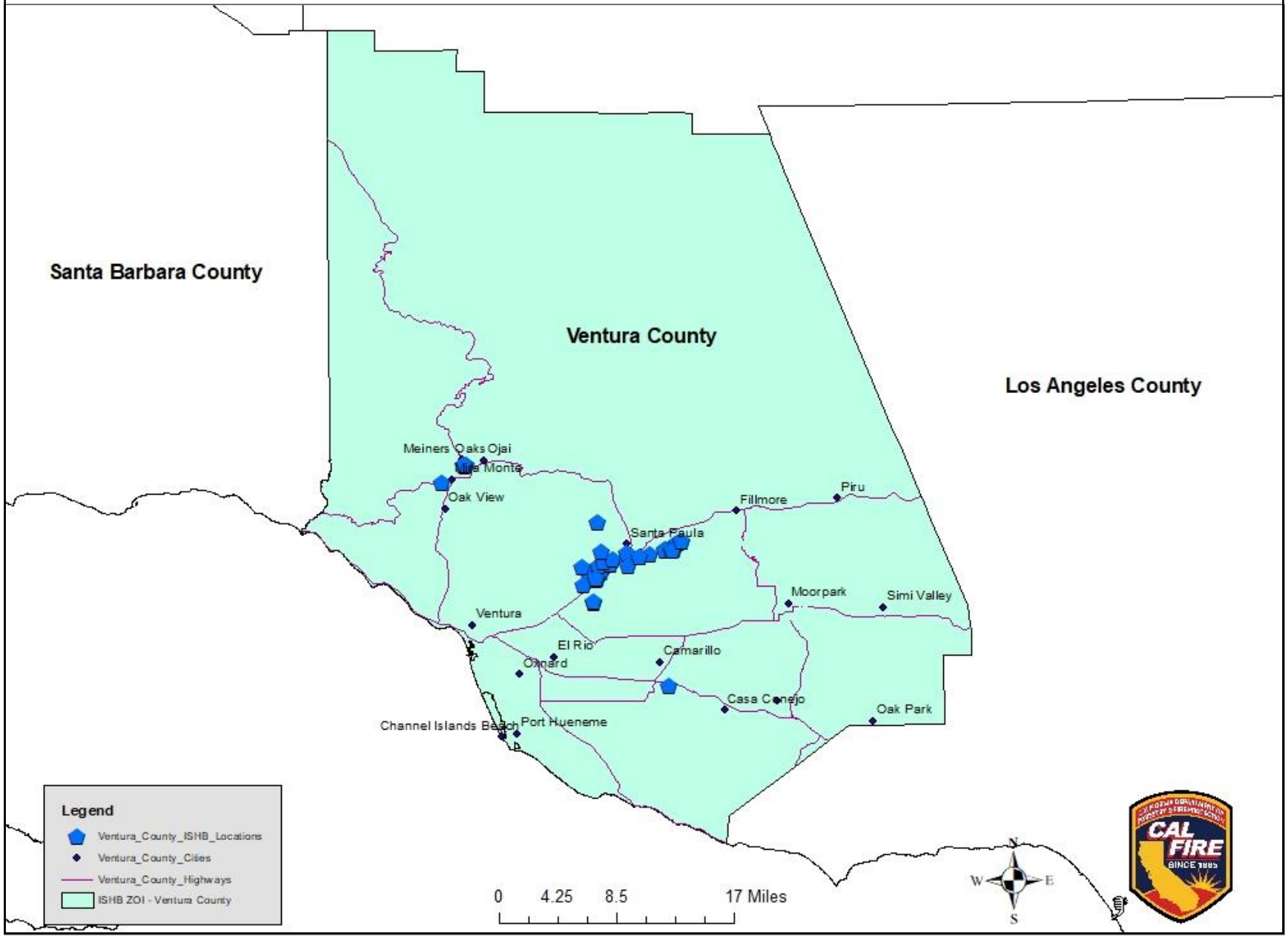
Appendix P: Proposed Map for the ISHB Zone of Infestation for Santa Barbara County



Appendix Q: Proposed Map for the ISHB Zone of Infestation for Santa Barbara County with Susceptible Vegetation



Appendix R: Proposed Map for the ISHB Zone of Infestation for Ventura County



Appendix S: Proposed Map for the ISHB Zone of Infestation for Ventura County with Susceptible Vegetation

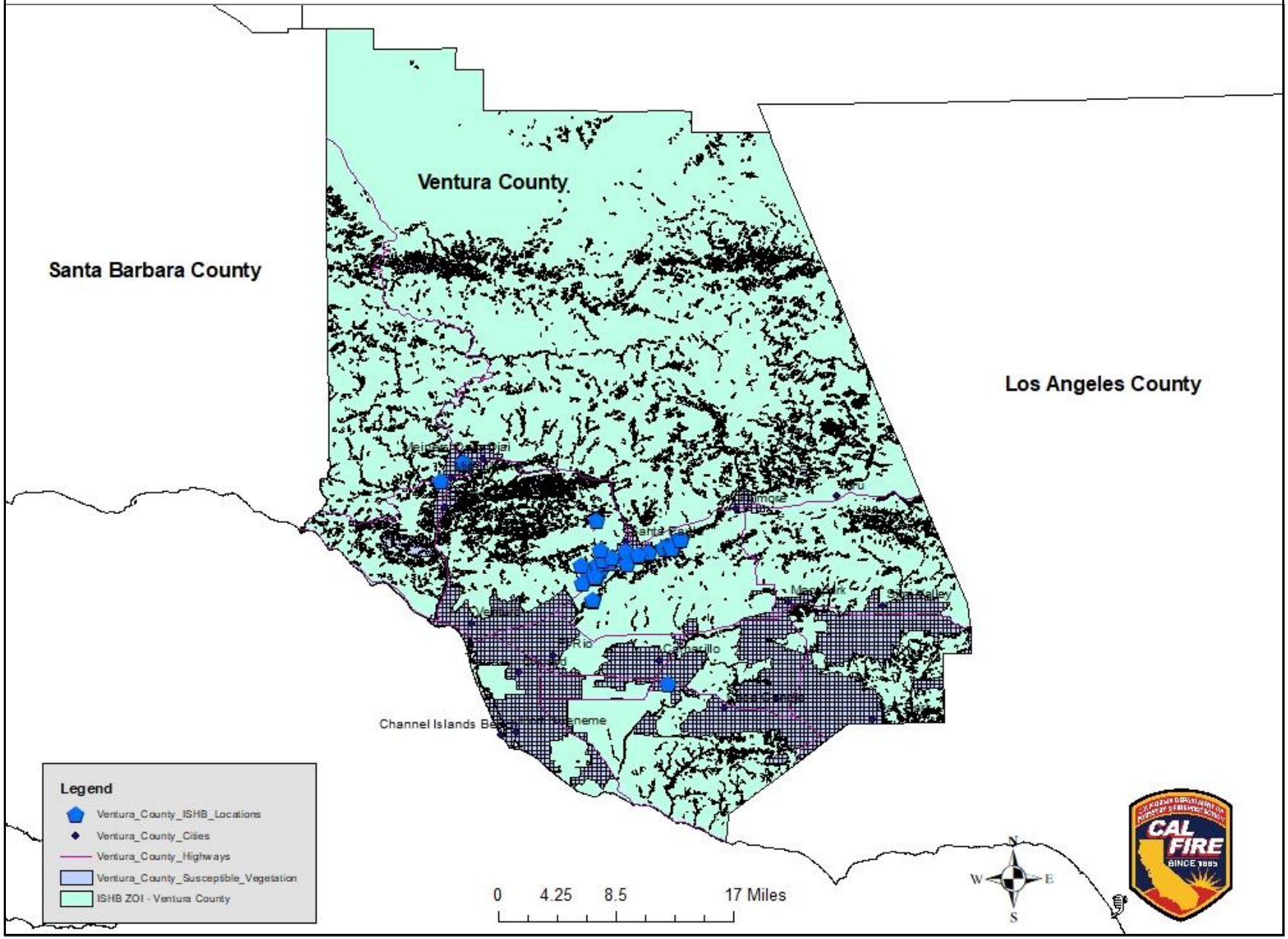


*Table 2. Willow infestation rates in the Tijuana River Valley survey units during the five survey years. * = no adult trees available, called 0% infestation; ** = no data collected during survey period, infestation rate estimated later; and nd = no data.*

SITES			INFESTATION RATES						
UNIT	AREA	WILLOWS	2015	2016	2017	2018	2019	MAX	
#	acres	est #	%	%	%	%	%	%	TOTAL #
A. Wet riparian forests									
2	4.4	16,026	94%	100%	1%	4%	2%	100%	16,026
3	7.5	5,517	100%	100%	0%	0%	0%	100%	5,517
4	12.7	1,282	91%	100%	7%	3%	0%	100%	1,282
5	44.7	13,561	96%	100%	19%	0%	0%	100%	13,561
6	30.3	9,194	95%	100%	5%	0%	0%	100%	9,194
7	2.0	4,407	100%	0%*	0%	1%	0%	100%	4,407
8	5.2	37,953	87%	76%	7%	14%	5%	87%	33,063
9	25.2	10,211	100%	0%*	7%	0%	2%	100%	10,211
10	56.9	17,280	98%	100%	15%	1%	1%	100%	17,280
11	11.6	9,365	100%	100%	0%	0%	0%	100%	9,365
12	7.8	9,421	100%	0%*	1%	0%	2%	100%	9,421
13	37.1	37,526	97%	100%	21%	6%	0%	100%	37,526
14	44.1	84,717	75%	95%	45%	14%	0%	95%	80,866
22	31.7	48,124	95%	100%	92%	11%	0%	100%	48,124
mean			**95%**	**77%**	**16%**	**4%**	**1%**	**99%**	
total	**321.1**	**304,583**							**295,843**
B. Dry riparian forests									
1	36.2	7,319	74%	74%	6%	2%	0%	74%	5,442
15	45.8	16,204	8%	52%	17%	10%	2%	52%	8,386
16	51.3	25,936	6%	79%	77%	88%	68%	88%	22,694
17	52.9	16,069	0%	73%	93%	88%**	82%	93%	14,997
18	17.5	7,062	2%	52%**	68%	91%	68%	91%	6,410
19	16.9	8,524	61%	91%	83%	73%	10%	91%	7,783
20	31.8	9,643	10%	52%**	80%	38%	0%	80%	7,714
21	23.6	7,172	6%	66%	86%	72%	4%	86%	6,134
mean			**21%**	**67%**	**64%**	**58%**	**29%**	**82%**	
total	**275.8**	**97,929**							**79,562**
C. Riparian shrub									
23	189.3	6,184	nd	nd	0%	0%	0%	0%	0
24	94.0	1,436	nd	nd	0%	9%	0%	9%	131
25	97.9	253	nd	nd	0%	0%	0%	0%	0
26	78.3	70	nd	nd	10%	0%	0%	10%	7
27	262.7	1,360	nd	nd	0%	0%	0%	0%	0
28	169.6	384	nd	nd	0%	4%	0%	4%	16
29	142.9	850	nd	nd	0%**	0%**	0%	0%	0
mean			**nd**	**nd**	**1%**	**2%**	**0%**	**3%**	
total	**1,034.8**	**10,537**							**154**
Grand	**1,631.7**	**413,050**							**375,558**
% total infested									**91%**

Invasive Shot-Hole Borers + Fusarium Dieback
Prioritizing Management Efforts

HOW TO USE THIS CHART

This chart is intended to help inform ISHB (Polyphagous and Kuroshio Shot-Hole Borers) management decisions. Consider potential safety hazards, tree value (economic and ecological), available resources, and other factors unique to each situation when using this tool.

REPRODUCTIVE HOSTS

A reproductive host is a species that supports 1) ISHB reproduction and 2) growth and development of the beetle's symbiotic fungi. These species are currently the priority for control efforts as they can produce more beetles that may spread the infestation. Some of the more susceptible reproductive hosts appear to be box elder, castor bean, valley oak, Engelmann oak, coral, and several species of sycamore, willow, and cottonwood.

Visit pshb.org for the full host list.

LIMB FAILURE HAZARD

The point of attachment between a tree branch and the main stem is called the branch collar. ISHB infestation in this area poses a serious safety hazard: a weakened collar may not be able to support the weight of the branch, creating potential for limb failure.

Infested trees—including those that have been treated or pruned—must be regularly monitored so that hazards can be identified and removed. When monitoring, consider beetle attacks in the branch collar as part of the branch.

AUTHORS

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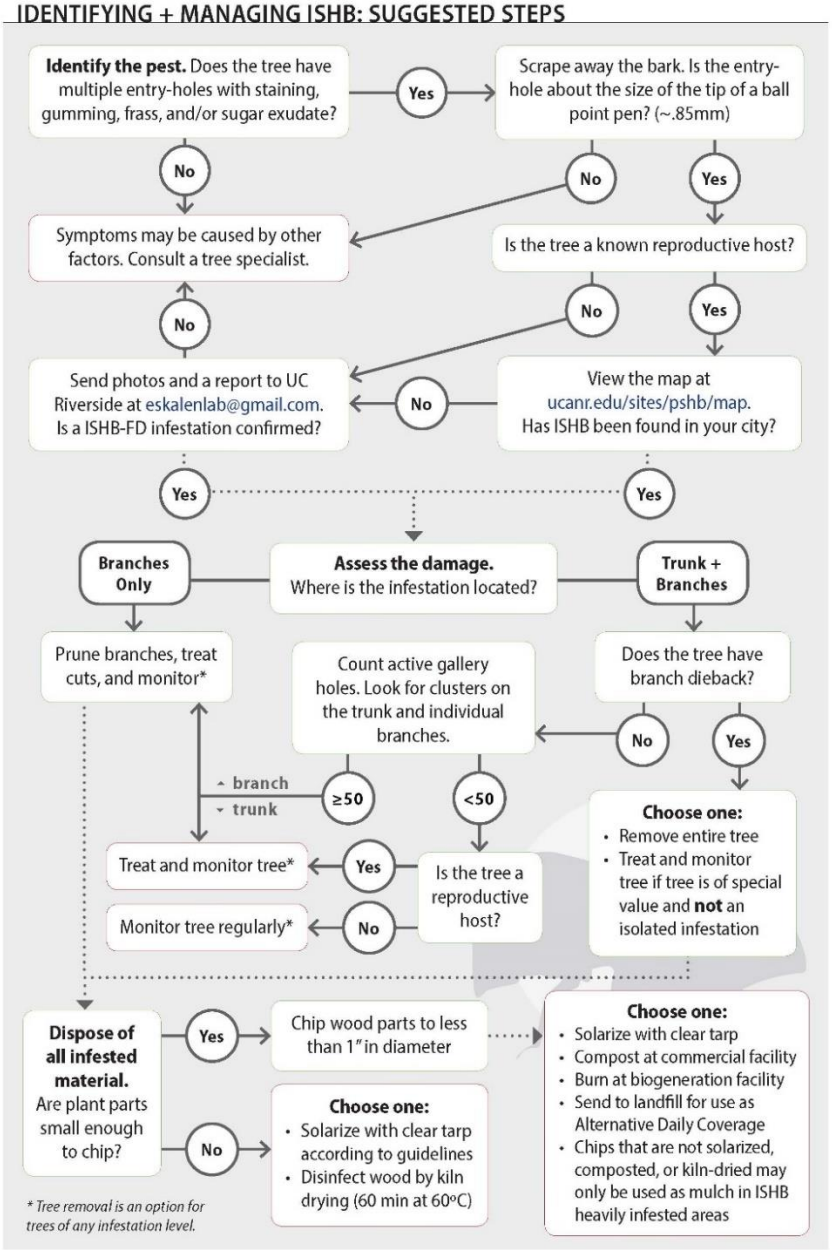
[1]UC Riverside [2]UC Cooperative Extension

IDENTIFYING + MANAGING ISHB: SUGGESTED STEPS



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Invasive Shot-Hole Borers + Fusarium Dieback
How to Handle Infested Plant Material

CURRENT OPTIONS

Options for handling infested plant material include the following:

- Chip (less than 1") + compost
- Chip (less than 1") + solarize
- Cut logs + solarize
- Chip (less than 1") + deliver to landfill for use as Alternative Daily Coverage
- Cut logs + kiln-dry

Guidelines for effective solarization and composting are included below.

****If relocating infested material, cover in-transit to prevent beetles from escaping****

SOLARIZATION GUIDELINES

Solarization is a suitable method for handling either infested chips or logs. When done properly, solar energy will heat plant material until both the beetle and fungi are killed. It is most effective during the peak of summer, when temperatures are higher and days are longer, but may be used during the rest of the year as long as time and space can be committed.

Follow these tips for proper solarization:

- Use sturdy plastic sheeting/tarp (clear is recommended) that can withstand rain/wind
- Fully contain chips/logs by wrapping plastic both underneath and over the material
- During July - August: cover chips/logs with sturdy plastic for **at least 6 weeks**
  - Temperatures during these months should be regularly above 95°F
- During September - June: cover chips/logs with sturdy plastic for **at least 6 months**
- **Keep log/chip layers as thin as possible** (2 logs deep maximum) to ensure even heating throughout the pile

COMPOSTING GUIDELINES

When done correctly, composting can effectively control the plant pathogens that cause Fusarium Dieback. Composted, chipped plant material may then be repurposed as mulch or added back into soil to improve texture and water retention.

Requirements for adequate decomposition

If transporting chipped material is not an option, you can compost chips yourself. These general composting guidelines will help assure the destruction of pathogenic fungi.

- Woody material should be chipped to less than 1 inch.
- A mixture of equal volumes of green plant and dry plant material will normally achieve a proper carbon-to-nitrogen ratio of 30 to 1.
- Do not add soil, ashes from a stove or fireplace, dairy or meat products, or manure from meat-eating animals.
- A pile should be in bins at least 36 x 36 x 36 inches to assure adequate heating. Maintain a temperature of 160°F, turn the pile every 1-2 days, and add nothing to it once the composting process has begun. If temperatures do not get up to 160°F within 1-2 days, the pile is too wet or dry. If too dry, add water. If not enough nitrogen, add green material.
- Healthy compost has a pleasant odor, gives off heat as vapor when turned, has a white fungal growth on the decomposing material, gets smaller each day, and changes color to dark brown. Compost is ready when it no longer produces heat.

Source: UC IPM, ipm.ucanr.edu/PMG/GARDEN/FRUIT/ENVIRON/composting.html
Read more about composting at uccemg.com/files/78738.pdf and calrecycle.ca.gov/Organics/

PRUNING BMPS

Poor pruning practices can facilitate the spread of plant disease. For pruning and tool sterilization tips, see UC Riverside's "Best Management Practices for Disease in Oak Woodlands" (Lynch and Eskalen 2014).

TRUSTED COMPOST FACILITIES

It is **recommended** that chipped material be taken to a composting facility that has earned the US Composting Council's Seal of Testing Assurance (STA). Facilities in the STA program are tested for proper decomposition and pathogen control.

Find your local STA Compost Facility at:
compostingcouncil.org/participants

ISHB RESOURCES

Find ISHB research updates and news at:
www.pshb.org
www.eskalenlab.ucr.edu

AUTHORS

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Revised 04/2017

FD – ISHB Management Matrix - Infested Urban and Peri-urban Forest

			ISHB Infestation Level & Management Options				
	Host Type	Hazard Level[1]	No Infestation	Low	Moderate I	Moderate II	Heavy
LOW VALUE TREES[1]	Reproductive Host	Low	Monitor	Monitor & Spot Inject	Monitor[2] Remove Actively Infested Branches	Monitor[2] Remove Actively Infested Branches	Remove Actively Infested Tree[2] & Stump
		High	Monitor	Monitor & Remove Hazard Branches	Monitor[2] Remove Hazard Branches	Remove Hazard Branches, or Remove Tree & Stump	Remove Tree[2] & Stump
	Non-Reproductive Host	Low	Monitor	Monitor	Notify UC ANR; consult with FD – ISHB experts to determine if species is a new reproductive host		
		High	Monitor	Monitor			

			ISHB Infestation Level & Management Options				
	Host Type	Hazard Level[1]	No Infestation	Low	Moderate I	Moderate II	Heavy
HIGH VALUE TREES[1]	Reproductive Host	Low	Monitor	Treat/Remove Infested Branches[3]	Treat/Remove Actively Infested Branches[3]	Treat/Remove Actively Infested Branches[2,3]	Remove Actively Infested Tree[2] & Stump
		High	Monitor	Treat/Remove Hazard Branches[3]	Treat/Remove Hazard Branches[3]	Remove Infested Branches, or Tree[2] & Stump	Remove Tree[2] & Stump
	Non-Reproductive Host	Low	Monitor	Monitor	Notify UC ANR; consult with FD – ISHB experts to determine if species is a new reproductive host		
		High	Monitor	Monitor			

[1] Definitions for tree value and hazard level vary. Classification must be determined by site and site use (e.g., economic or cultural value and risk to people or property).
[2] Confirm if beetle is actively reproducing in galleries by painting over select entry holes with water-based latex; gallery is active if entry hole is re-opened on painted area.
[3] If ISHB attack is confined to the branches of host tree, prune affected branches immediately to prevent advancement to the trunk. Prune hazardous branches on high-value hosts and treat pruning wounds to prevent re-infestations.

FD – ISHB management matrix for infested urban forests and locations on the leading edge of the infestation. The matrix was developed by Beatriz Nobua - Behrmann (UC ANR), Monica Dimson (UCLA), Shannon C. Lynch (UCSC), John Kabashima (UC ANR), and Akif Eskalen (UCD), and revised July 2019.

Definitions to terms introduced in the Management Matrix in Appendix S.

Tree Value[1]	
Low	Species of low economic value; smaller and/or younger trees; trees with undesirable form, structural issues (e.g., codominant branches), or other issues (e.g., other pests)
High	Species of high economic or cultural value (e.g., heritage trees); larger and/or older trees
Host Type	
Reproductive	Plant species suitable for beetle reproduction and growth of *Fusarium euwallaceae* or *F. kuroshium* (see pshb.org for updated list of ISHB-FD reproductive hosts)
Non- Reproductive	Plant species that have not yet proved suitable for beetle reproduction; however, these species may be susceptible to *Fusarium euwallaceae* or *F. kuroshium*
Hazard Level[1]	
Low	Trees that pose a low risk to people or property
High	Trees that pose a high-risk to people or property (e.g., trees adjacent to walkways, playgrounds, high-use lawns, parking lots)
Infestation Level	Attacks (number of entry holes observed)
Low	<50
Moderate I	≥50 and <150
Moderate II	≥150
Heavy	≥150 + dieback
Treatment Options	
Reproductive Host (infested)	• Imidacloprid drench, trunk or soil injection. • Emamectin Benzoate trunk or spot injection • Propiconazole trunk or spot injection • Optional - Pentra Bark + *Bacillus subtilis* and/or bifenthrin trunk spray • Optional - Pentra Bark + tebuconazole and/or bifenthrin trunk spray
Reproductive Host (no infestation)	Monitor - Preventative treatment not recommended.
Non-Reproductive Host (Infested)	Notify UC ANR; reclassify species as reproductive host in consultation with PSHB/FD experts
Non-Reproductive Host (no infestation)	Monitor - Preventative treatment not recommended.
Tree Removal	Remove tree and grind or bury stump. Treat stump with bifenthrin or *Bacillus subtilis*.
Agricultural Trees	Monitor, remove infested branches, or remove tree.