The Latest Strategies for Managing Asian Citrus Psyllid in your Groves

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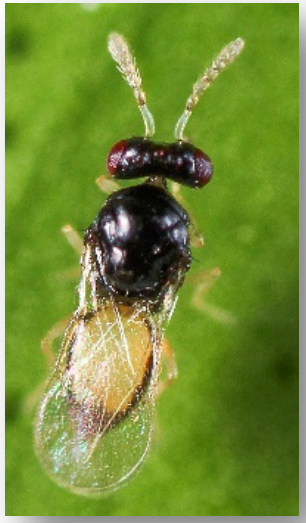
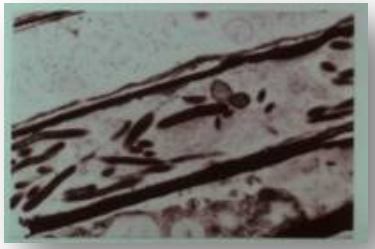


University of California
Agriculture and Natural Resources



Huanglongbing disease (HLB)

Bacterial disease:
***Candidatus* Liberibacter asiaticus *C*las**

As the disease progresses:

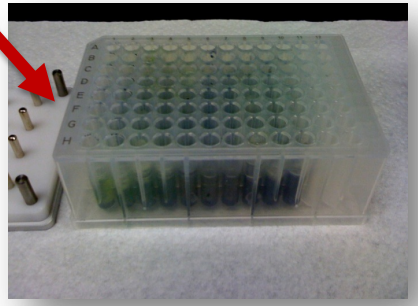
- *Roots decline
- Leaves become yellow
- Foliage becomes thin
- Fruit drops off easily
- Fruit is smaller
- Juice is bitter
- Tree death (there is no cure)

Why is this disease so quick to spread and so hard to detect?

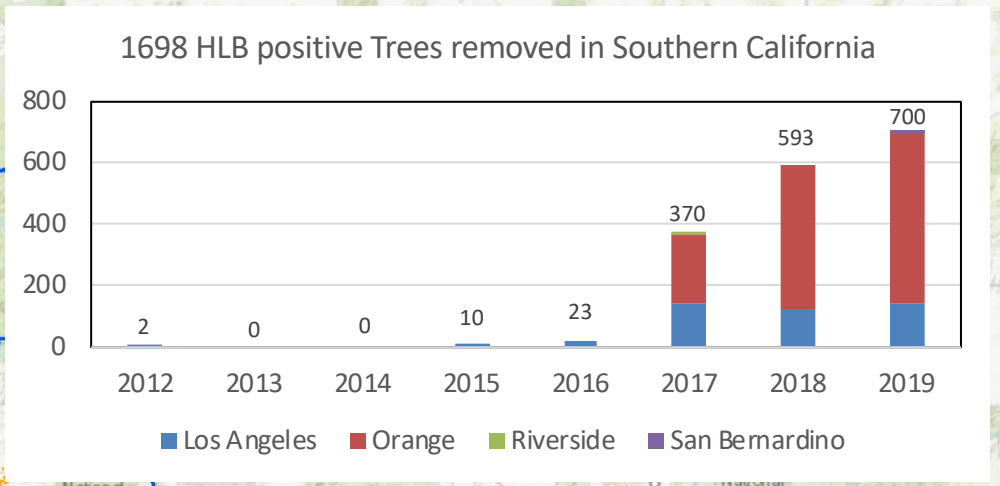
The nymphs hatch and immediately pick up the bacterium and spread it when they molt and fly away 4-6 weeks later.

The eggs are laid on new flush next to the where the psyllid injects the bacterium.

When leaves are sampled, they must have the bacteria for PCR to detect it.
It takes 9 months to 2 years for the bacteria to spread throughout the tree for sampling to pick the right leaf.

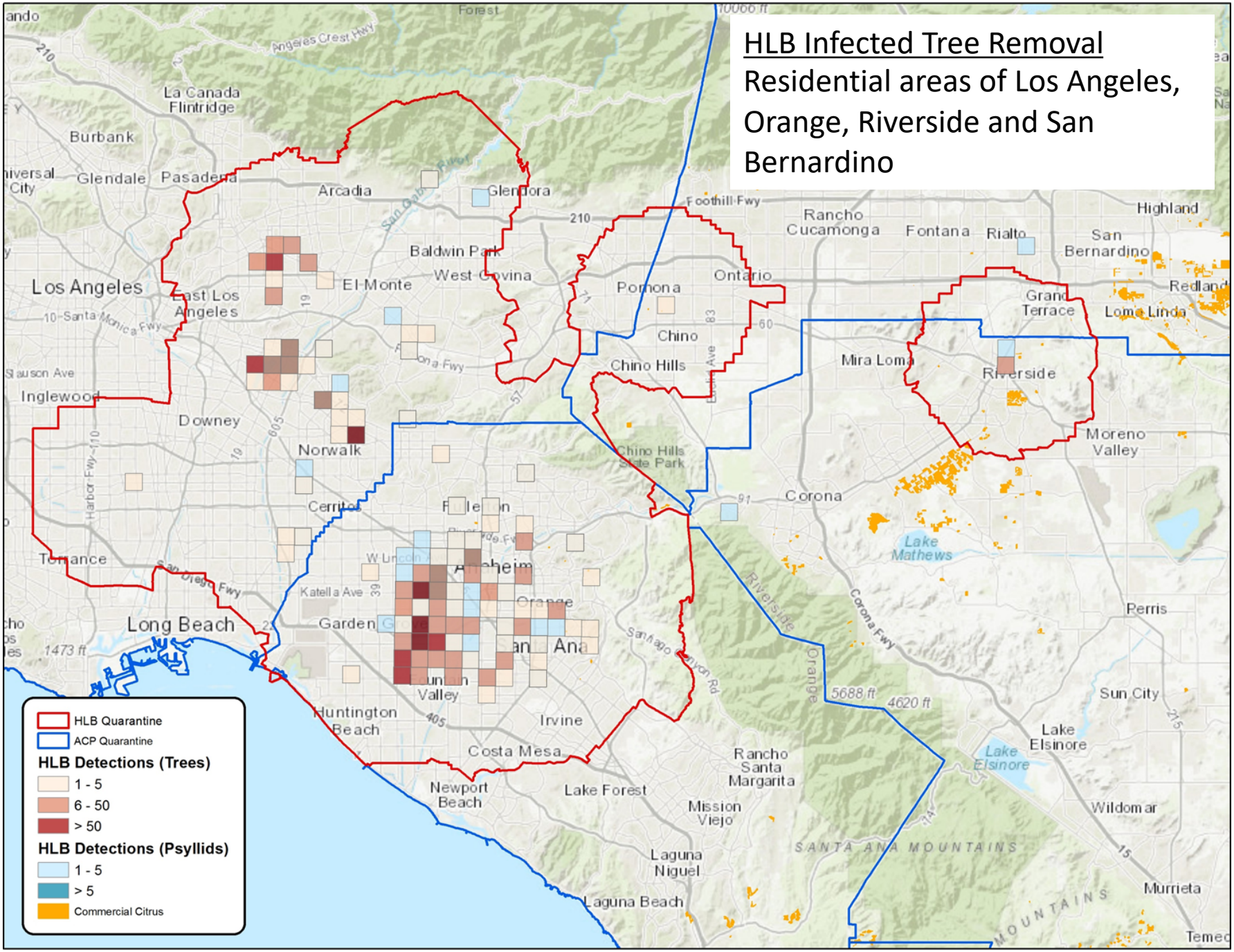


https://ucanr.edu/acpmap



1698 HLB-infected tree removals from residential citrus

HLB Quarantine
ACP Quarantine
HLB Detections (Trees)
1 - 5
6 - 50
> 50
HLB Detections (Psyllids)
1 - 5
> 5
Commercial Citrus


HLB Infected Tree Removal
Residential areas of Los Angeles, Orange, Riverside and San Bernardino
HLB Quarantine
ACP Quarantine
HLB Detections (Trees)
1 - 5
6 - 50
> 50
HLB Detections (Psyllids)
1 - 5
> 5
Commercial Citrus
Los Angeles
Long Beach
Riverside
Orange
Anaheim
Santa Ana
Pomona
Ontario
Chino
Chino Hills
Corona
Mira Loma
Moreno Valley
Perris
Sun City
Lake Elsinore
Wildomar
Murrieta
Rancho Cucamonga
Fontana
Rialto
San Bernardino
Highland
Redland
Loma Linda
Grand Terrace
Arcadia
Glendora
Baldwin Park
West Covina
El Monte
East Los Angeles
Downey
Norwalk
Cerritos
Inglewood
Torrance
Garden Grove
Huntington Beach
Irvine
Costa Mesa
Newport Beach
Lake Forest
Rancho Santa Margarita
Mission Viejo
Laguna Niguel
Laguna Beach
Lake Mathews
Chino Hills State Park
SANTA ANA MOUNTAINS
Foothill Fwy
Corona Fwy
Riverside
Orange
Santiago Canyon Rd
Katella Ave
San Diego Fwy
Harbor Fwy
Santa Monica Fwy
Angeles Crest Hwy
Forest
La Canada Flintridge
Burbank
Glendale
Pasadena
Universal City
Slauson Ave
Pomona Fwy
Eucla Ave
Lake Elsinore
Lake Mathews
10066 ft
5688 ft
4620 ft
1473 ft

The California Situation

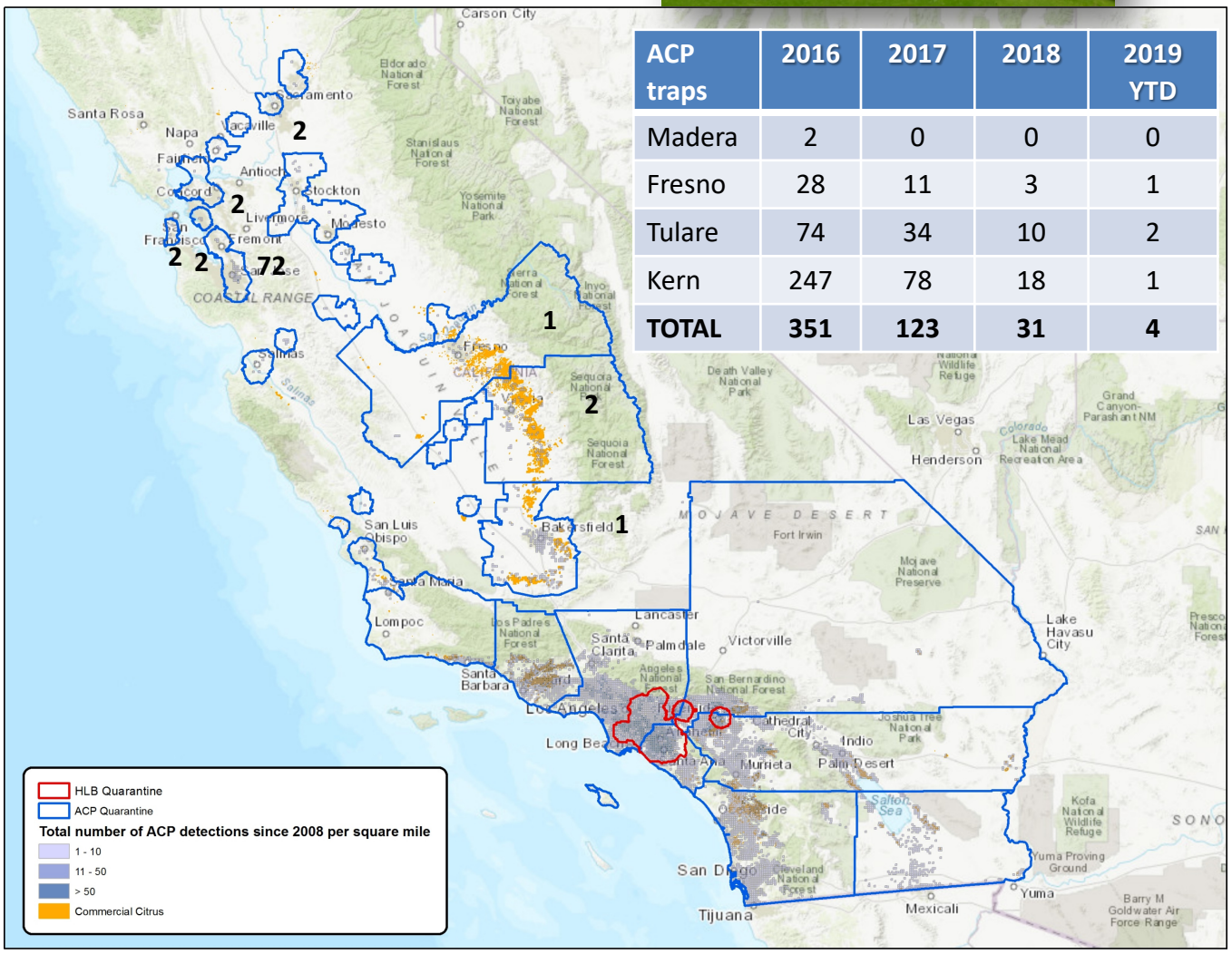
Goal: reduce psyllids to reduce the spread of disease

http://ucanr.edu/sites/ACP/

Central/Northern CA:
Eradicative/ Coordinated Treatments – treat find sites with two insecticides
Commercial citrus: 800 meters or coordinated treatments
Urban: 400 meters

Southern California:
Area-wide treatment program
Commercial citrus: Growers treat together over a 2-3 week window (fall and winter) coordinated by PMAs, pest control districts, or task forces
Urban: parasites released

ACP traps	2016	2017	2018	2019 YTD
Madera	2	0	0	0
Fresno	28	11	3	1
Tulare	74	34	10	2
Kern	247	78	18	1
TOTAL	**351**	**123**	**31**	**4**



Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

San Joaquin Valley Pest Management Navels & Mandarins

Citrus Red Mite ⟷ **Oils, miticides**

Citrus thrips + katydids ⟷

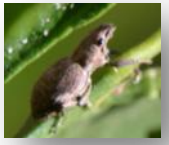
Thrips: spinetoram, cyantraniliprole, spinosad, abamectin, formetanate

Katydids: pyrethroid, diflubenzuron, kryocide

Citricola scale ⟷ acetamiprid, thiamethoxam, imidacloprid, buprofezin

California red scale ⟷ pyriproxyfen, spirotetramat, buprofezin, oil, carbaryl

Fuller rose beetle ⟷ thiamethoxam or bifenthrin x 2

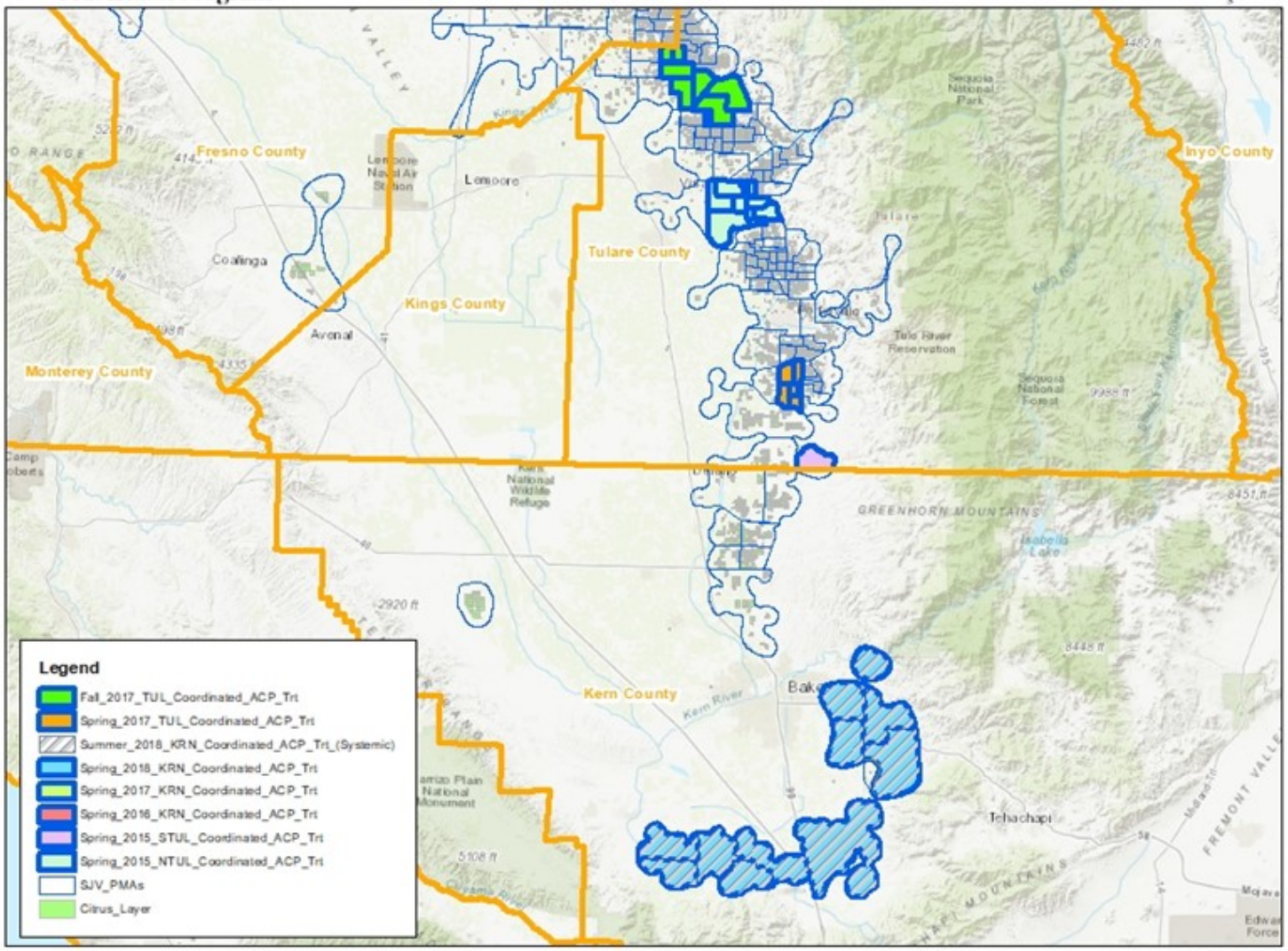


ACP effective

Soft on natural enemies

Citrus Pest & Disease Prevention Program

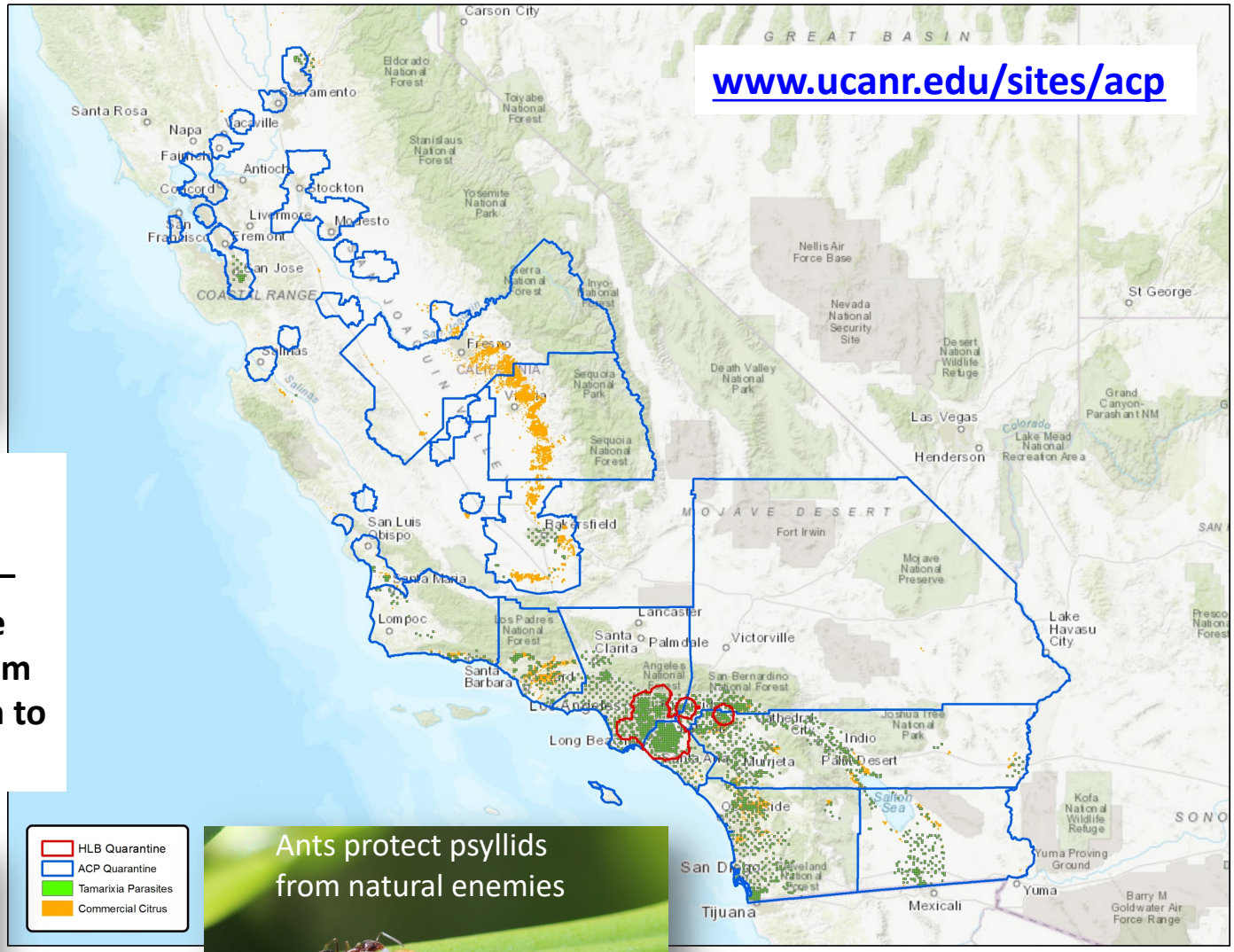
San Joaquin Valley
Coordinated ACP Treatments to date 1/31/2019



Miles
0 5 10 20 30 40

Tamarixia radiata parasite releases

USDA/UC Releases have been successful in establishing the parasites – however the tamarixia are very expensive % parasitism levels are not high enough to prevent disease spread.



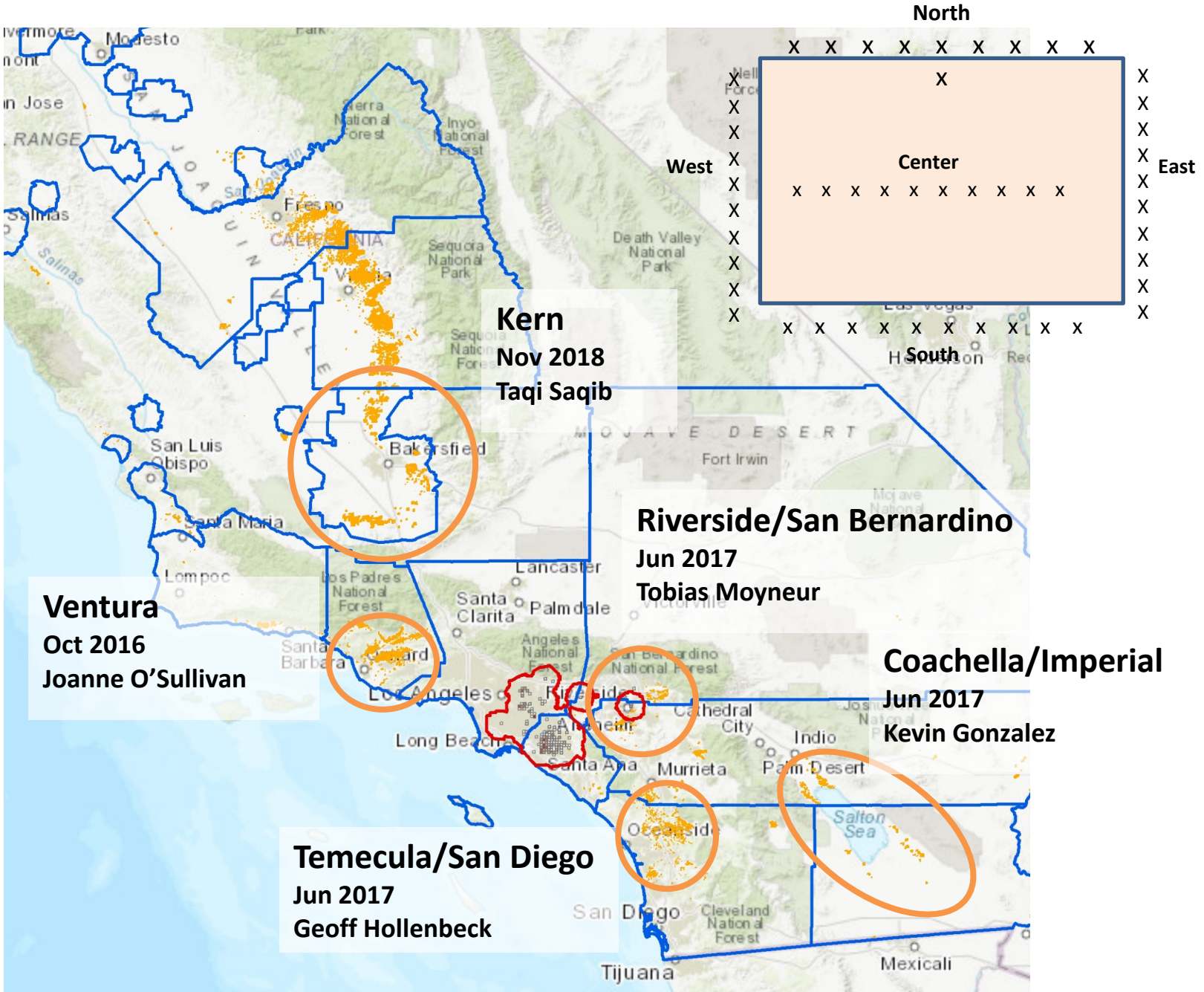
Areawide ACP Management

The goal is to keep psyllids below 0.5/flush

	4+ weeks	2-4 weeks	< 2 weeks
Broad	Baythroid, Danitol, Tombstone Actara Agri-Flex Leverage Admire Pro	Mustang OPs Carbamate Platinum Sivanto	
Soft		Delegate Exirel, Verimark Fujimite Movento Surround Minecto Pro	Micromite Pyganic Success Entrust Oil

UC IPM Guidelines for Citrus

5 Technicians survey 246 commercial orchards to determine the impact of psyllid treatments



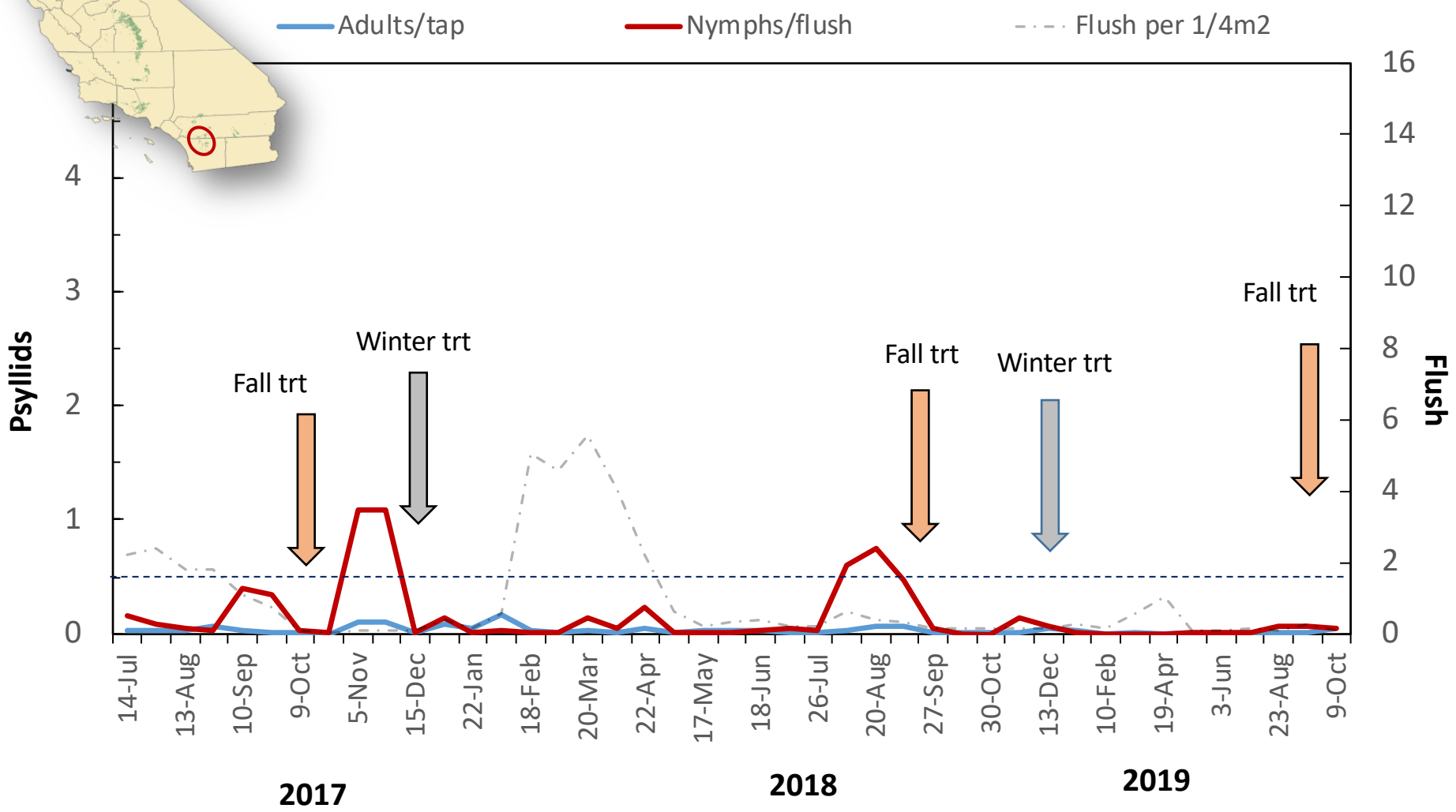
Psyllid Management Programs

Psyllid control depends on where you are:

Areawide Management	Psyllid pressure	Winter Pyrethroid Dec-Feb	Summer Other pests	Aug-Sep	Oct-Nov
Desert - Coachella and Imperial	Low	X	CLM, thrips, Mites	X	
San Diego	Mixed	X	CRS, Mites	X	
Ventura	High	X	Mites	X	X
Riverside/San Bernardino	High	X	CRS	X	X

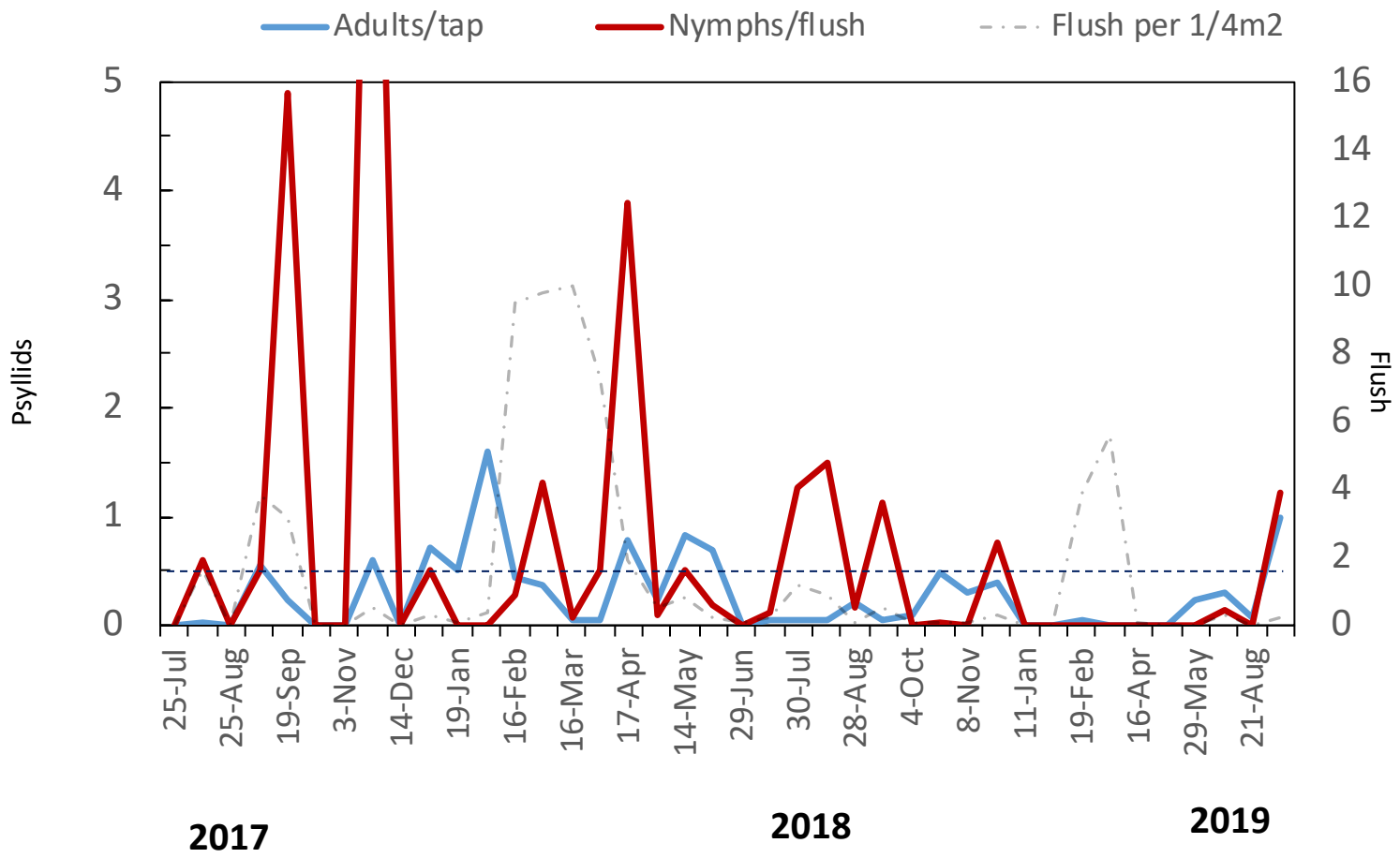
Eradicative		
San Joaquin Valley & north & parts of the coast	Low	Treat with a pyrethroid and systemic imidacloprid in coordinated treatments to locally eradicate ACP

41 Temecula/San Diego Sites – Average Nymphs per Flush

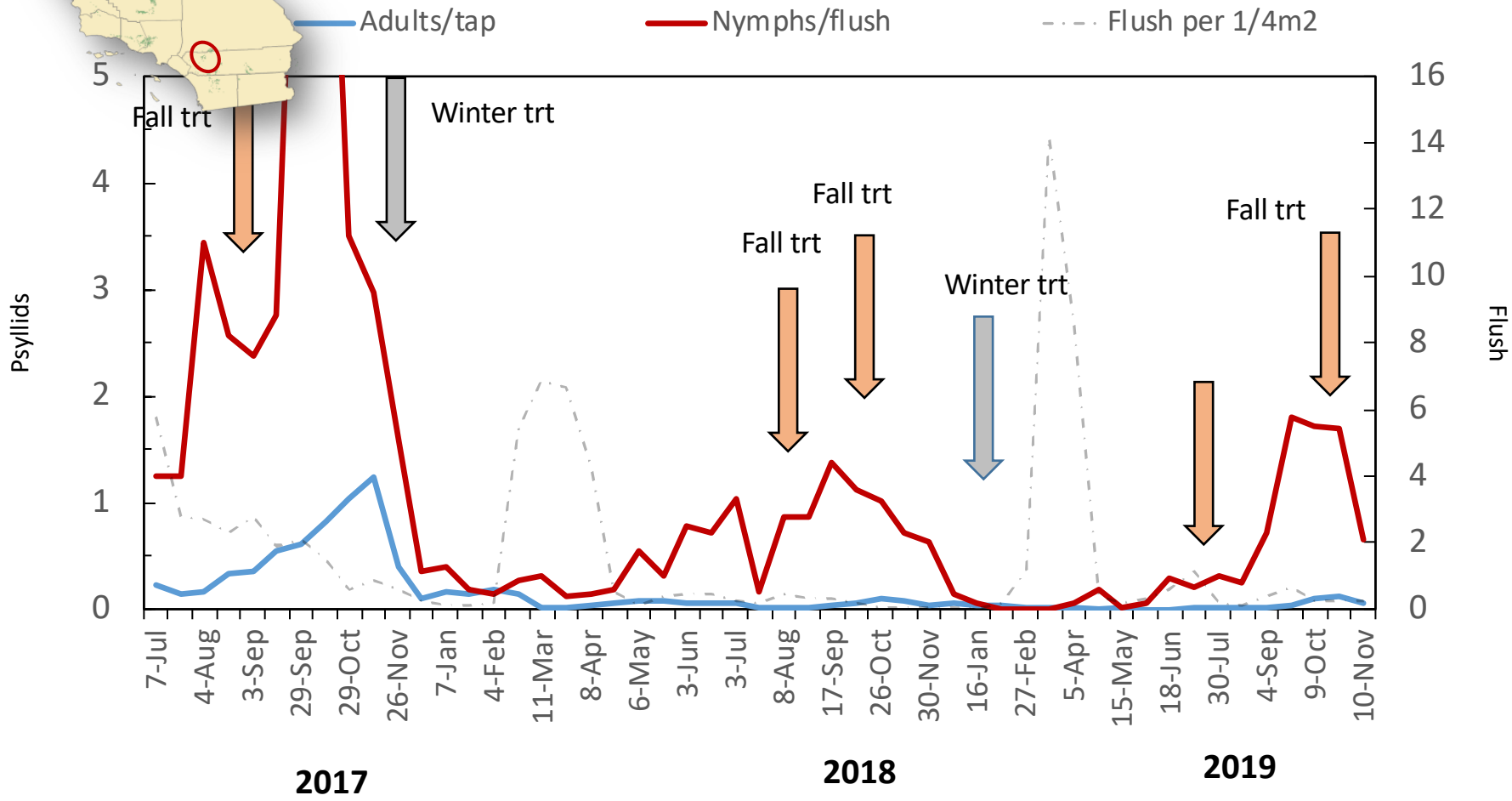


San Diego Site #28
Oranges 17 acres
2017-2019

3/42 San Diego/Temecula sites have noticeable populations: lack of treatments = ACP

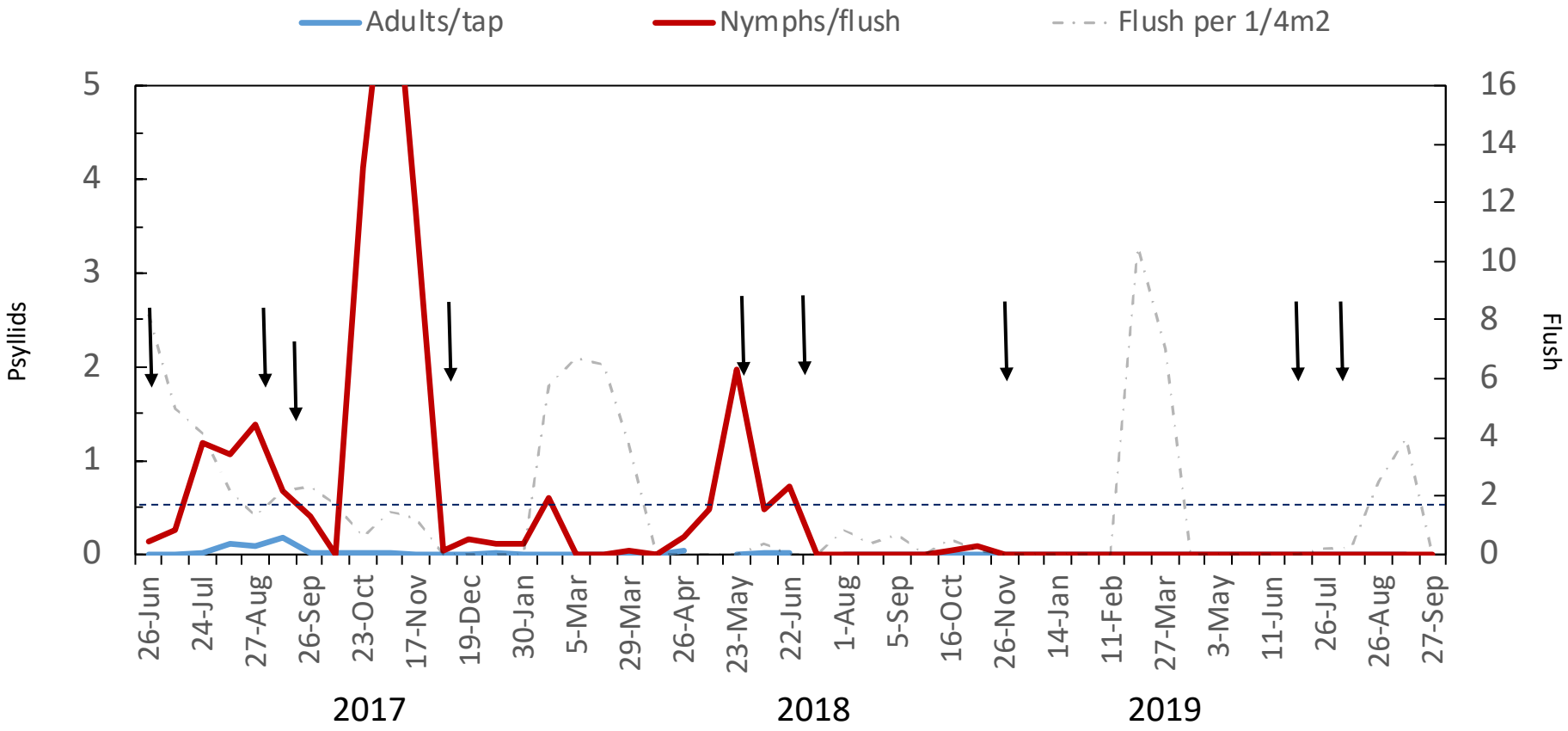


44 Riverside/San Bernardino Sites – Average Nymphs per Flush



Site #1
SBD-7
Grapefruit 11 acres
2017 - 2018

Riverside/San Bernardino
33/42 sites have suppressed ACP in 2019
***Using Admire or Platinum in June-July**



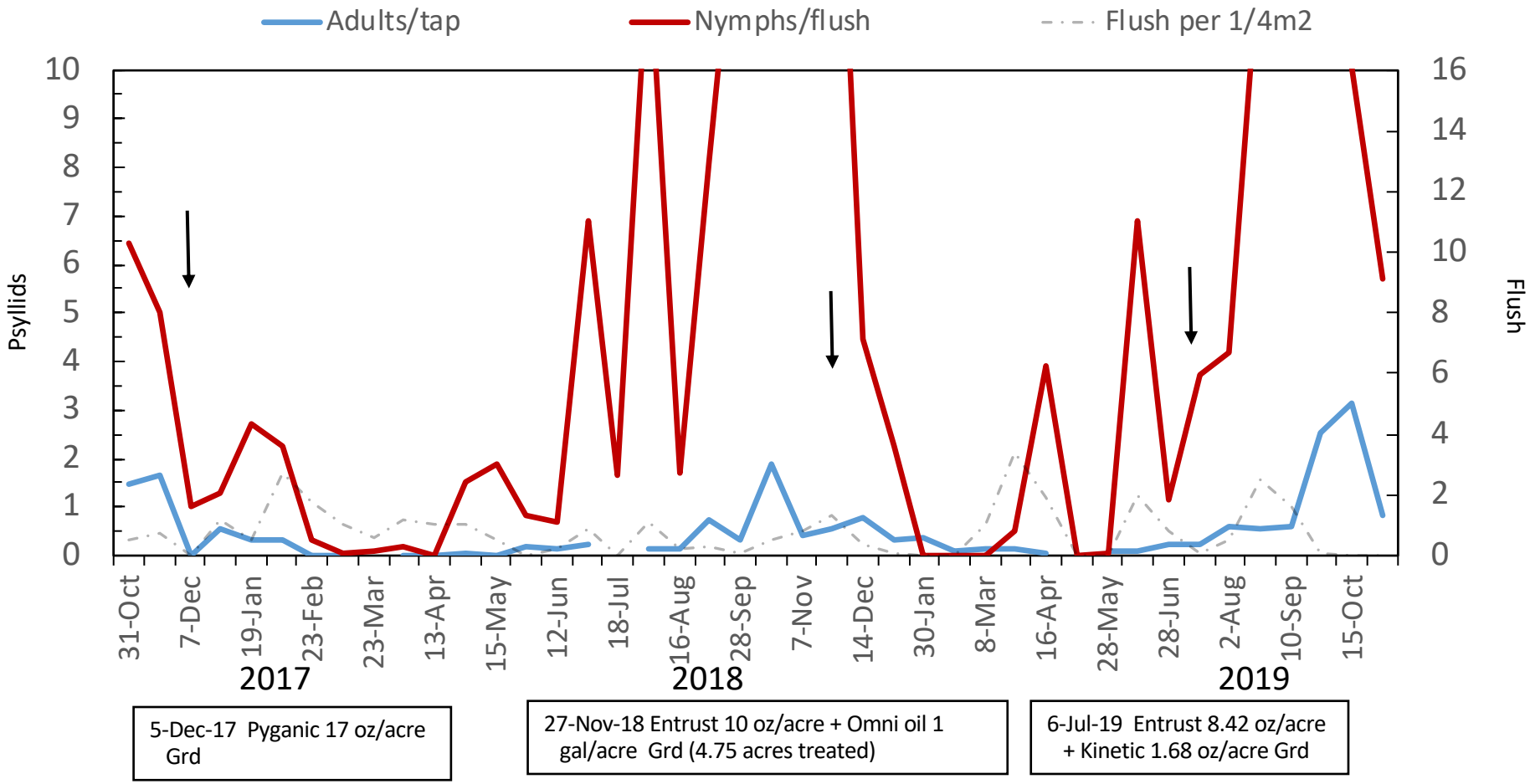
7-Jun-17 Movento 10 oz/acre + Abamectin 20 oz/acre + Omni oil 1 gal/acre 100 gpa Grd
19-Aug-17 Movento 10 oz/acre + Abamectin 10 oz/acre + Dyne-Amic 10 oz/acre 100 gpa Grd
2-Sep-17 Platinum 3.67 oz/acre Chm
25-Nov-17 Danitol 16 oz/acre 250 gpa Grd

3-May-18 Movento 10 oz/acre + Abamectin 10 oz/acre + Omni oil 100 1 gal/acre 100 gpa Grd
23-Jun-18 Admire Pro 14 oz/acre Grd
26-Nov-18 Danitol 16 oz/acre 250 gpa Grd

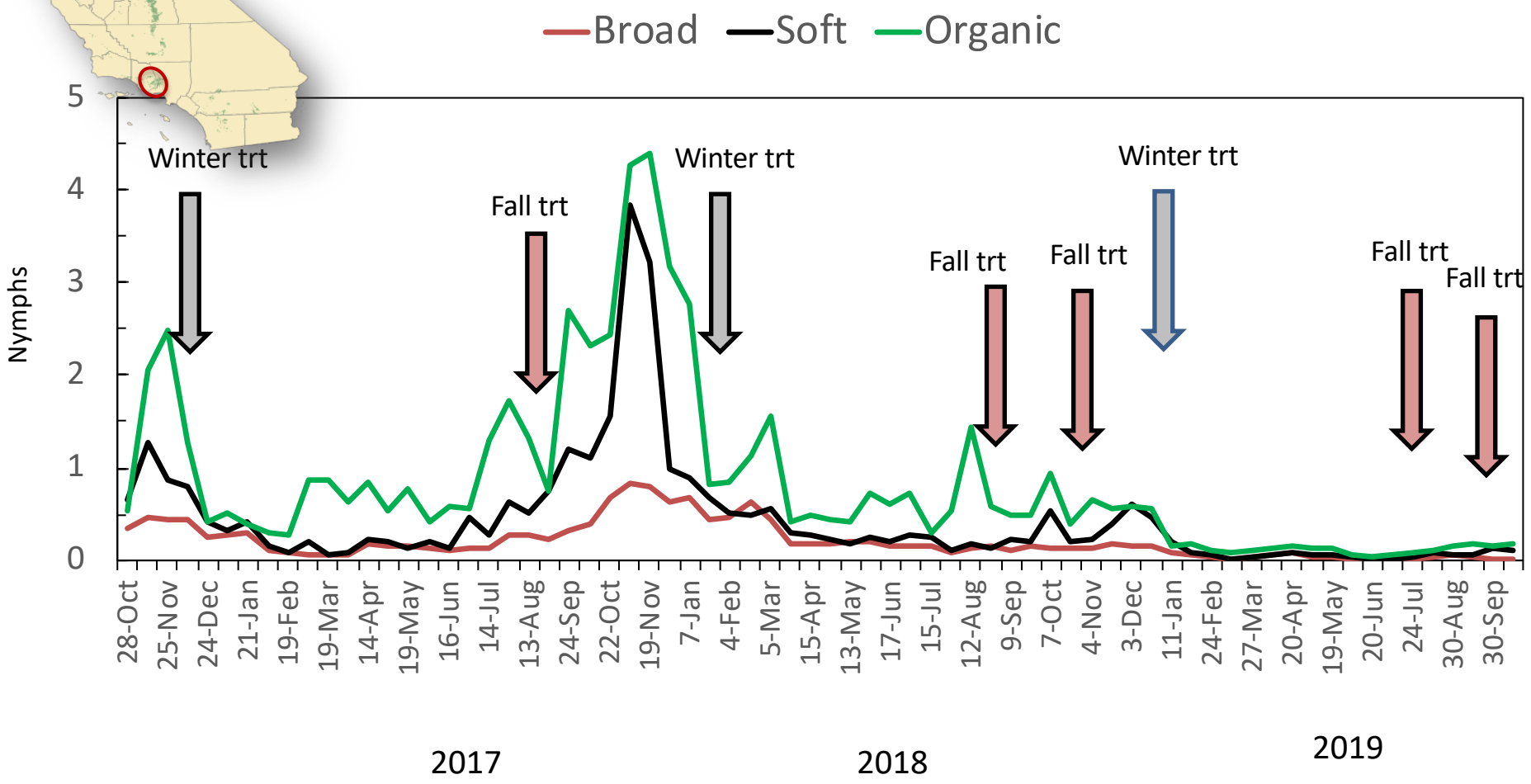
8-Jul-19 Abba 10 oz/acre + Movento 10 oz/acre + Omni oil 1.2 gal/acre Grd
30-Jul-19 Admire Pro 14 oz/acre Grd

Site #40
SBD-13

9/42 San Bernardino/Riverside sites high pops in 2019
Poor choice of chemicals and low treatment frequency



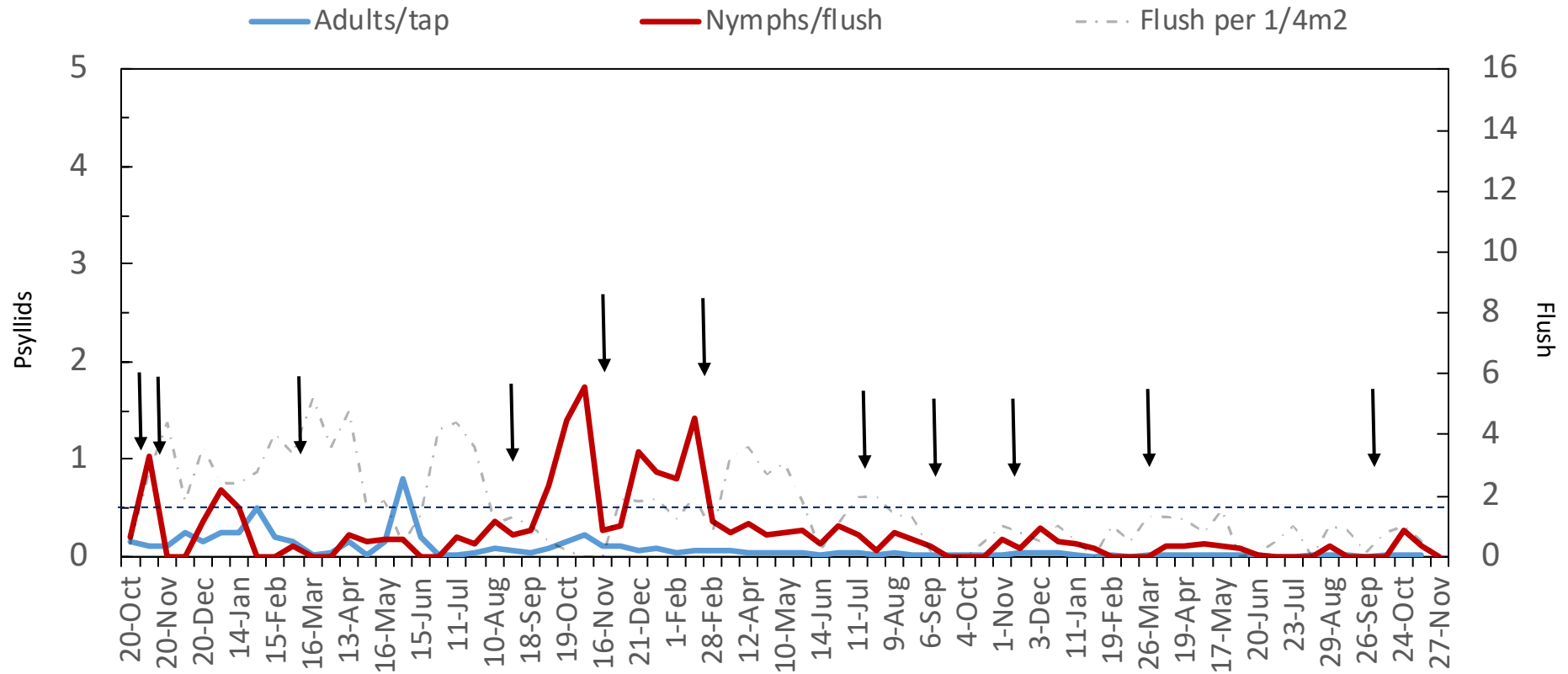
44 Ventura Sites by Management Strategy –Nymphs per Flush



Broad: pyrethroids, imidacloprid, thiamethoxam, flupyradifurone, OPs
Soft: spinetoram, spirotetramat, cyantraniliprole, abamectin
Organic: pyrethrins, spinosad, Oil, kaolin

Site #13
PMA 12
Lemon 135 acres
2016-2019

33/44 sites low ACP in 2019
Weather + consistent treatments



2017

26-Oct-16 Actara 5.5 oz/acre + Omni Oil 3.5 gal/acre 250 gpa Grd
8-Nov-16 Actara 5.9 oz.acre + Omni Oil 3.7 gal/acre 250 gpa Grd
6-Mar-17 Danitol 20.62 oz/acre + Omni Oil 2.03 gal/acre 200 gpa Grd
10-Aug-17 Agriflex 8.33 oz/acre + Omni Oil 14 gal/acre 500 gpa Grd
3-Nov-17 Actara 5.67 oz/acre + Omni Oil 7 gal/acre 250 gpa Grd

2018

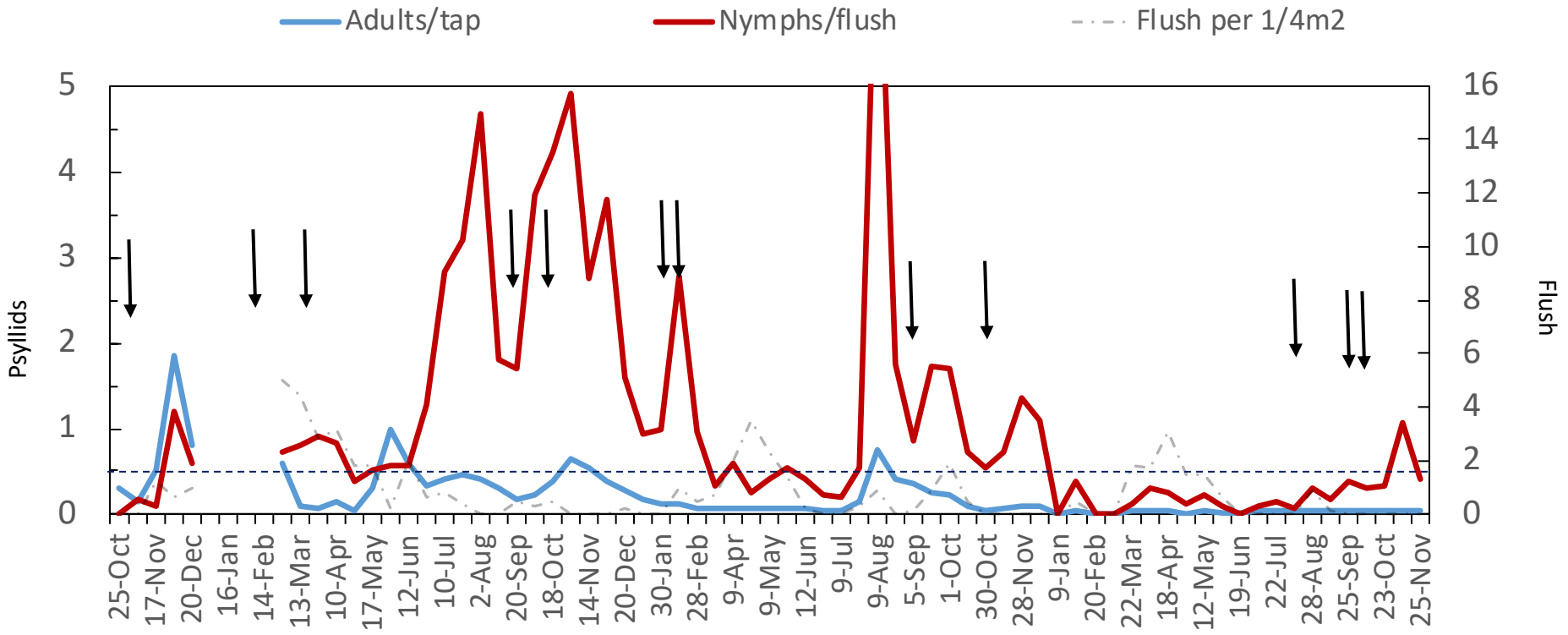
26-Feb-18 Danitol 20 oz/acre + Omi oil 1 gal/acre Grd
12-Jul-18 Agri-flex 8.25 oz/gal + Omni oil 13.85 gal/acre Grd Perimeter
5-Sep-18 Agri-flex 10.5 oz/acre + Omni oil 8.4 gal/acre Grd
30-Oct-18 Timectin 10 oz/acre + Omni oil 3.5 gal/acre Grd

2019

16-Mar-19 Danitol 20.6 oz/acre + Omni spray 1 gal/acre Grd
27-Sep-19 Agri-flex 8.4 oz/acre + Omni oil 10 gal/acre Grd

Site #32
PMA 31
Lemon 17 acres
2016-2019

7/44 sites persistent ACP in 2019 – organic sites



2017

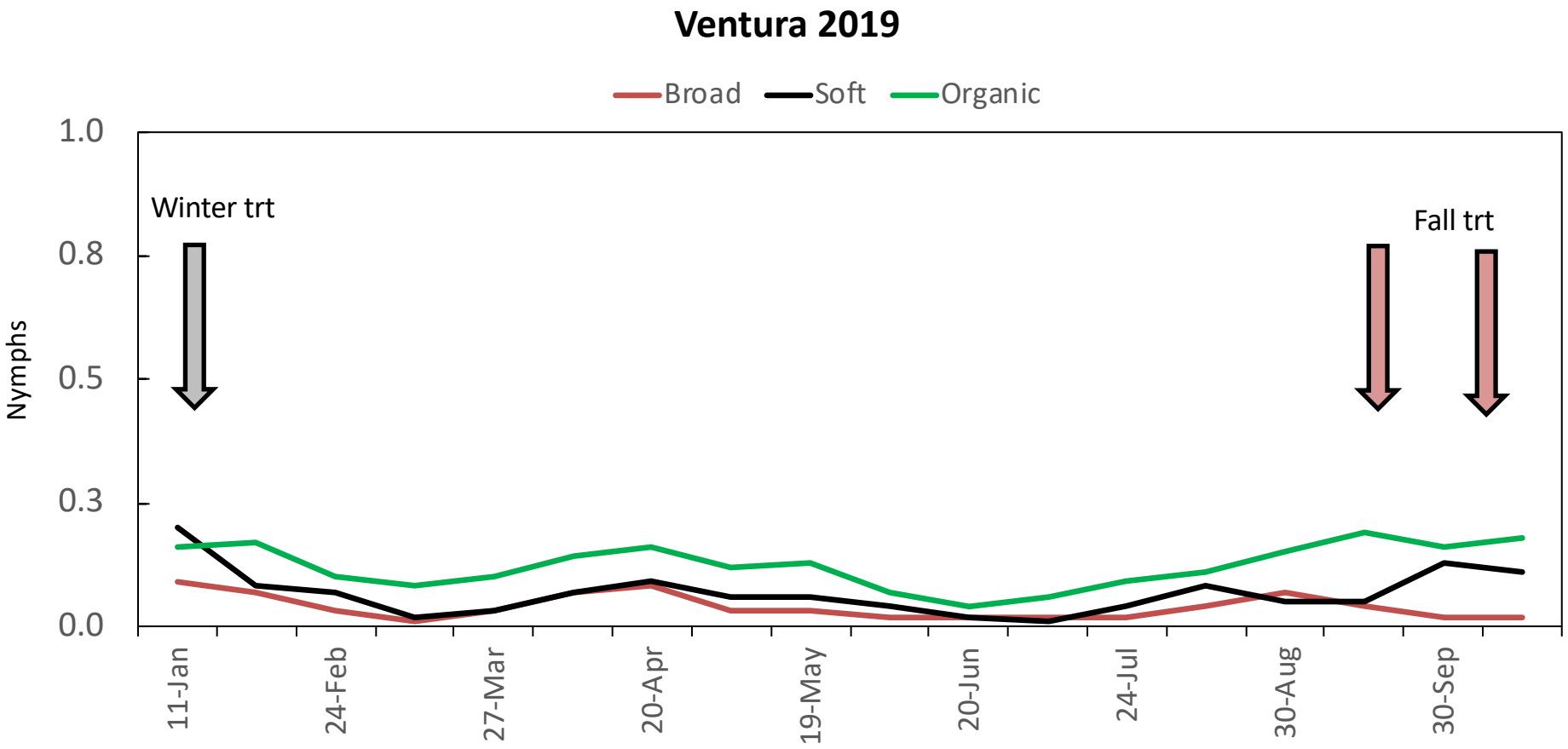
24-Oct-16 Pyganic 16 oz/acre + 440 Oil 10.5 gal/acre Grd
26-Jan-17 Entrust 3.5 oz/acre + 440 Oil 1 gal/acre Grd
10-Mar-17 Pyganic 16 oz/acre + 440 Oil 12 gal/acre Grd
24-Aug-17 Pyganic 16 oz/acre + 440 oil 10 gal/acre Grd
14-Sep-17 Entrust 7.98 oz/acre + 440 Oil 2 gal/acre Grd
28-Dec-17 Entrust 8 oz/acre + 440 oil 1 gal/acre Grd

2018

1-Feb-18 Pyganic 17 oz/acre + 440 oi 1 gal/acre Grd
31-Aug-18 Entrust 8 oz/acre + 440 oil 2 gal/acre Grd
22-Oct-18 Pyganic 17 oz/acre + 440 oil 14 gal/acre Grd

2019

31-Jul-19 Pyganic 16.89 oz/acre + Oil 7 gal/acre Grd
13-Sep-19 Entrust 8 oz/acre + 440 oil 2 gal/acre Grd
9-Oct-19 Pyganic 16 oz/acre + 440 oil 5 gal/acre Grd



- **Psyllids are still out there**
- **Treatments + weather are helping to keep them low**
- **Don’t stop treating, but consider additional perimeter treatments in the fall**
- **The fewer the psyllids the slower the spread of the disease**

Scouting psyllid nymphs is essential

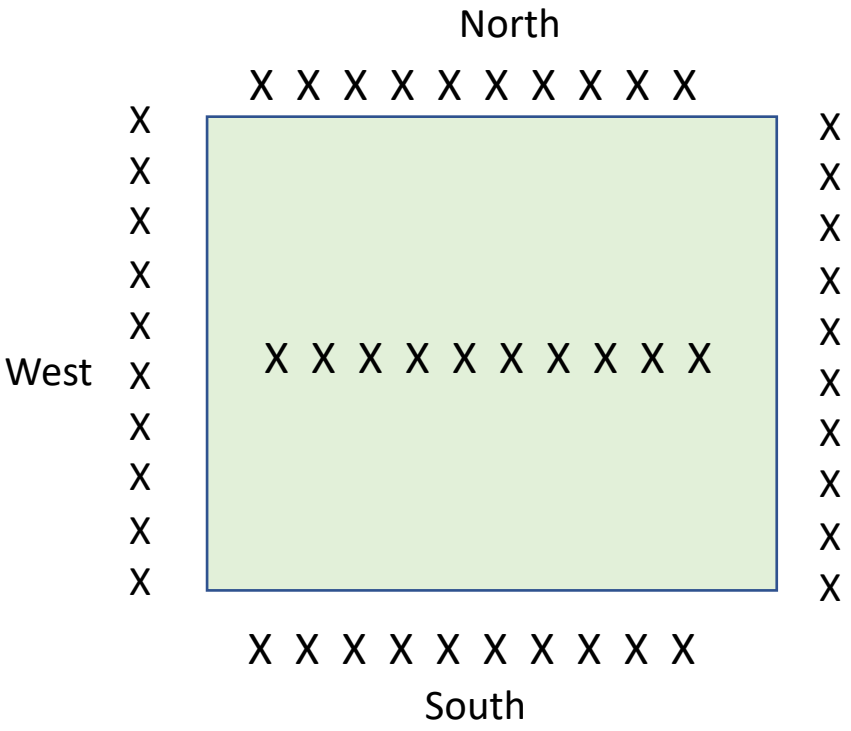
The yellow sticky traps are not very attractive

Tap sampling doesn't reveal many adults

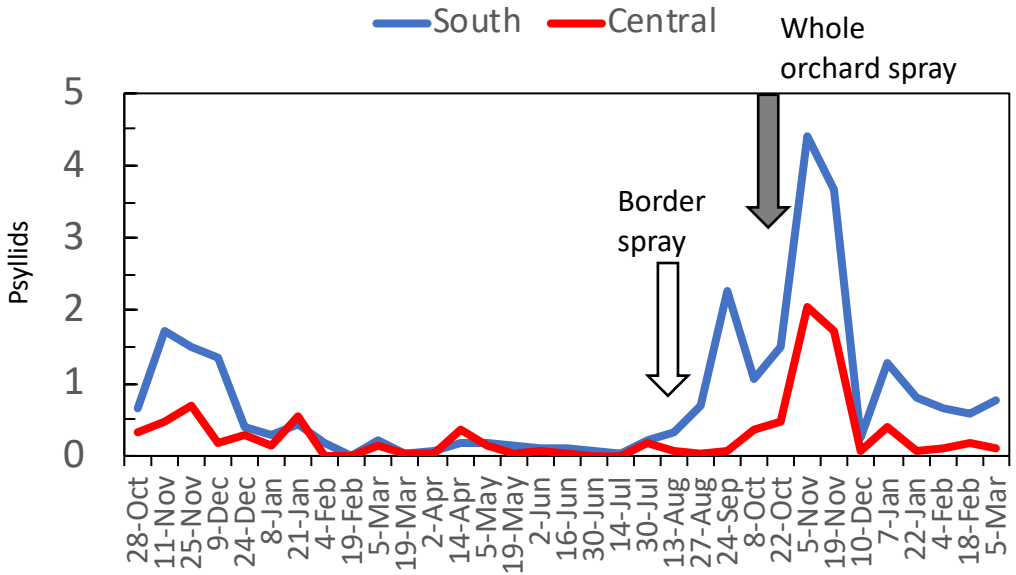
Examining suitable flush for psyllid **nymphs** is much better

Every 2 weeks – 10 trees on each border and one row in the center

Threshold for treatment is 0.5 nymphs per flush (5 psyllids/10 trees)

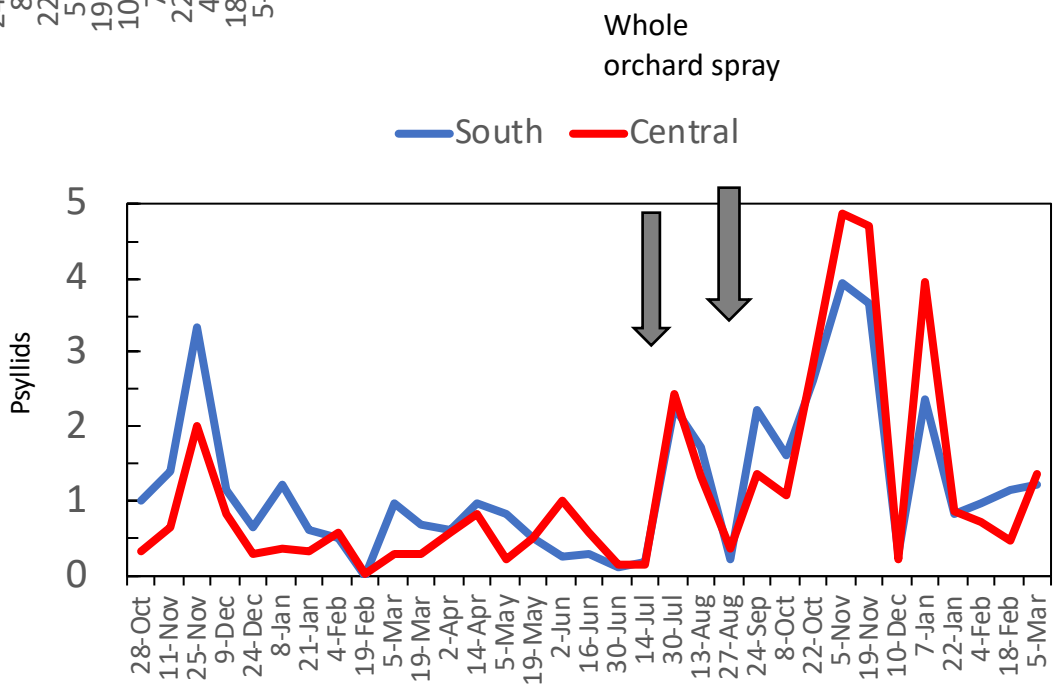


What does the preference for edges mean for managing ACP?



Nymphs per Flush

- Low levels ACP stay on the border
- High levels, small or young blocks ACP are found throughout
- Treat borders whenever psyllids start to increase (don't wait for the areawide scheduled treatment)



Young trees/replants – they are very attractive to psyllids

- Additional insecticides – entire block
- Mesh tree covers
- Repellent sprays
- Reflective mulches

Citrus Under Protective Screen (CUPS) for California?

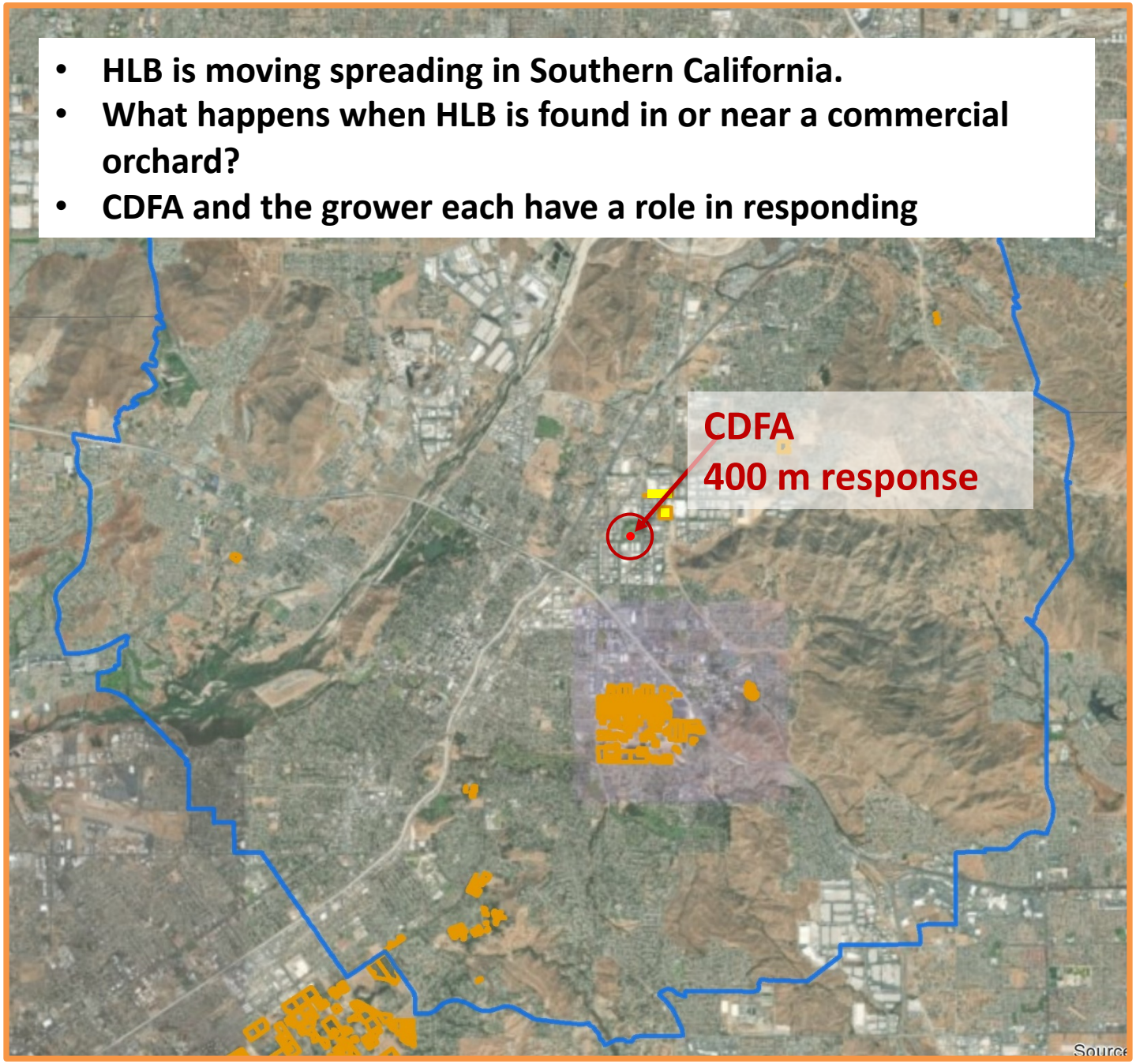
Windbreaks, barriers, etc. to block psyllid flight into the orchard

- **Windbreak – living barrier**
- **Fence (screen mesh) – artificial barrier**
- **Repellents (Celite and kaolin clay)**
- **Trap crop (for example Murraya)?**

Not every technique will work in every orchard, and good efficacy may require **'stacking'** techniques

Growers should learn what's new, be creative and figure out what works for their situation.

- **HLB is moving spreading in Southern California.**
- **What happens when HLB is found in or near a commercial orchard?**
- **CDFA and the grower each have a role in responding**



Riverside County

CLas (HLB) tree or psyllid nymph

CDFA Mandatory response

- 400 meter testing and treatment
- 5 mile zone that bulk citrus needs extra mitigations to move it out of the area

Mandatory Protocols For HLB

HLB+ tree

Mandatory actions by grower

- Treat the tree with insecticide within 72 hours
- Remove the tree and destroy the roots 48 h after REI has ended
- Treat all citrus within 400 meters of the disease tree within 7 days
  - 1 foliar if in areawide
  - 2 treatments if no areawide treatment

Actions by CDFA

- Collect leaf samples from perimeter trees in the orchard and neighboring orchards within 400 m and test for HLB
- **Establish a 5 mile quarantine**
- Resample once a year

HLB+ ACP nymph

Mandatory actions by grower

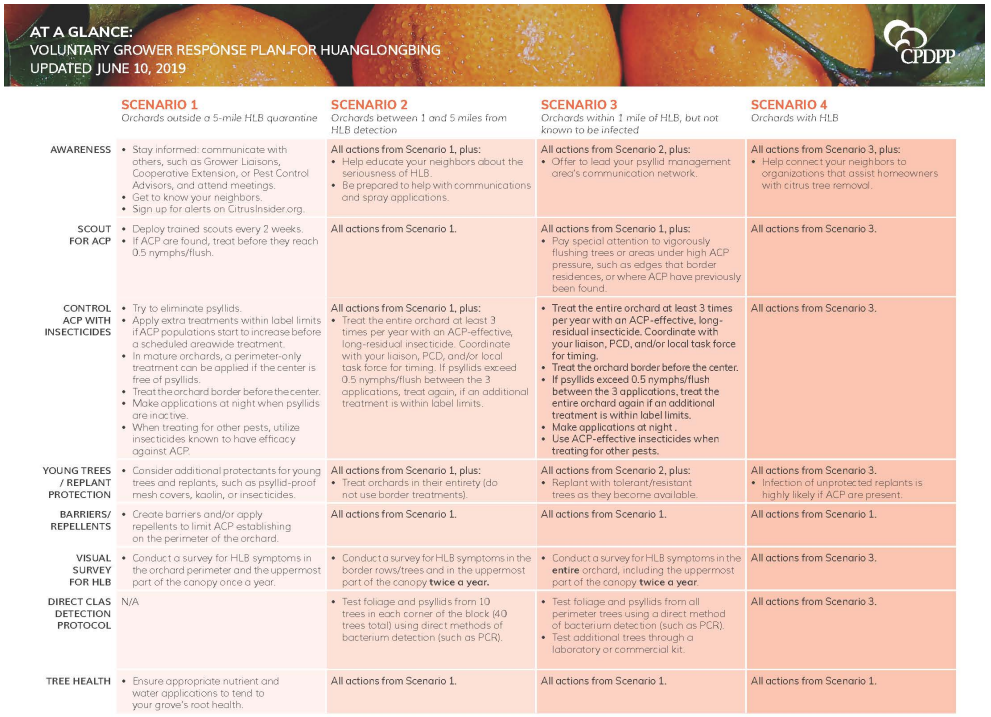
- Treat the tree with insecticide within 72 hours
- Remove the tree and destroy the roots 48 h after REI has ended
- Treat all citrus within 400 meters of the disease tree within 7 days
  - 1 foliar if in areawide
  - 2 treatments if no areawide treatment

Actions by CDFA

- Collect leaf samples from perimeter trees in the orchard and neighboring orchards within 400 m and test for HLB
- ***No 5 mile quarantine***
- Resample once a year

Voluntary Grower Response Plan

- ✓ **Awareness**
- ✓ **Scouting for ACP**
- ✓ **Insecticidal Control of ACP**
- ✓ **Young tree & Replant Protection**
- ✓ **Barriers & Repellents**
- ✓ **Visual Survey for HLB**
- ✓ **HLB Detection**
- ✓ **Tree Health**



AT A GLANCE:
VOLUNTARY GROWER RESPONSE PLAN FOR HUANGLONGBING
UPDATED JUNE 10, 2019

CPDPP

	SCENARIO 1 *Orchards outside a 5-mile HLB quarantine*	SCENARIO 2 *Orchards between 1 and 5 miles from HLB detection*	SCENARIO 3 *Orchards within 1 mile of HLB, but not known to be infected*	SCENARIO 4 *Orchards with HLB*
AWARENESS	• Stay informed: communicate with others, such as Grower Liaisons, Cooperative Extension, or Pest Control Advisors, and attend meetings. • Get to know your neighbors. • Sign up for alerts on CitrusInsider.org.	All actions from Scenario 1, plus: • Help educate your neighbors about the seriousness of HLB. • Be prepared to help with communications and spray applications.	All actions from Scenario 2, plus: • Offer to lead your psyllid management area's communication network.	All actions from Scenario 3, plus: • Help connect your neighbors to organizations that assist homeowners with citrus tree removal.
SCOUT FOR ACP	• Deploy trained scouts every 2 weeks. • If ACP are found, treat before they reach 0.5 nymphs/flush.	All actions from Scenario 1.	All actions from Scenario 1, plus: • Pay special attention to vigorously flushing trees or areas under high ACP pressure, such as edges that border residences, or where ACP have previously been found.	All actions from Scenario 3.
CONTROL ACP WITH INSECTICIDES	• Try to eliminate psyllids. • Apply extra treatments within label limits if ACP populations start to increase before a scheduled areawide treatment. • In mature orchards, a perimeter-only treatment can be applied if the center is free of psyllids. • Treat the orchard border before the center. • Make applications at night when psyllids are inactive. • When treating for other pests, utilize insecticides known to have efficacy against ACP.	All actions from Scenario 1, plus: • Treat the entire orchard at least 3 times per year with an ACP-effective, long-residual insecticide. Coordinate with your liaison, PCD, and/or local task force for timing. If psyllids exceed 0.5 nymphs/flush between the 3 applications, treat again, if an additional treatment is within label limits.	• Treat the entire orchard at least 3 times per year with an ACP-effective, long-residual insecticide. Coordinate with your liaison, PCD, and/or local task force for timing. • Treat the orchard border before the center. • If psyllids exceed 0.5 nymphs/flush between the 3 applications, treat the entire orchard again if an additional treatment is within label limits. • Make applications at night. • Use ACP-effective insecticides when treating for other pests.	All actions from Scenario 3.
YOUNG TREES / REPLANT PROTECTION	• Consider additional protectants for young trees and replants, such as psyllid-proof mesh covers, kaolin, or insecticides.	All actions from Scenario 1, plus: • Treat orchards in their entirety (do not use border treatments).	All actions from Scenario 2, plus: • Replant with tolerant/resistant trees as they become available.	All actions from Scenario 3. • Infection of unprotected replants is highly likely if ACP are present.
BARRIERS/ REPELLENTS	• Create barriers and/or apply repellents to limit ACP establishing on the perimeter of the orchard.	All actions from Scenario 1.	All actions from Scenario 1.	All actions from Scenario 1.
VISUAL SURVEY FOR HLB	• Conduct a survey for HLB symptoms in the orchard perimeter and the uppermost part of the canopy once a year.	• Conduct a survey for HLB symptoms in the border rows/trees and in the uppermost part of the canopy **twice a year.**	• Conduct a survey for HLB symptoms in the **entire** orchard, including the uppermost part of the canopy **twice a year.**	All actions from Scenario 3.
DIRECT CLAS DETECTION PROTOCOL	N/A	• Test foliage and psyllids from 10 trees in each corner of the block (40 trees total) using direct methods of bacterium detection (such as PCR).	• Test foliage and psyllids from all perimeter trees using a direct method of bacterium detection (such as PCR). • Test additional trees through a laboratory or commercial kit.	All actions from Scenario 3.
TREE HEALTH	• Ensure appropriate nutrient and water applications to tend to your grove's root health.	All actions from Scenario 1.	All actions from Scenario 1.	All actions from Scenario 1.

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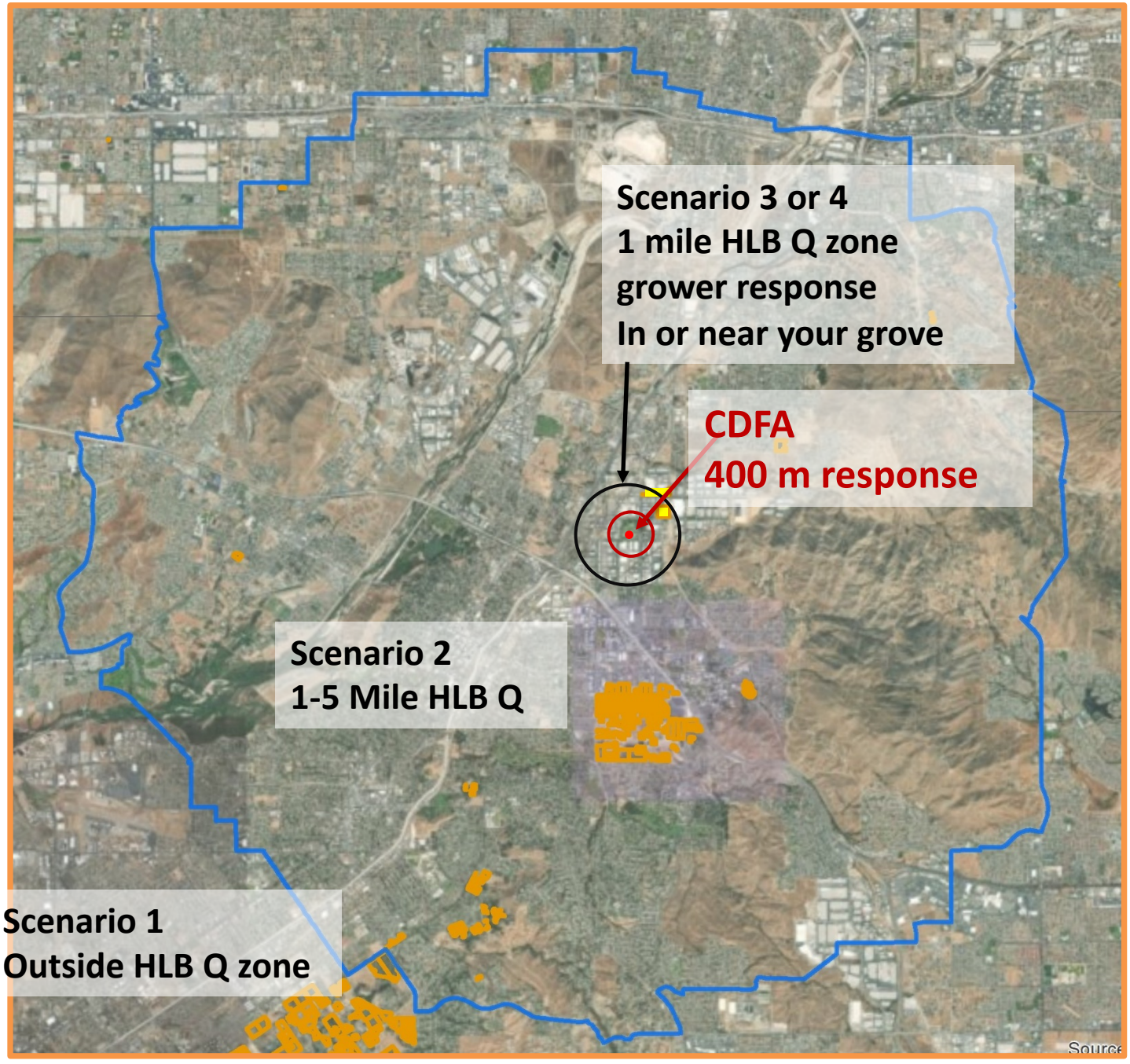
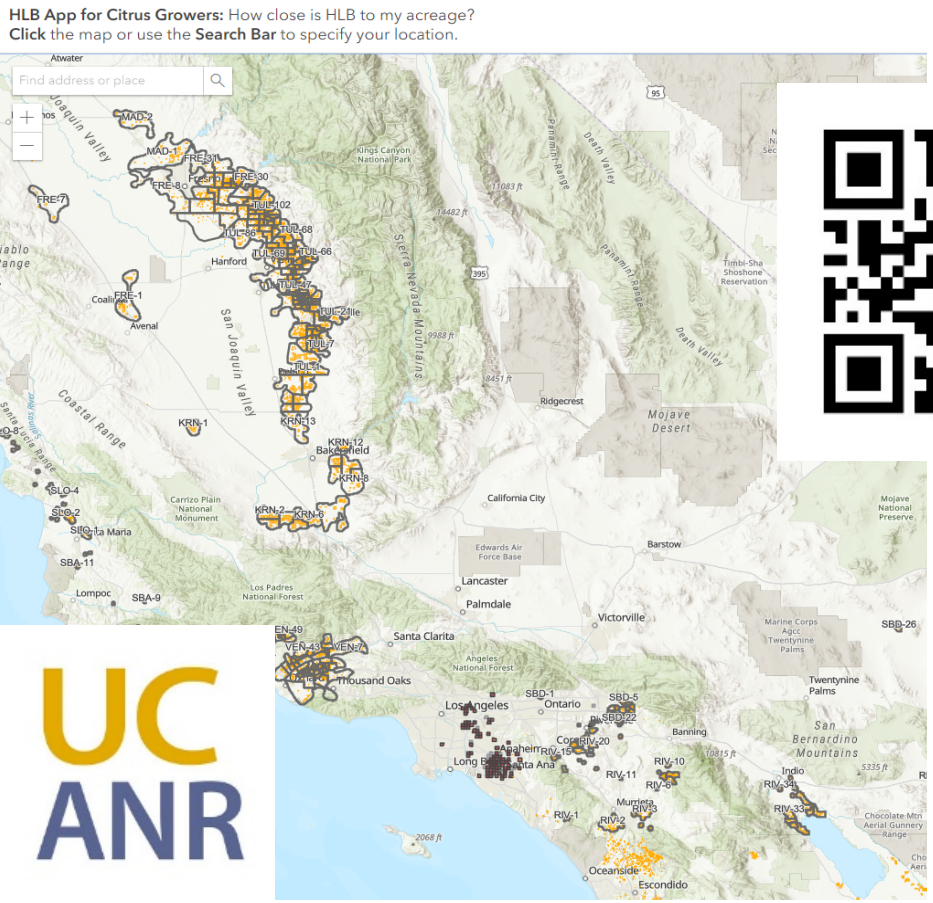

Scenario 3 or 4
1 mile HLB Q zone
grower response
In or near your grove
CDFA
400 m response
Scenario 2
1-5 Mile HLB Q
Scenario 1
Outside HLB Q zone
CLas Find
CDFA Mandatory response
Scenario 3 or 4
Scenario 2
Scenario 1
Commercial Citrus

HLB App for Citrus Growers

ucanr.edu/hlbgrowerapp



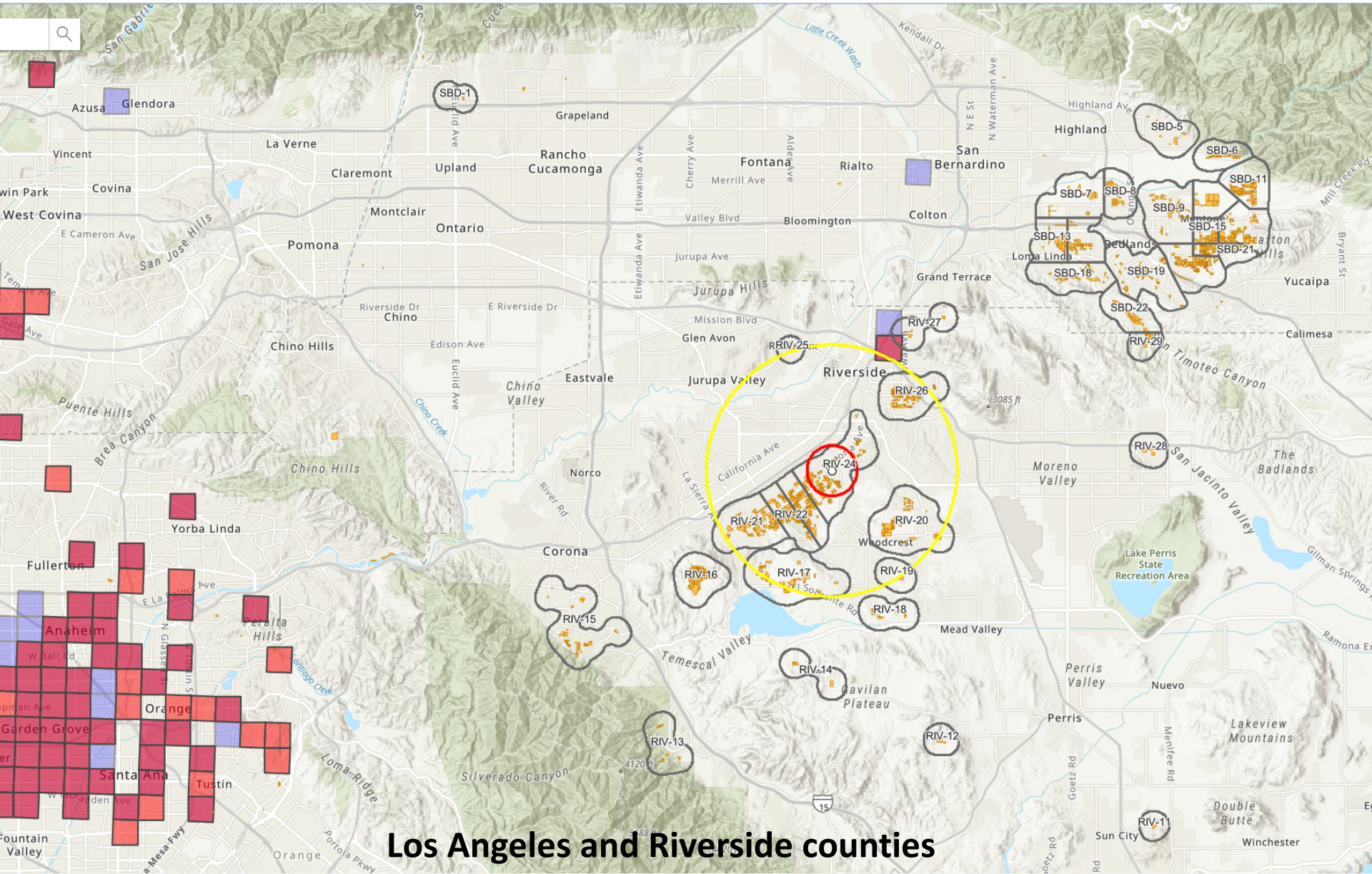
Use your phone to open this UC ANR app and take a quick look at how close HLB+ trees are to your orchard.

To best understand how to protect your citrus from HLB, follow the link on the other side of this card to the **Voluntary Grower Response Plan** that provides the latest recommendations for protecting citrus from HLB.

UC ANR

Psyllid management areas, citrus layer, HLB+ tree removals (red), HLB+ psyllids (purple)

5 miles of an HLB detection in a psyllid or tree. The **red ring shows < 1 mile** and the **yellow ring shows 1-5 miles** distance from infection. Your trees may be infected with H
control and regularly test the perimeter of your orchard for HLB. See the voluntary grower response plan for more details.

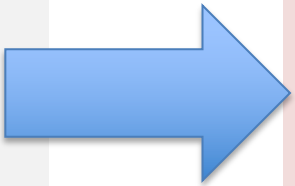


Los Angeles and Riverside counties

How does the response change as you get closer to HLB?

Scenarios 1 (outside the 5 mile HLB Q zone)

- Awareness
- Scouting for ACP
- Control of ACP
- Young tree/Replant
- Barriers/Repellents
- Visual Survey for HLB
- HLB Detection
- Tree Health



Scenarios 2-4 (inside the 5 mile HLB Q zone)

- Intensify types and number of treatments for ACP
- Install barriers/repellents
- Increase surveillance for HLB
- Comply with treatment and tree removal of HLB+ trees

What about early detection techniques (EDTs)?

- The **metabolism** of sick trees changes and that can be measured (Slupsky, UCD)
- Sick trees produce **proteins** (small RNAs) to protect themselves (Jin, UCR)
- The bacteria produce **proteins** that circulate and can be measured (Ma, UCR)
- Sick trees have different **microbes** living on them (Leveau and Roper, UCR)
- Sick trees emit **VOCs** (volatile organic compounds) that can be measured with a gas chromatograph (Davis, UCD)
- **Canines can detect the bacteria and alert (sit) by individual trees (Gottwald, UFL)**

EDTs are not included in the voluntary grower response plan because they are not readily available - growers should watch for updates

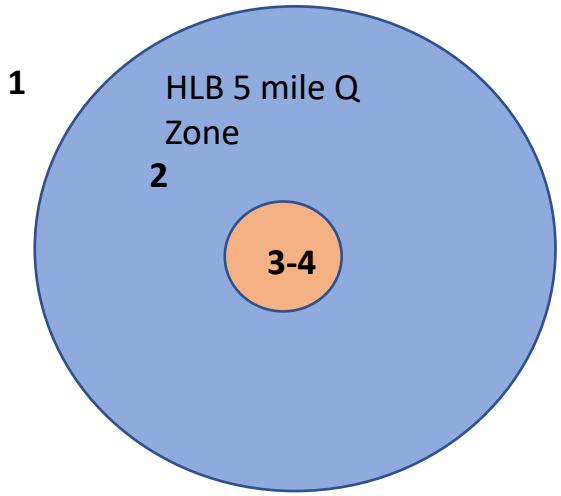
F1K9

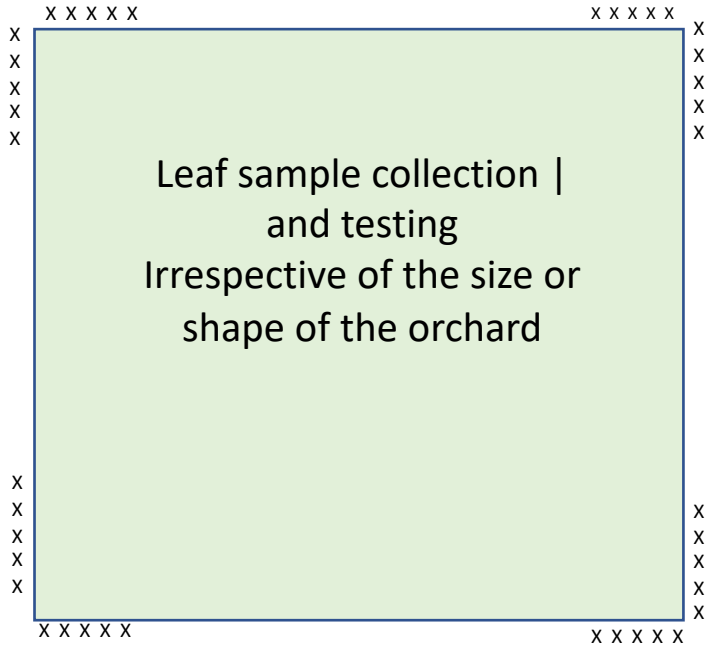
Intensify HLB-Detection Efforts – Grower testing

Scenario 2 (inside HLB Q zone, 1-5 miles from an HLB find)

Visual survey: walk the block twice a year and look for symptoms

Pay a lab to test leaves with PCR or ELISA: Test leaves from a total of 40 trees (10/corner) once a year using a lab permitted by CDFA or a commercial kit (Citrus Pest & Disease program formerly the CCTEA)





If a PCR+ tree or psyllid is detected the scenario shifts to 4

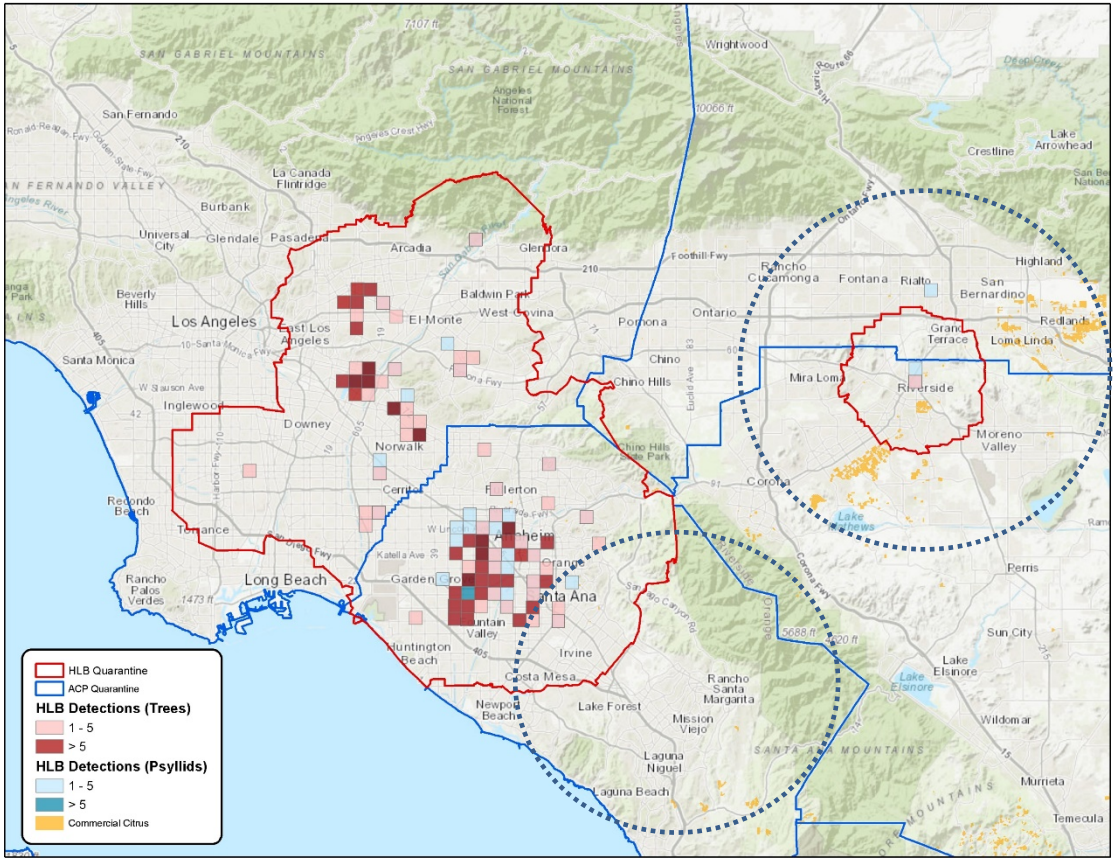
What about bactericides?

Bactericides help prevent bacteria from establishing in the citrus leaf.

However, they break down fast so they must be applied frequently.

- 6 treatments (4 spring flush/2 fall flush) minimum 21 days apart
- Rotate between **FireWall 50 WP** (streptomycin) and **FireLine 17 WP** (oxytetracycline) + adjuvant for resistance management
- Limited use in commercial citrus
  - ❑ HLB Quarantine
  - ❑ 15 miles around an HLB Q
  - ❑ 15 miles around a PCR+ psyllid
- They could be applied as a border treatment as this is where the infections usually start

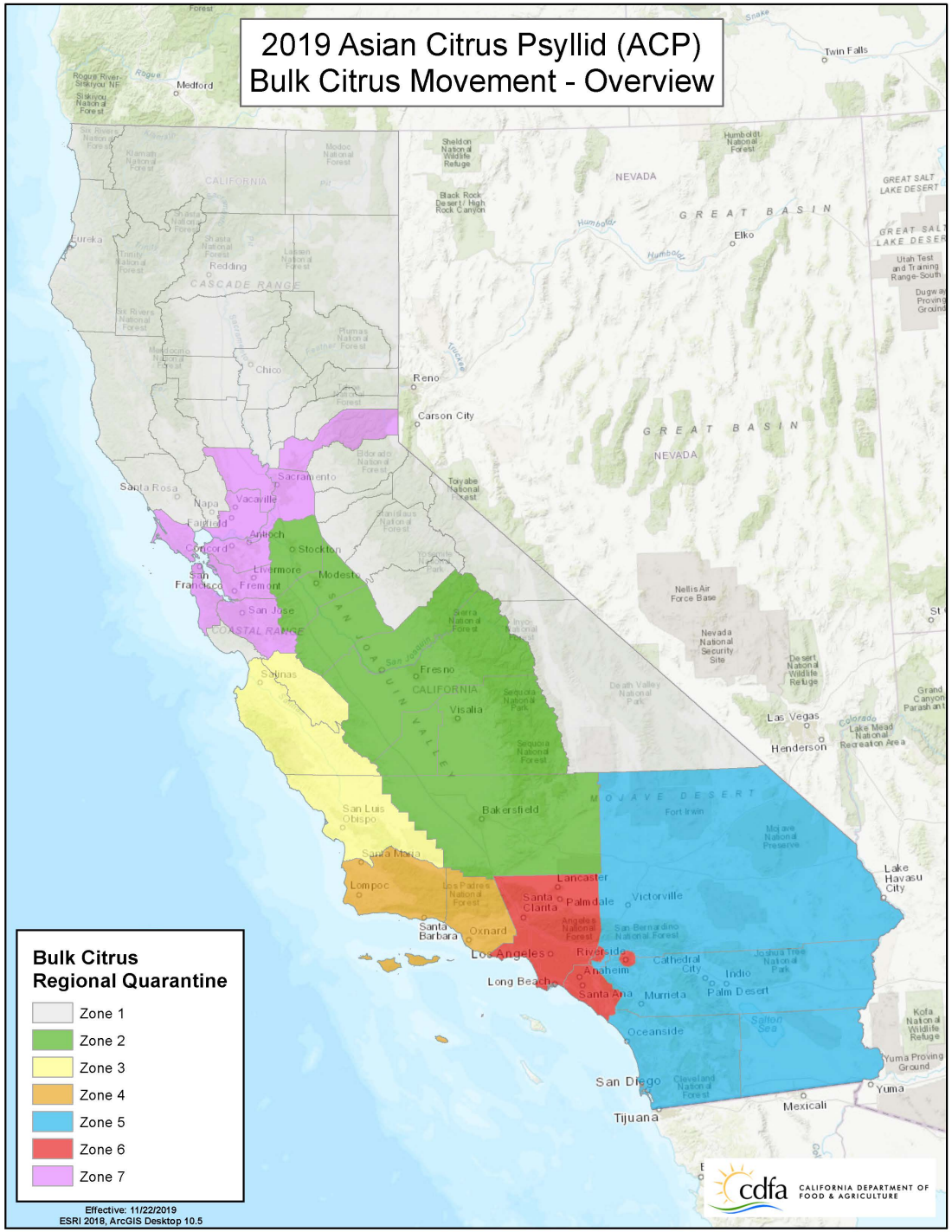
Bactericides are not included in the voluntary grower response plan because we do not know how effectively they will prevent HLB infections - growers should watch for updates



Bulk Citrus Movement

between zones requires a mitigation to make sure there are no psyllids riding on the fruit.

TWO mitigations are required for shipping out of zone 6 where HLB has been found



Bulk Citrus Movement in HLB Q areas requires TWO mitigations

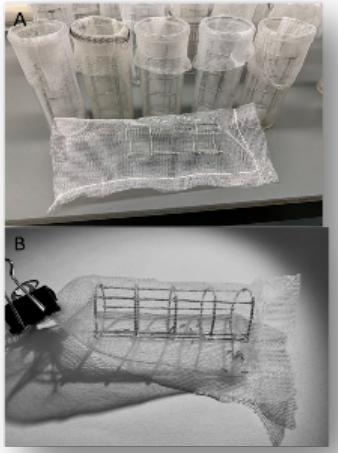
1. spray the orchard with a pesticide prior to harvest (Actara, pyrethroids, Lannate)
2. Mechnically clean or wash the fruit after harvest
3. Evergreen pressurized spray

Fumigation with Ethyl Formate gas – 2020

2019 Trial (Walse, Gautam, Mitcham)

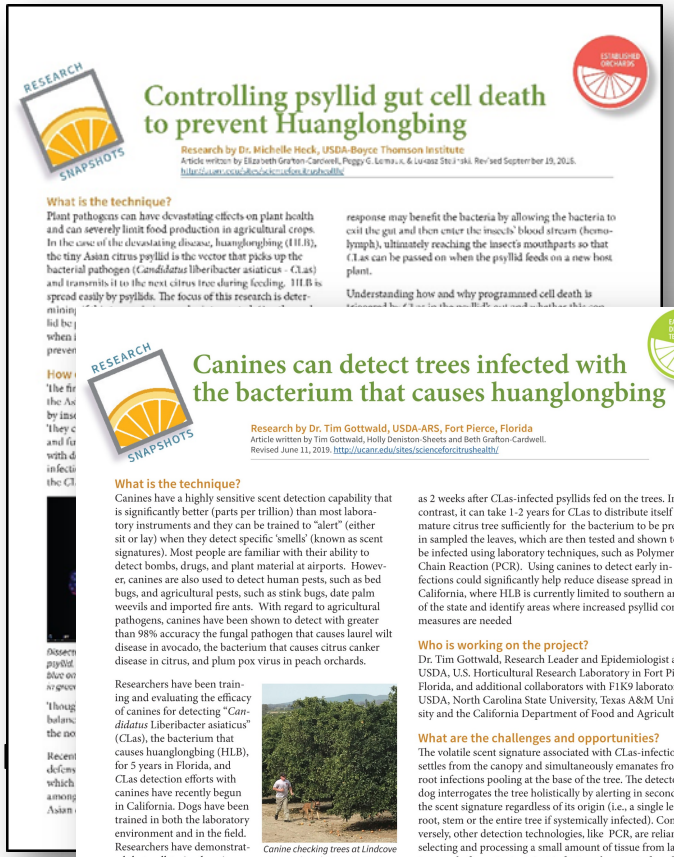
1 hour exposure with Ethyl formate (250 g/m^3)

72 cages of psyllids, replicated trial – no survival of the 2,194 psyllids tested



Scientists are studying every conceivable way to stop this disease

- **Early detection techniques** to find and destroy diseased trees
- Improved **Psyllid traps** – attract and kill
- **Bactericide** treatments and new ways to kill the bacterium
- **Resistant** rootstocks and scions (traditional breeding and gene editing)
- Genetically engineer an **altered citrus tristeza virus to introduce anti-HLB genes into plants** Inserting a **Bt toxin gene or psyllid virus** into citrus or a trap crop to kill the psyllid
- Genetically engineer the psyllid so it can't vector the disease and release the **altered psyllid** as a sterile insect to replace the wild ones (GE)



RESEARCH SNAPSHOTS

Controlling psyllid gut cell death to prevent Huanglongbing

Research by Dr. Michelle Heck, USDA-Boyce Thompson Institute

Article written by Elizabeth Grafton-Cardwell, Peggy G. Lemaux, & Lukasz Stelinski. Revised September 19, 2018.

http://ucanr.edu/sites/scienceforcitrushealth/

What is the technique?

Plant pathogens can have devastating effects on plant health and can severely limit food production in agricultural crops. In the case of the devastating disease, huanglongbing (HLB), the tiny Asian citrus psyllid is the vector that picks up the bacterial pathogen (*Candidatus* liberibacter asiaticus - CLas) and transmits it to the next citrus tree during feeding. HLB is spread easily by psyllids. The focus of this research is deter-

response may benefit the bacteria by allowing the bacteria to exit the gut and then enter the insects' blood stream (hemo-lymph), ultimately reaching the insect's mouthparts so that CLas can be passed on when the psyllid feeds on a new host plant.

Understanding how and why programmed cell death is

RESEARCH SNAPSHOTS

Canines can detect trees infected with the bacterium that causes huanglongbing

Research by Dr. Tim Gottwald, USDA-ARS, Fort Pierce, Florida

Article written by Tim Gottwald, Holly Deniston-Sheets and Beth Grafton-Cardwell.

Revised June 11, 2019. http://ucanr.edu/sites/scienceforcitrushealth/

What is the technique?

Canines have a highly sensitive scent detection capability that is significantly better (parts per trillion) than most laboratory instruments and they can be trained to "alert" (either sit or lay) when they detect specific 'smells' (known as scent signatures). Most people are familiar with their ability to detect bombs, drugs, and plant material at airports. However, canines are also used to detect human pests, such as bed bugs, and agricultural pests, such as stink bugs, date palm weevils and imported fire ants. With regard to agricultural pathogens, canines have been shown to detect with greater than 98% accuracy the fungal pathogen that causes laurel wilt disease in avocado, the bacterium that causes citrus canker disease in citrus, and plum pox virus in peach orchards.

Researchers have been training and evaluating the efficacy of canines for detecting "*Candidatus* Liberibacter asiaticus" (CLas), the bacterium that causes huanglongbing (HLB), for 5 years in Florida, and CLas detection efforts with canines have recently begun in California. Dogs have been trained in both the laboratory environment and in the field. Researchers have demonstrated that well-trained canines can detect CLas over 95% of the time in commercial trees and over 92% of the time in residential trees. Researchers did not observe any differences in canine performance between citrus species and varieties. The training that the canines receive is very specific to CLas. When they are taken into citrus orchards infected with *Citrus tristeza* virus, viroids, the fungal pathogen *Phytophthora*, or the bacterium that causes citrus stubborn, the CLas-trained canines do not respond to these diseases.

Canine checking trees at Lindcove Research and Extension Center, Exeter, CA

The canines provide a significant opportunity to be used as an Early Detection Technology (EDT) in California. In a field study using potted citrus in Florida, dogs could detect CLas in some of the trees as early as 2 weeks after CLas-infected psyllids fed on the trees. In contrast, it can take 1-2 years for CLas to distribute itself in a mature citrus tree sufficiently for the bacterium to be present in sampled the leaves, which are then tested and shown to be infected using laboratory techniques, such as Polymerase Chain Reaction (PCR). Using canines to detect early infections could significantly help reduce disease spread in California, where HLB is currently limited to southern areas of the state and identify areas where increased psyllid control measures are needed

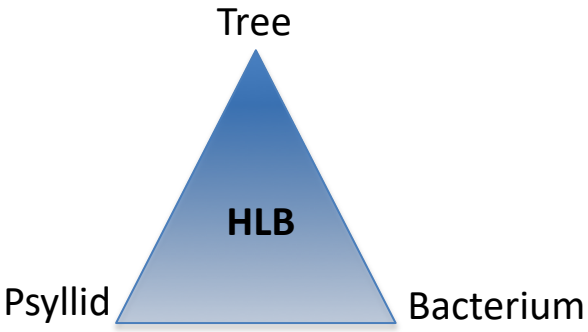
Who is working on the project?

Dr. Tim Gottwald, Research Leader and Epidemiologist at the USDA, U.S. Horticultural Research Laboratory in Fort Pierce, Florida, and additional collaborators with F1K9 laboratories, USDA, North Carolina State University, Texas A&M University and the California Department of Food and Agriculture..

What are the challenges and opportunities?

The volatile scent signature associated with CLas-infection settles from the canopy and simultaneously emanates from root infections pooling at the base of the tree. The detector dog interrogates the tree holistically by alerting in seconds on the scent signature regardless of its origin (i.e., a single leaf, root, stem or the entire tree if systemically infected). Conversely, other detection technologies, like PCR, are reliant on selecting and processing a small amount of tissue from large trees and often miss incipient infections because infected tissue is so rare in newly infected trees. Early detection via dogs is devoid of these sampling issues. Therefore, it is difficult to confirm CLas detections by dogs using currently available molecular or chemical detection methods. Dogs have been tested in hot and cold temperatures and with wind speeds up to 20 MPH with no perceptible degradation in detection.

Human scouts require several minutes per tree to visually examine it for symptoms, then they must collect tissue which must be transported to a diagnostic lab for processing and analysis, which is time consuming and labor-intensive. Whereas, in a residential environment dogs can assess all trees in even large yards in a couple of minutes. The major limitation to the number of trees a dog can assess per day is access to these residential properties and the time required to relocate from property to property. In commercial groves a team of two dogs and one handler can survey a 10 acre planting (~1500 trees) in 1-2 hours depending on the number

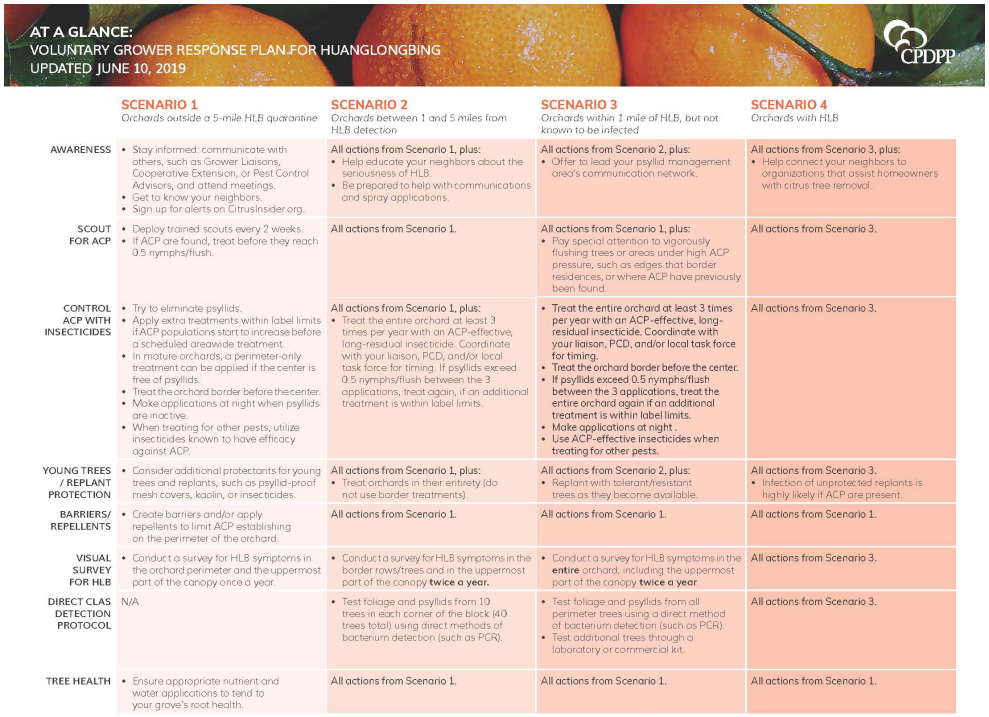


Science for Citrus Health

www.ucanr.edu/sites/scienceforcitrushealth

Voluntary Grower Response Plan

- ✓ **Awareness**
- ✓ **Scouting for ACP**
- ✓ **Insecticidal Control of ACP**
- ✓ **Young tree & Replant Protection**
- ✓ **Barriers & Repellents**
- ✓ **Visual Survey for HLB**
- ✓ **HLB Testing**
- ✓ **Tree Health**



AT A GLANCE:
VOLUNTARY GROWER RESPONSE PLAN FOR HUANGLONGBING
UPDATED JUNE 10, 2019

CPDPP

	SCENARIO 1 *Orchards outside a 5-mile HLB quarantine*	SCENARIO 2 *Orchards between 1 and 5 miles from HLB detection*	SCENARIO 3 *Orchards within 1 mile of HLB, but not known to be infected*	SCENARIO 4 *Orchards with HLB*
AWARENESS	• Stay informed: communicate with others, such as Grower Liaisons, Cooperative Extension, or Pest Control Advisors, and attend meetings. • Get to know your neighbors. • Sign up for alerts on CitrusInsider.org.	All actions from Scenario 1, plus: • Help educate your neighbors about the seriousness of HLB. • Be prepared to help with communications and spray applications.	All actions from Scenario 2, plus: • Offer to lead your psyllid management area's communication network.	All actions from Scenario 3, plus: • Help connect your neighbors to organizations that assist homeowners with citrus tree removal.
SCOUT FOR ACP	• Deploy trained scouts every 2 weeks. • If ACP are found, treat before they reach 0.5 nymphs/flush.	All actions from Scenario 1.	All actions from Scenario 1, plus: • Pay special attention to vigorously flushing trees or areas under high ACP pressure, such as edges that border residences, or where ACP have previously been found.	All actions from Scenario 3.
CONTROL ACP WITH INSECTICIDES	• Try to eliminate psyllids. • Apply extra treatments within label limits if ACP populations start to increase before a scheduled areawide treatment. • In mature orchards, a perimeter-only treatment can be applied if the center is free of psyllids. • Treat the orchard border before the center. • Make applications at night when psyllids are inactive. • When treating for other pests, utilize insecticides known to have efficacy against ACP.	All actions from Scenario 1, plus: • Treat the entire orchard at least 3 times per year with an ACP-effective, long-residual insecticide. Coordinate with your liaison, PCD, and/or local task force for timing. If psyllids exceed 0.5 nymphs/flush between the 3 applications, treat again, if an additional treatment is within label limits.	• Treat the entire orchard at least 3 times per year with an ACP-effective, long-residual insecticide. Coordinate with your liaison, PCD, and/or local task force for timing. • Treat the orchard border before the center. • If psyllids exceed 0.5 nymphs/flush between the 3 applications, treat the entire orchard again if an additional treatment is within label limits. • Make applications at night. • Use ACP-effective insecticides when treating for other pests.	All actions from Scenario 3.
YOUNG TREES / REPLANT PROTECTION	• Consider additional protectants for young trees and replants, such as psyllid-proof mesh covers, kaolin, or insecticides.	All actions from Scenario 1, plus: • Treat orchards in their entirety (do not use border treatments).	All actions from Scenario 2, plus: • Replant with tolerant/resistant trees as they become available.	All actions from Scenario 3. • Infection of unprotected replants is highly likely if ACP are present.
BARRIERS/ REPELLENTS	• Create barriers and/or apply repellents to limit ACP establishing on the perimeter of the orchard.	All actions from Scenario 1.	All actions from Scenario 1.	All actions from Scenario 1.
VISUAL SURVEY FOR HLB	• Conduct a survey for HLB symptoms in the orchard perimeter and the uppermost part of the canopy once a year.	• Conduct a survey for HLB symptoms in the border rows/trees and in the uppermost part of the canopy **twice a year.**	• Conduct a survey for HLB symptoms in the **entire** orchard, including the uppermost part of the canopy **twice a year.**	All actions from Scenario 3.
DIRECT CLAS DETECTION PROTOCOL	N/A	• Test foliage and psyllids from 10 trees in each corner of the block (40 trees total) using direct methods of bacterium detection (such as PCR).	• Test foliage and psyllids from all perimeter trees using a direct method of bacterium detection (such as PCR). • Test additional trees through a laboratory or commercial kit.	All actions from Scenario 3.
TREE HEALTH	• Ensure appropriate nutrient and water applications to tend to your grove's root health.	All actions from Scenario 1.	All actions from Scenario 1.	All actions from Scenario 1.

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