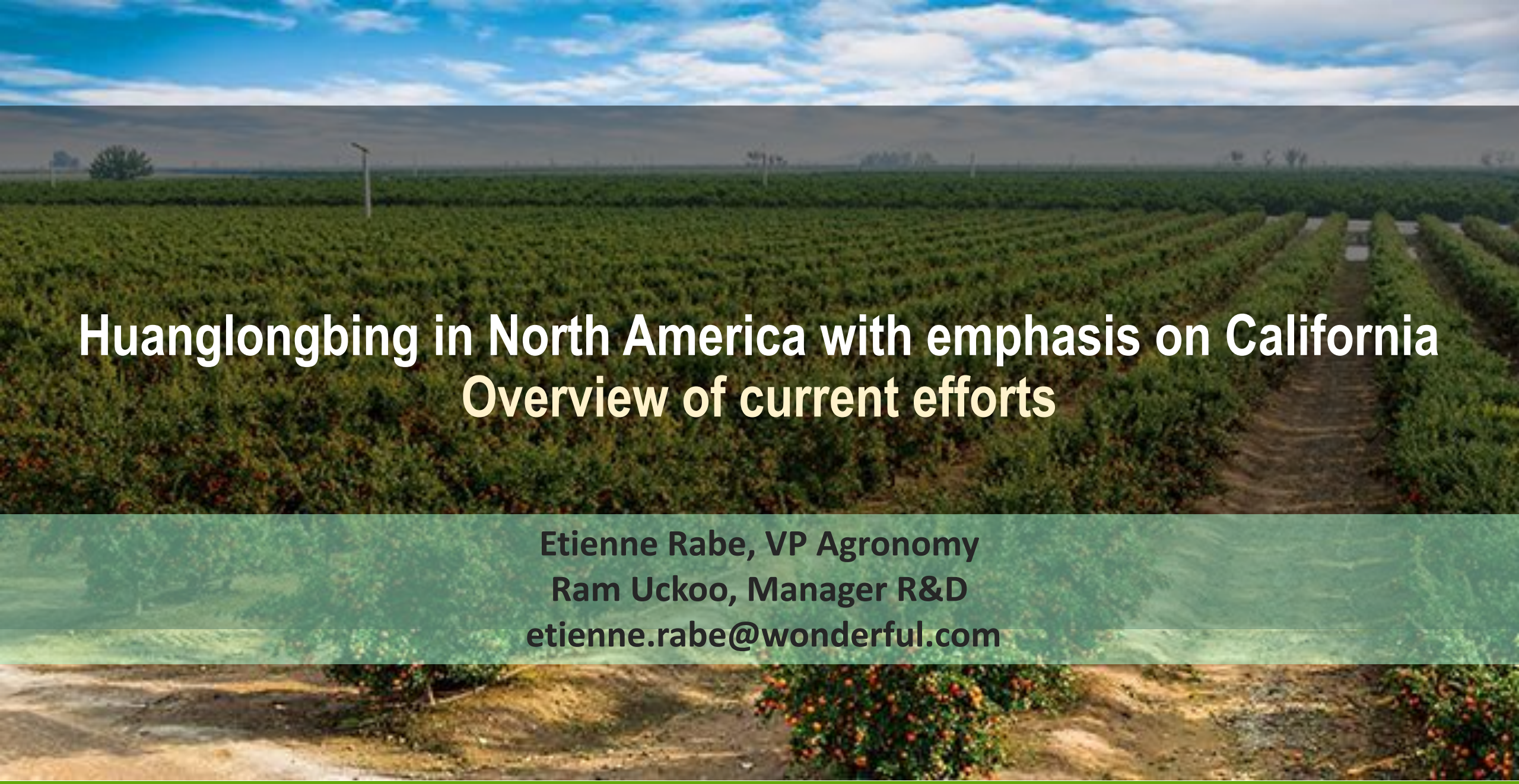


Huanglongbing in North America with emphasis on California
Overview of current efforts

Etienne Rabe, VP Agronomy
Ram Uckoo, Manager R&D
etienne.rabe@wonderful.com

Preamble

- Experience as grower
- Involved in the California ACP/HLB fight since inception in 2008
- Serious disease and consequences
- Convey my view of what is happening and why we are not always right
- Accept my views at that of someone with biology background and in the trenches of fight
- Test my views against others to validate

Overview…

- HLB and ACP
- California: HLB timeline
  - Grower board: CPDPP
  - HLB- current scenario
- Mitigation strategies
  - Backyard
  - Commercial
- HLB: Florida, Texas, Mexico
- Climatic conditions-ACP
- Future?
- Message for Australia

HuangLongBing (HLB) – *Candidatus Liberibacter asiaticus (Clas)*

- Leaves have mottled appearance
- Symptoms can look like nutrient deficiency
- Latency effect: 5mo to 2yrs

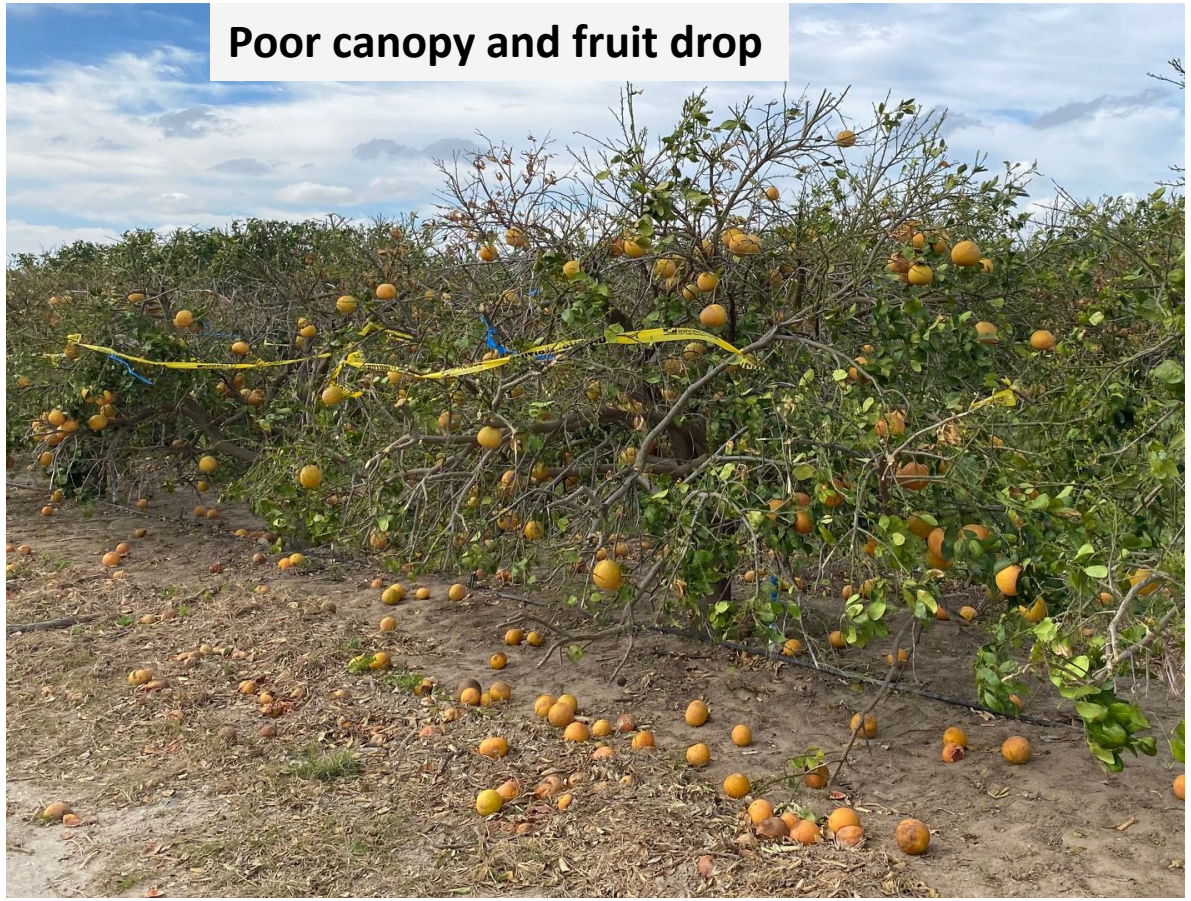
- Fruit of infected plants remain partially green and fall off the tree easily and prematurely

- Fruit of infected plants are small, misshapen/deformed/oblong with thicker rind.
- There is no known cure for HLB

HLB: Impact

Latency

5 mo – 2 yrs for first symptoms of mottling after first infection by ACP.



HLB is transmitted by Asian Citrus Psyllid (ACP)

- Enlarged view of Asian Citrus Psyllid
- 1/8 – 1/6 inch (3 – 4 mm) in length[1]
- Live 1 to 2 months[1]

Source: [1]UC ANR Publication 8205

California:

Citrus snapshot and HLB timeline

California citrus: snapshot

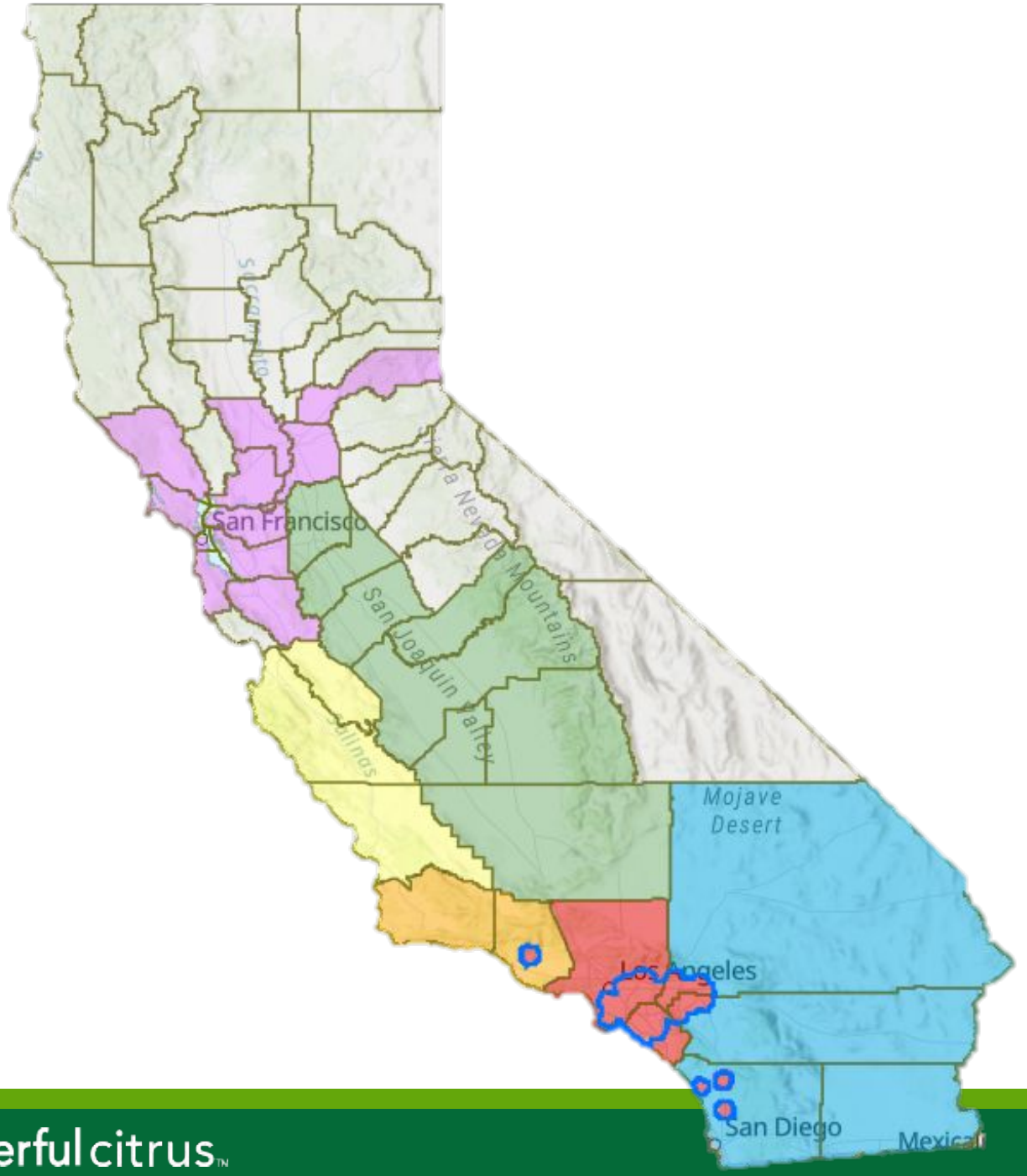
3,900 farmers

292,000 acres of citrus production

$3.4 billion in sales

$7 billion in economic revenue

22,000 jobs



HLB in California: Timeline

[5 years from ACP to HLB detection; only residential HLB --- 7400 trees removed; 12 years]

ACP detection in San Diego, CA

2008

HLB detection in citrus trees

2012

First ACP+ found in commercial grove in Riverside

2020

HLB + found in Ventura County

2023

2009

Citrus Pest & Disease Prevention Committee established

2018

1000th HLB tree found in Orange county

2021

First HLB+ found in San Diego County

2024

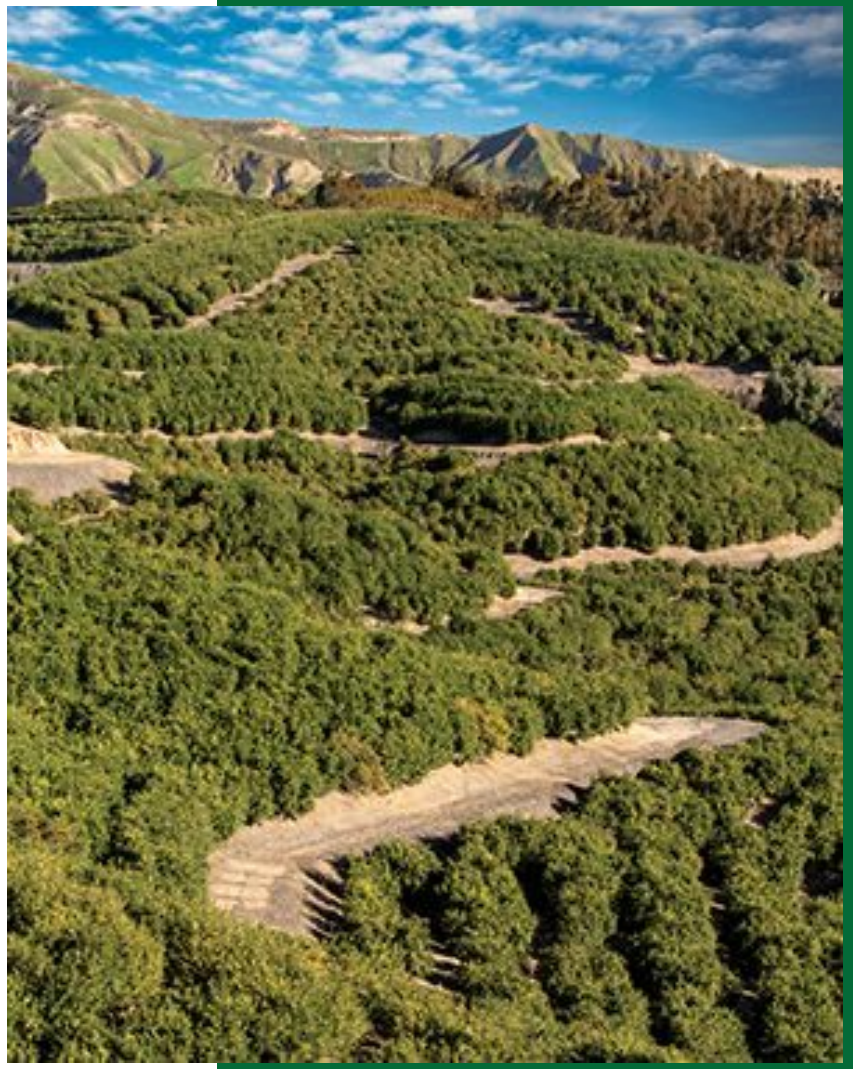
7415+ HLB positive trees removed from residential backyards

Grower board: CA CPDPP

Citrus Pest and Disease Prevention Program

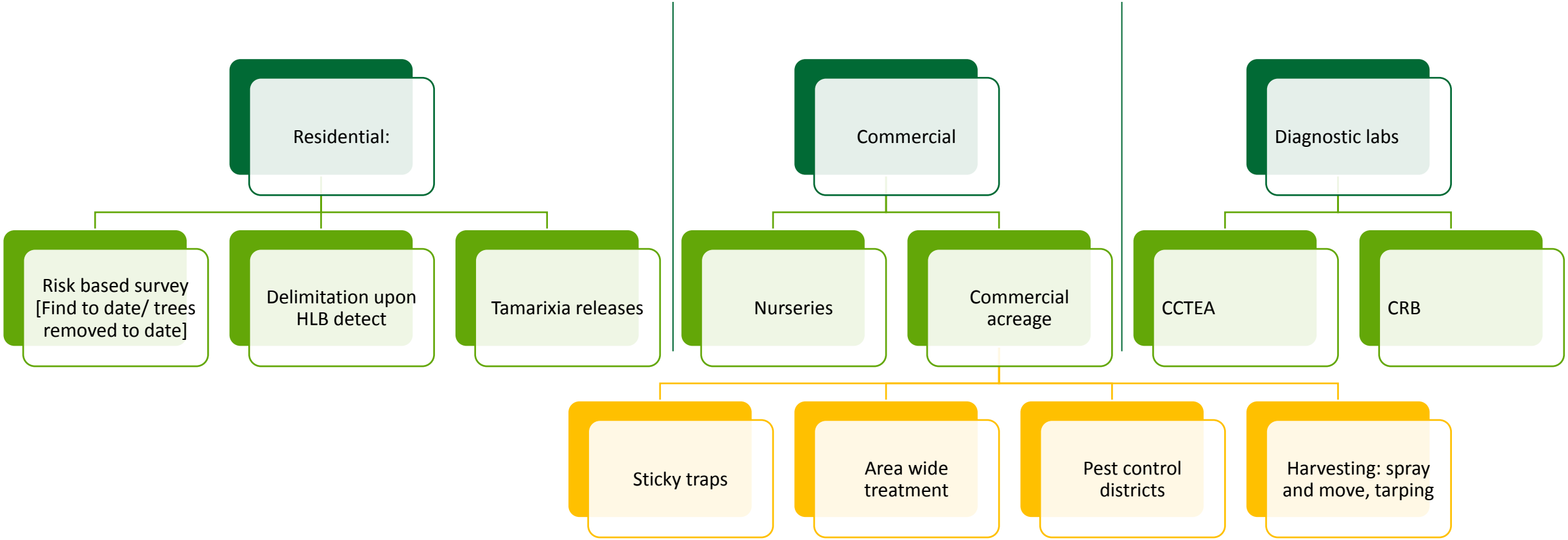
Grower Board

- 18 member Grower Board; appointed by CA Secretary of AG
- Quarterly meetings
- Oversees the CDFA dedicated Citrus program
- Subcommittees: Finance, Operations, Science meeting more frequently



CA Citrus Pest and Disease Prevention Program

CDFA dedicated program: 168 staff

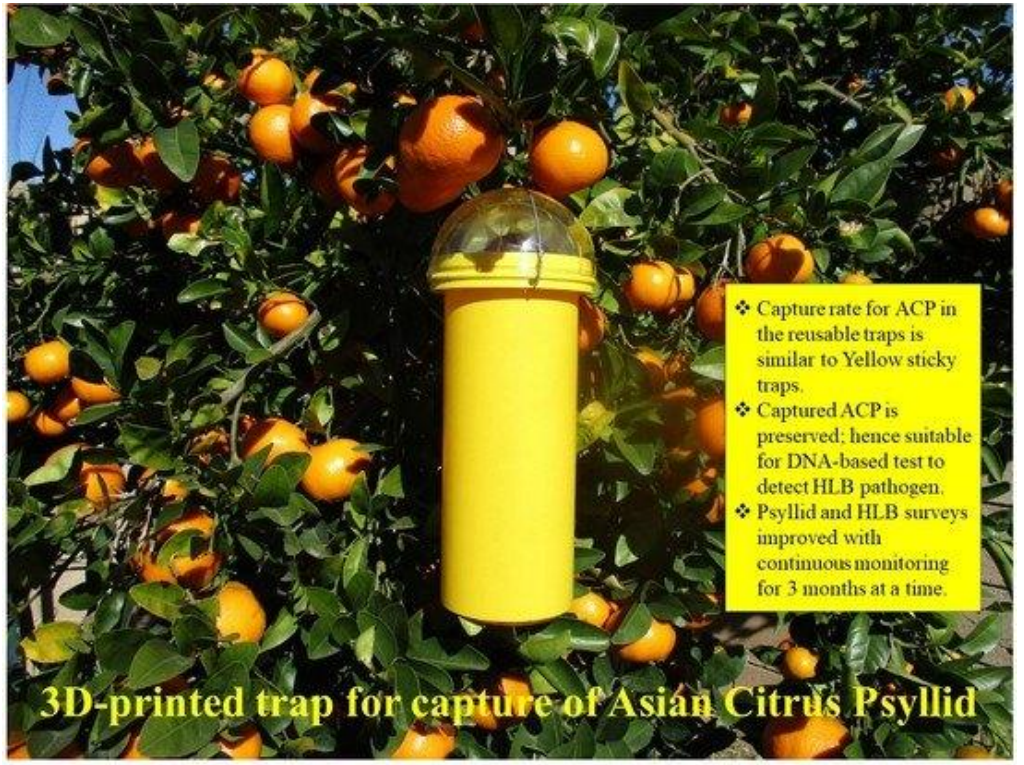


Main activities of CPDPP

https://www.cdfa.ca.gov/citrus/

- 3 regions: south, central, north
- Risk-based survey:
  - mostly SoCal; also residential in other areas
  - STRs: program based on population dynamics; previous HLB finds
  - Delimitation; treatment
  - Tree removal
- Commercial citrus surveys
- Areawide treatment recommendations
- Laboratory capacity
- [ACP endemic in SoCal, somewhat in coastal regions; very sporadic in SJV]

ACP psyllid traps: “blunder” traps: limited advancement here



Budget

$40m plus p.a; approx. 50% Growers; Federal 40%; State 10%

FY & Timeline	Approved Budget	Expenditures
19-20	$40,487,142	$26,165,166
20-21	$42,281,262	$29,521,516
21-22	$44,588,810	$31,164,934
22-23	$44,449,755	$36,239,404
23-24	$41,500,000	

Grower contribution

$16m to $18m annually; $200/ha for 40 t/ha [per 40lbs field cartons]

[CRB: additional $100/ha]

FY	Revenue received	$ per carton	Field cartons
19-20	$18,468,051	$0.09	205,200,567
20-21	$15,537,943	$0.08	194,224,287
21-22	$11,939,008	$0.07	170,557,257
22-23	$13,022,888	$0.07	186,041,257
23-24 (Oct - Jan)	$3,656,564	$0.09	40,628,488

Federal, State and Grower spending on HLB aspects to date in the USA

- Various entities involved in the HLB fight and funding R&D and mitigation efforts
- To date between $1.5 and $2.0 billion spent
- The solution box is empty at this time

Big $$$ research

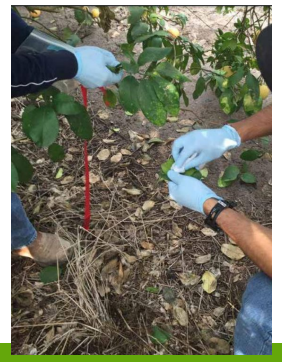
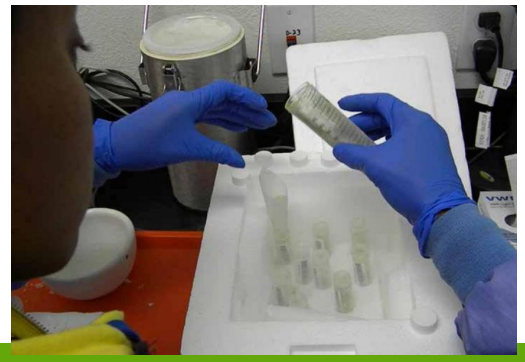
- Research:
  - Defensin gene
  - nu-Psyllid: releasing a nu-psyllid population that is incapable of moving the disease.
  - Peptides:
    a) UCR: Finger lime peptide: no validation
    b) Innate immunity: no validation
  - CRISPR CAS9
  - Breeding: finger lime

Diagnostic labs

Major part of infrastructure: 100K plant samples; 40K ACP

Capacity	CDFA HLB High-throughput Plant Testing Laboratory	Jerry Dimitman High-throughput Testing Laboratory (CRB Lab)
Plant samples	7000/month [84,000/yr]	1000/month [12,000/yr]
ACP	420/month [5,000/yr]	3000/month [36,000/yr]
Staff	1 Senior Plant Pathologist, 2 Full-time Environmental Scientists, 7 Full-time Agricultural Biological Technicians, 2 Part-time Seasonal AgTechs	1 Lab director, 4 Full-time Lab Technicians



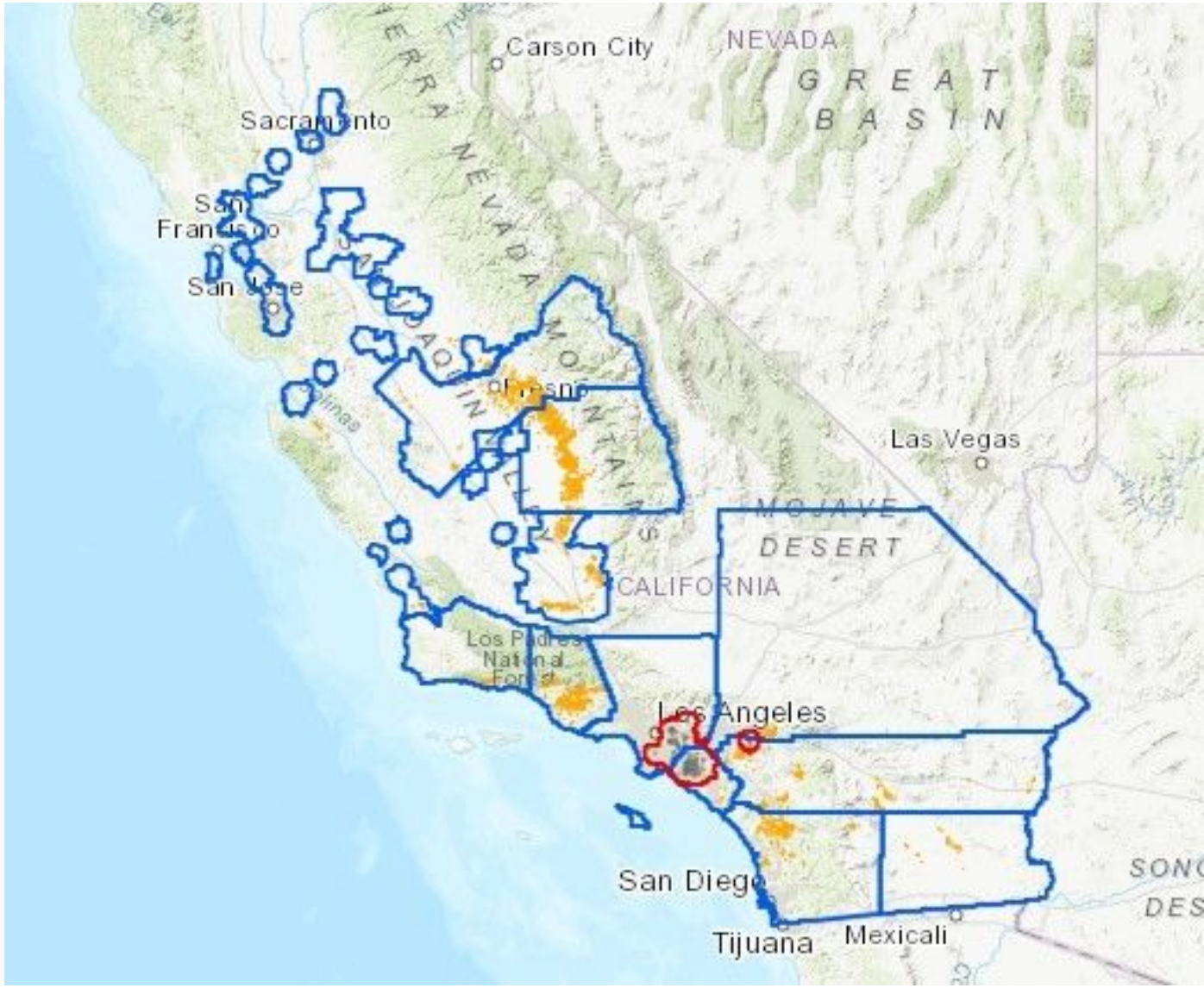

CCRF-BSL3

- $8 million [CA Citrus Research Foundation]
- Researchers from UC Riverside and elsewhere can find ways to prevent and cure HLB
- Research focus:
  - Breeding
  - Screening
  - Peptides/Antibiotics

Current scenario

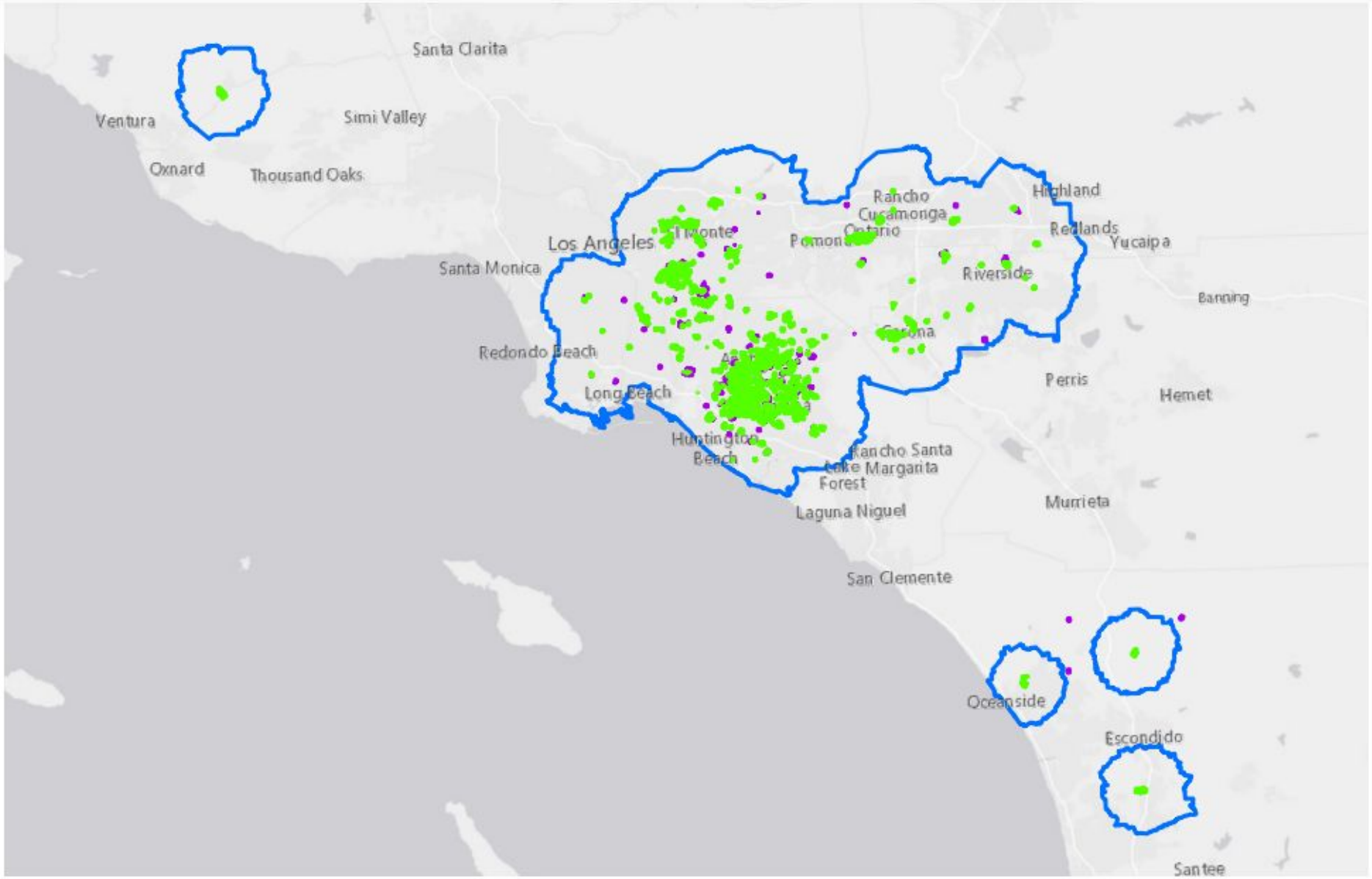
Current scenario

- ACP spread
- Endemic SoCal; sporadic in north
- HLB in residential southern California only
- Commercial orchards: none found yet
- HLB find -- mandated removal
- 5-mile quarantine radius
- 250m delimitation/search and destroy
- Refusals!



Current scenario

- HLB quarantine

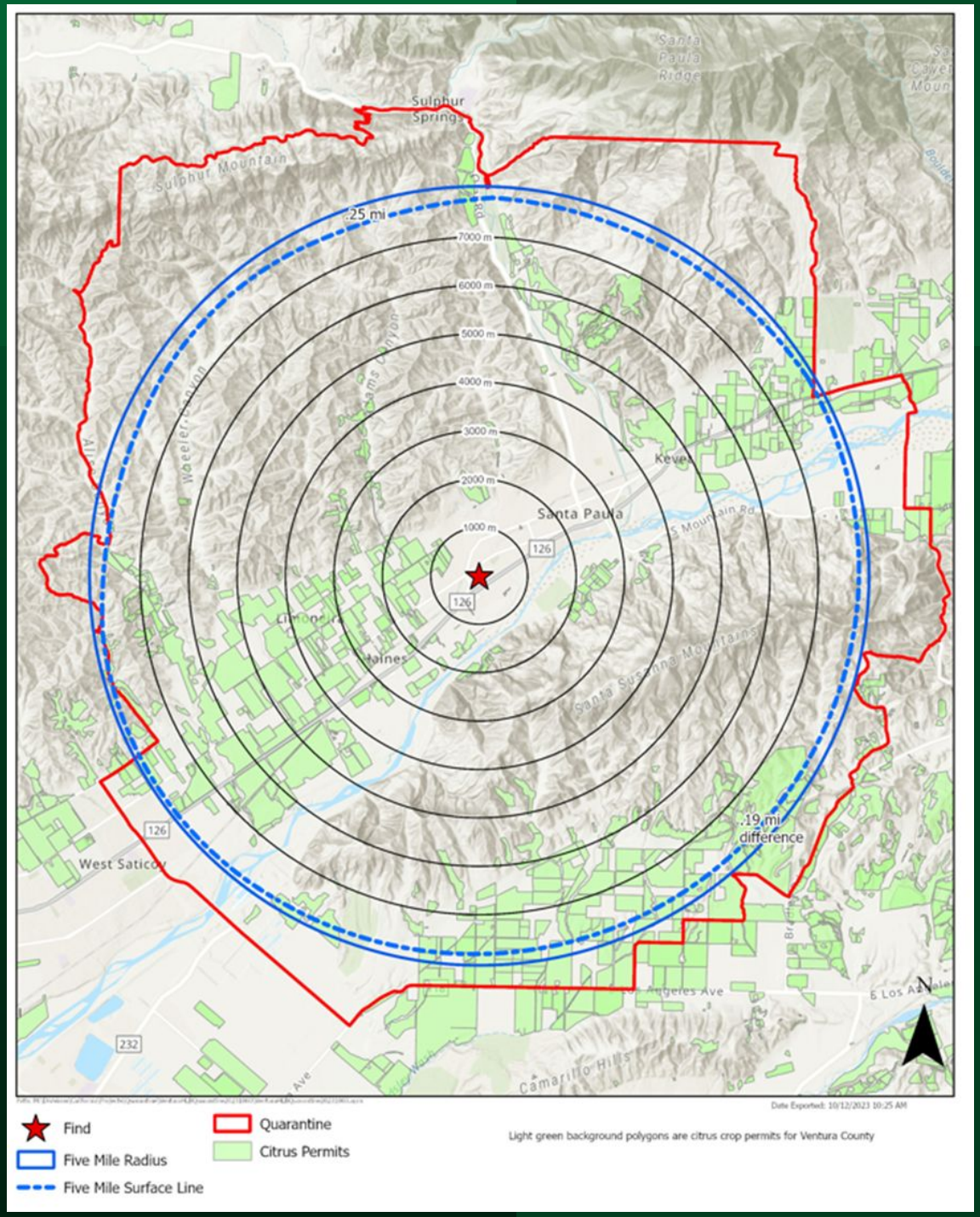


Current scenario: Ventura

- HLB finds
- 5 mile radius
- 250 m delimination

Concerns:

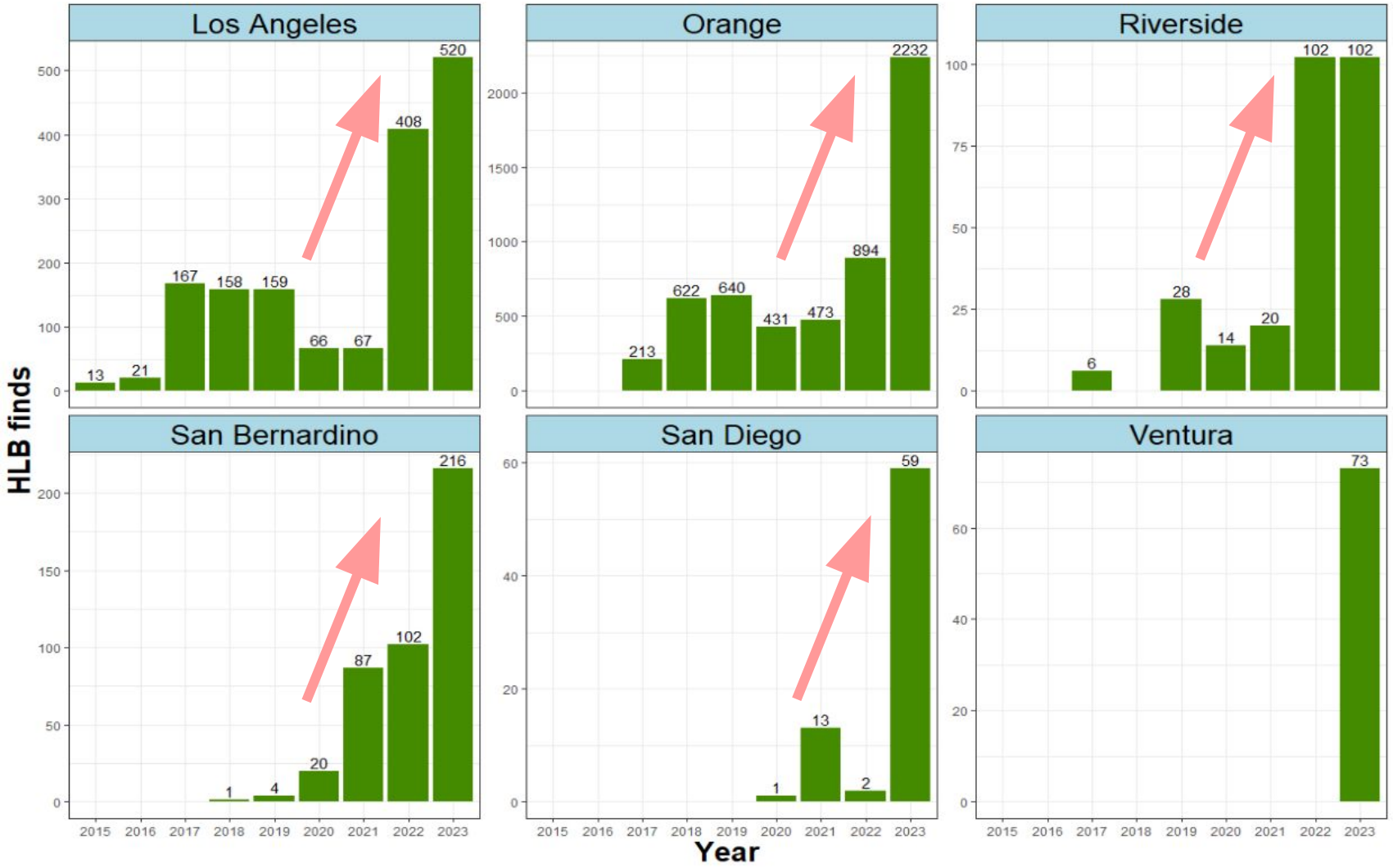
- 5 miles somewhat arbitrary
- No consideration of terrain
- Non-contiguous citrus



HLB detections in Southern CA, 2015 - 2023

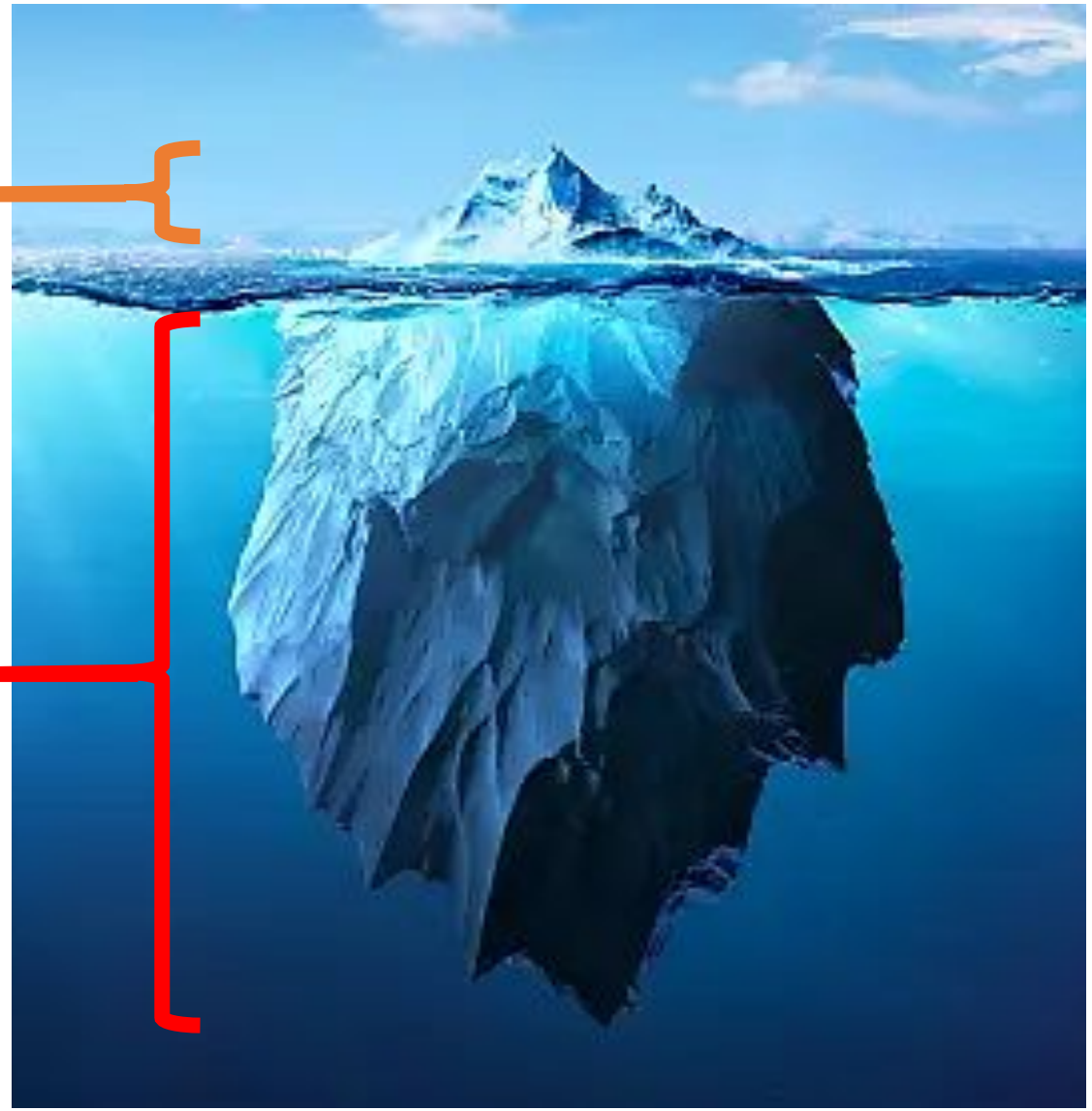
- Dynamic scale for temporal trend identification
- Each panel has its own Y axis

- **Exponential increase phase?**
- **Despite RBS and tree removal**
- **What is the actual HLB situation?**



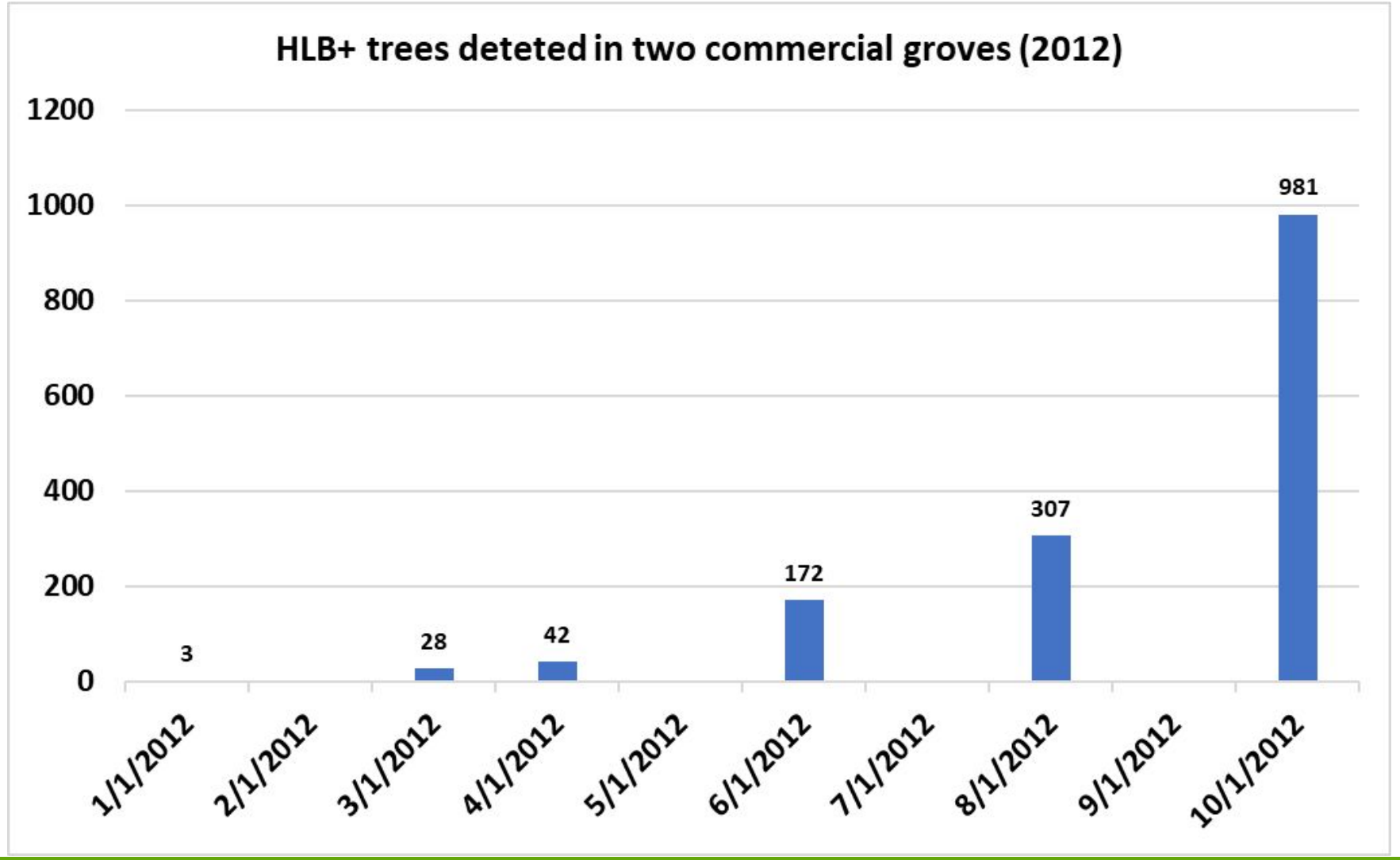
Iceberg analogy

- Symptomatic finds approx. 10% of total reservoir of infected/asymptomatic trees



- 5 mo to 2 yr latency period prior to symptom expression
- 90% estimated as asymptomatic
- BUT: Infectious!!!
- Residential areas are important reservoirs for ACP and CLas in California

Exponential HLB detection in Texas – 7 mo timefrme Less than 10% symptomatic on 1st sampling



Backyard citrus

Estimated 6m trees; approx. 18,000 ha!!!

County	Number of residential properties with dooryard	Estimated number of properties with citrus	Estimated % properties with citrus	Total properties sampled with dooryard citrus	Average tree number per property
LA	1,457,525	924,121	63.40%	43524	1.9
Orange	556,582	231,299	41.56%	13,673	2.17
Riverside	584,710	327,405	55.99%	12,841	3.04
San Diego	554,319	430,599	77.68%	20,916	3.06
Imperial	59,465	37,095	62.38%	1,017	2.39
San Bernardino	498,854	339,952	68.15%	3,920	2.42
Ventura	174,837	109,634	62.71%	12,319	2.4
Total	3,886,292	2,400,105	62%	108,210 (3%)	2.5

Estimated HLB prevalence (minimum and maximum)

Estimated Minimum HLB Prevalence (assuming no spread beyond confirmed HLB+ STRs)

County	2015	2016	2017	2018	2019	2020	2021	2022	2023
Los Angeles	0.1%	0.3%	0.8%	1.5%	2.3%	2.9%	3.0%	4.9%	5.7%
Orange	0.0%	0.0%	3.1%	6.9%	11.0%	13.8%	15.3%	17.8%	24.7%
Riverside	0.0%	0.0%	0.2%	0.2%	0.2%	0.6%	0.7%	1.6%	2.2%
San Bernardino	0.0%	0.0%	0.0%	0.1%	0.4%	0.7%	1.0%	1.2%	1.5%
San Diego	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	0.6%
Ventura	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%

Estimated Maximum HLB Prevalence (assuming up to 5km spread from confirmed HLB+ locations)

County	2015	2016	2017	2018	2019	2020	2021	2022	2023
Los Angeles	2.0%	5.8%	11.0%	13.1%	17.7%	21.9%	23.3%	28.9%	30.6%
Orange	0.0%	1.3%	25.7%	41.3%	47.4%	53.6%	55.1%	58.6%	61.2%
Riverside	0.0%	0.0%	2.1%	2.1%	3.4%	10.7%	13.9%	17.3%	17.4%
San Bernardino	0.0%	0.0%	0.6%	3.1%	7.9%	12.7%	13.3%	14.7%	15.3%
San Diego	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%	4.5%	7.6%	12.0%
Ventura	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.2%

How many hidden HLB+ trees out there?

Estimated 50K to 100K trees HLB infected; 7000 found to date

Estimated Minimum hidden HLB+ trees in the landscape

County	2015	2016	2017	2018	2019	2020	2021	2022	2023	% of total residential citrus tree (2023)
Los Angeles	154	245	2,105	2,757	4,112	5,291	5,543	11,141	15,005	0.79%
Orange	0	0	3,067	4,338	8,372	10,306	11,982	15,139	24,157	4.22%
Riverside	0	0	74	67	342	645	630	1,566	2,210	0.21%
San Bernardino	0	0	0	50	506	820	1,468	2,019	2,824	0.35%
San Diego	0	0	0	0	0	85	251	289	442	0.03%
Ventura	0	0	0	0	0	0	0	0	87	0.03%

Estimated Maximum hidden HLB+ trees in the landscape

County	2015	2016	2017	2018	2019	2020	2021	2022	2023	
Los Angeles	1,326	1,626	6,796	8,063	11,502	13,341	14,219	23,068	31,068	1.63%
Orange	0	36	6,178	10,656	15,656	17,534	20,039	24,706	36,721	6.41%
Riverside	0	0	230	193	845	1,704	1,904	3,682	5,011	0.48%
San Bernardino	0	0	46	387	1,843	3,562	6,589	8,029	10,571	1.32%
San Diego	0	0	0	0	0	169	1,188	1,131	1,710	0.12%
Ventura	0	0	0	0	0	0	0	0	118	0.04%

HLB situation in residential backyards

"Tree removal without vector control,
[which is impossible in residential areas],
makes the Southern California HLB eradication effort immensely difficult, if not totally ineffective"

Dr Mamoudou Setamou, Texas A&M

Mitigation strategies: Residential Backyard

CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE
COUNTY AGRICULTURAL COMMISSIONER'S OFFICE

NOTICE OF INSECTICIDE TREATMENT FOR ASIAN CITRUS PSYLLID

On _____ at approximately _____ A.M. / P.M., your property was treated with the insecticide(s) checked below. If you have any questions, please call the **Project Office** at **(800) 491-1899.**

To learn more about the Asian citrus psyllid, please visit the CDFA website: http://www.cdfa.ca.gov/phpps/acp/

Tempo® SC Ultra (cyfluthrin) is a formulation of a pyrethroid contact inse
controlling Asian citrus psyllid adults and nymphs. This material will be applie
of one time to the foliage of host plants on designated residential properti

Merit® 2F (imidacloprid, a systemic insecticide) applied to the s
signated residential properties. The material is taken up
and provides approximately 12 months of protecti
conditions.

prid, a systemic insecti

Backyard citrus: California
Mandated removal if found
Level of refusals: 20%

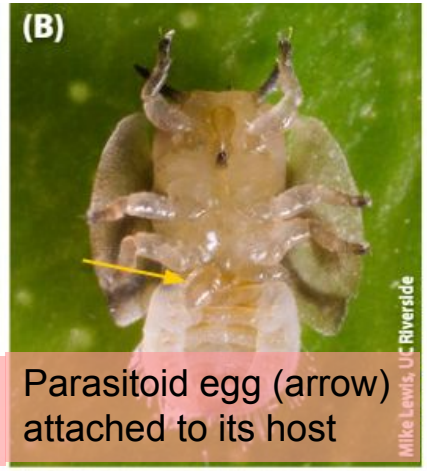
RBS → SURVEY → TRAP → DIAGNOSIS → TREATMENT → CULL

ACP predator: *Tamarixia radiata* [30 to 70% parasitism]

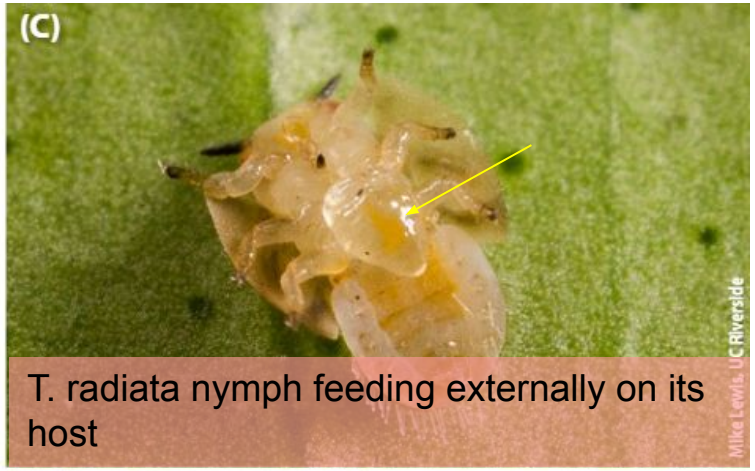
Tamarixia radiata feed ACP through a combination of parasitism and host feeding.

Host-specific ectoparasitoid of fourth and fifth instar ACP nymphs

Female laying an egg underneath a psyllid nymph



Parasitoid egg (arrow) attached to its host



T. radiata nymph feeding externally on its host

T. radiata has established widely in Southern California since releases began in late 2011

https://doi.org/10.3733/ca.2017a0027

Canine detection:

- ACP [some potential?]
- HLB [very disappointing results]

Mitigation strategies: Commercial

Commercial impacts: mitigations/stopgaps

- **Nurseries:** ACP exclusion structures [All regions]
- **Spray and move** [CA]
- **Tarping** [CA]
- **Regional areawide** treatments in SJV upon ACP detection
- **Truck Fumigation options** being registered [CA]
- **ACP Exclusion bags** [FLA/TX]
- **CUPS** [FLA]
- **Trunk injections** [FLA]
- [**Trap crops**: Murraya --- no!]

Nurseries: ACP exclusion compliant nurseries: FLA, CA, TX, MX

Commercial: Mitigations --- harvesting and transport

1. Spray and harvest [Shooting limited bullets; repeated sprays in lemons; 14 day]
2. Field cleaning by machine
3. Grate cleaning (with approval)
4. Wet wash in packinghouse: not always within area

Safeguarding in transit – always required and is not considered a mitigation

Spray and Move/Tarping

Tarping of bins during hauling from field to packinghouse

Ongoing efforts:

Fumigation using Ethyl formate

In process of registration

ACP exclusion bags [Texas] -- growing a root system

Citrus Under Protective Screen (CUPS)

- >$125K per hectare!
- Test Facility in TX

Trunk injections: Oxytetracycline

Chemjet trunk injection system: Xylem

Trecise trunk injection system: phloem

Efficacy and residual trials ongoing to register OTC for use in Texas grapefruit.

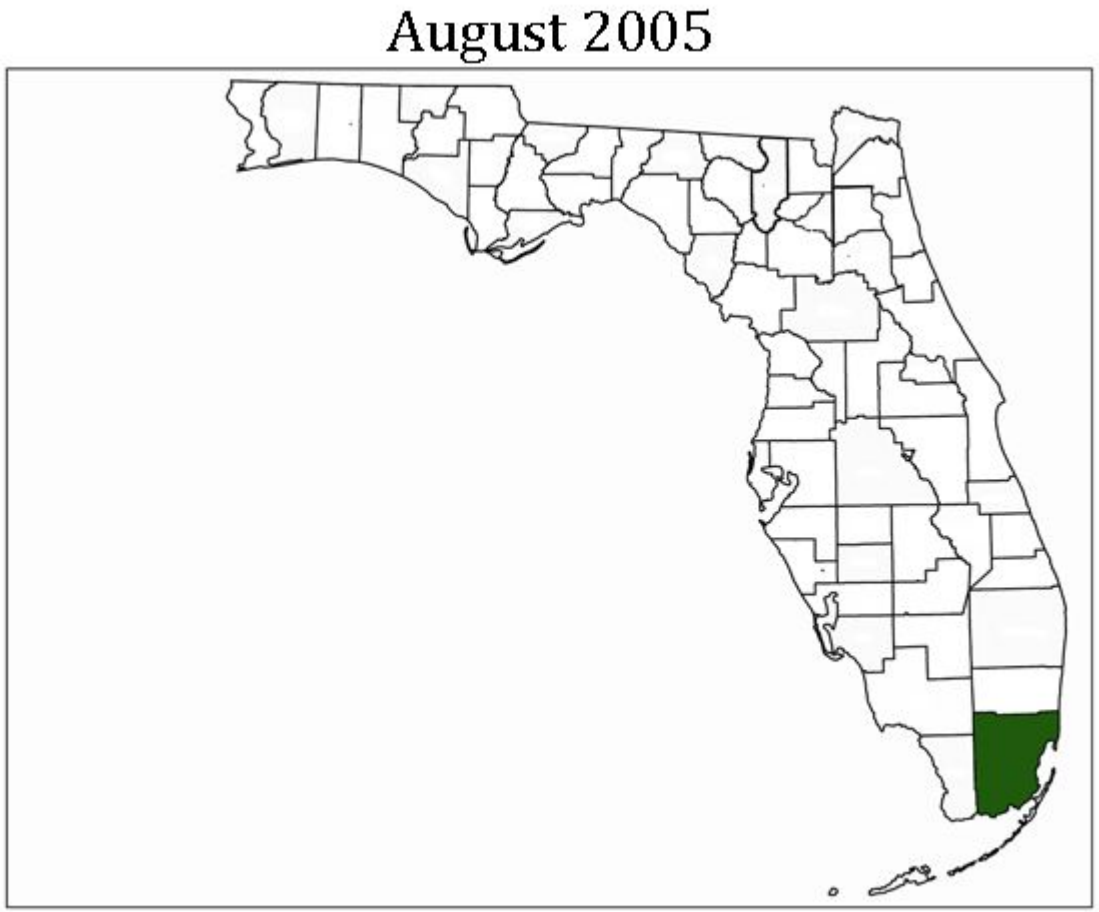
Commercial impacts: mitigations/stopgaps

- **Nurseries:** ACP exclusion structures [All regions]
- **Spray and move** [CA]
- **Tarping** [CA]
- **Regional areawide** treatments in SJV upon ACP detection
- **Truck Fumigation options** being registered [CA]
- **ACP Exclusion bags** [FLA/TX]
- **CUPS** [FLA]
- **Trunk injections** [FLA]
- [**Trap crops**: Murraya (orange jasmine/Curry leaf) --- no!]

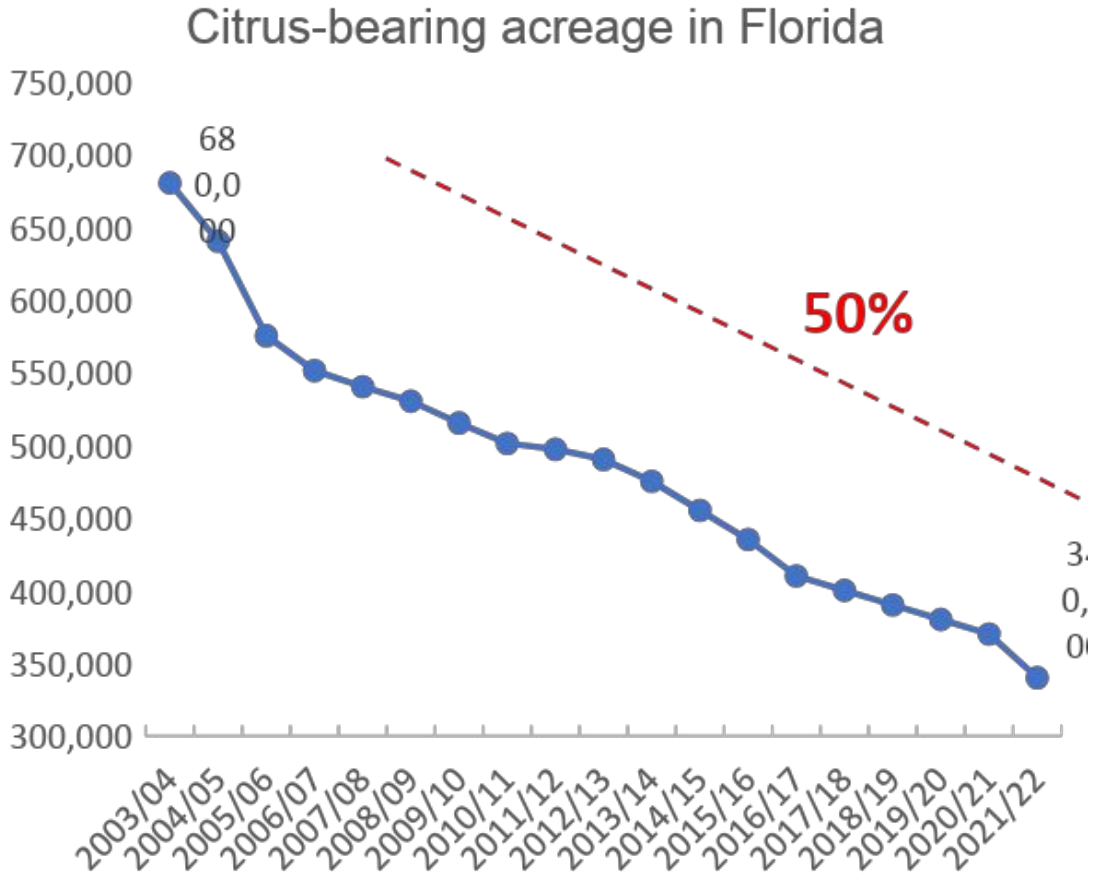
HLB: Florida

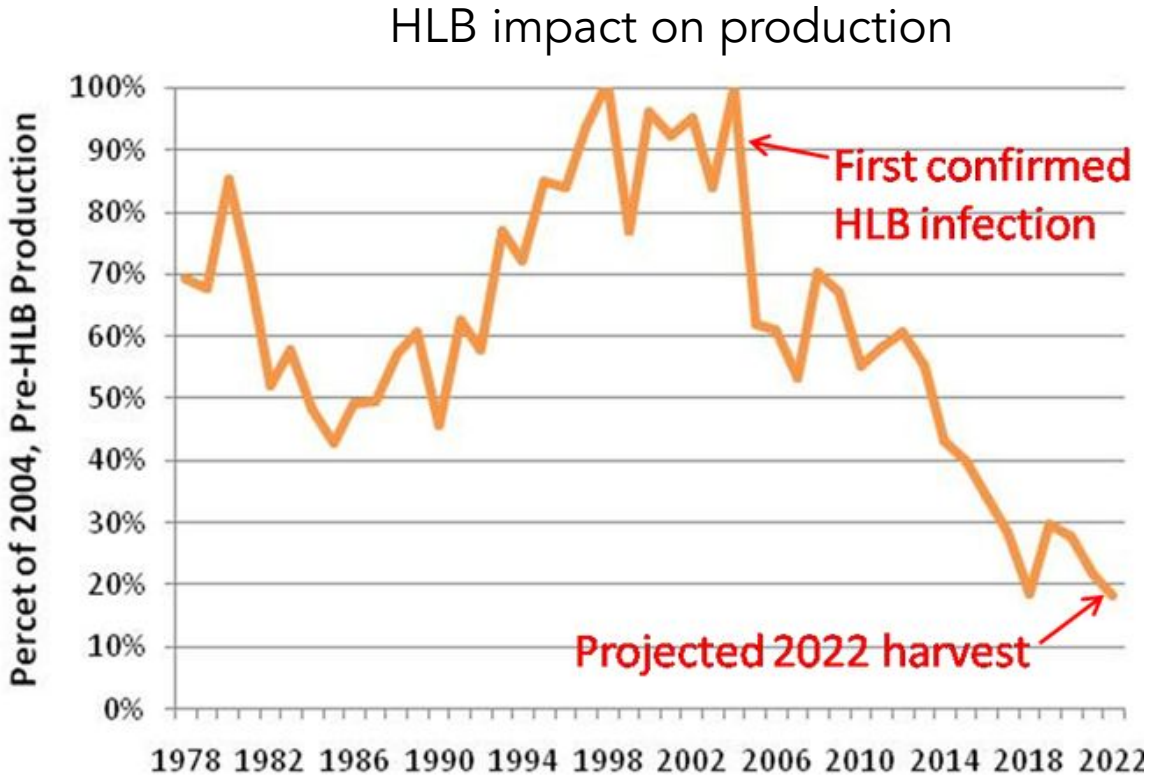
Florida: HLB

HLB spread throughout Florida within 5 years of initial detection



Florida: citrus bearing acreage [40% acreage decline; yields 20%]





HLB: Texas

HLB in Texas : Snapshot

9 yrs from ACP detection to HLB finds

ACP detection in Texas

2001

Area-wide control program for ACP

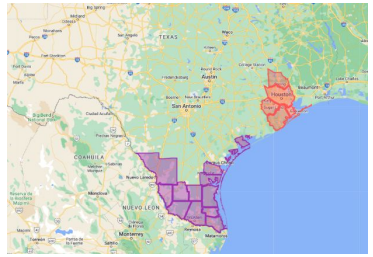
2010

HLB detection in citrus trees

2012

Enclosed nursery regulation

2014



Quarantine regions

2023

2006

Statewide monitoring efforts for early detection of CLas in ACP and in citrus trees

2011

First CLas-infected ACP

HLB management:

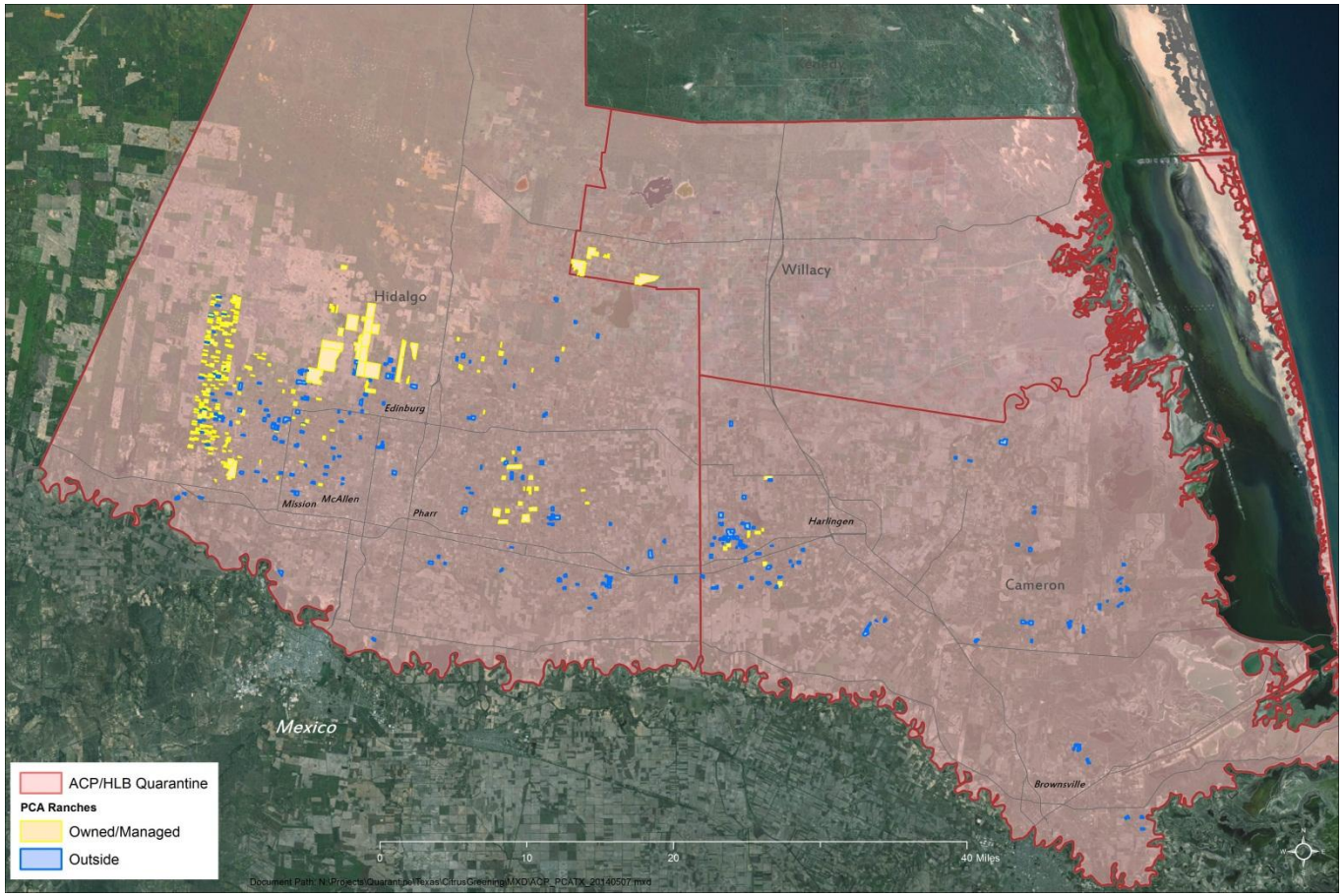
- Vector control
- Infected trees removal
- Disease-free nursery production

2021

HLB Endemic

(Feb freeze)

Texas: Entire citrus region is in an HLB quarantine zone

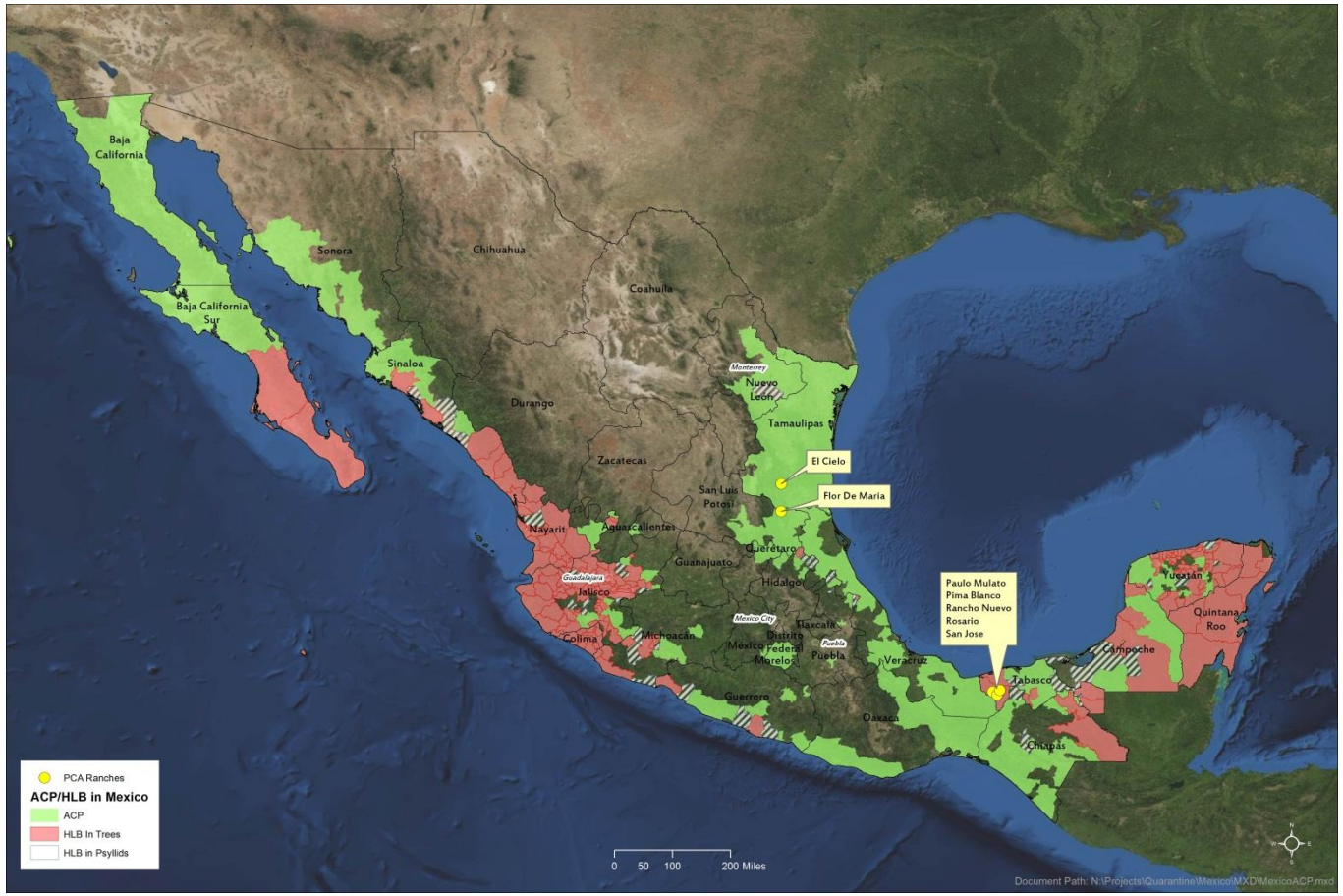


- All citrus ranches and packinghouses now located inside HLB quarantine zone
- Industry working with Texas Dept. of Ag. to relax rules regarding tarping of trucks, notification of harvest, pre-harvest inspections, and psyllid traps
- Many trees in zone propagated outside of insect resistant screen structure – these trees have a higher risk of HLB infection

Texas: new planting design

HLB: Mexico

Mexico: ACP endemic in all citrus regions; HLB detected in most regions



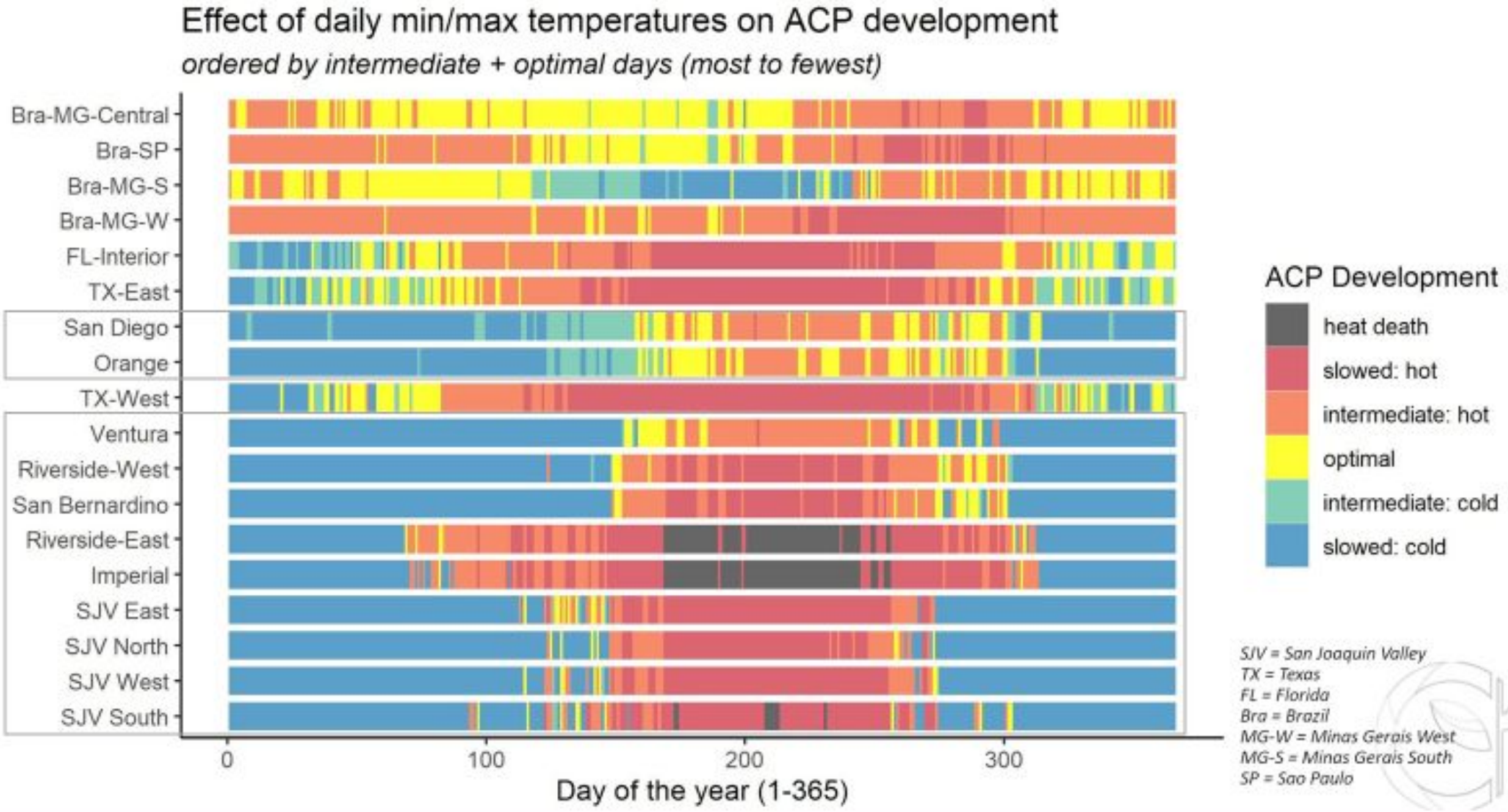
North (Flor and Cielo)

- Relatively isolated; Flor totally; can "protect" ourselves
- Currently aggressive ACP program, resulting in other pest flare-ups

South

- Surrounded by neglected orchards
- Historically no ACP control; being instituted now with program to minimize other pest flare-ups
- Young, new plantings aggressively treated but older plantings without irrigation and with low tree population less aggressive

Climatic effect


Effect of daily min/max temperatures on ACP development
ordered by intermediate + optimal days (most to fewest)
Bra-MG-Central
Bra-SP
Bra-MG-S
Bra-MG-W
FL-Interior
TX-East
San Diego
Orange
TX-West
Ventura
Riverside-West
San Bernardino
Riverside-East
Imperial
SJV East
SJV North
SJV West
SJV South
0
100
200
300
Day of the year (1-365)
ACP Development
heat death
slowed: hot
intermediate: hot
optimal
intermediate: cold
slowed: cold
SJV = San Joaquin Valley
TX = Texas
FL = Florida
Bra = Brazil
MG-W = Minas Gerais West
MG-S = Minas Gerais South
SP = Sao Paulo

Future?

The future……?

- California: climate an ally (especially Central Valley), hot dry/low RH, no summer rain, easier to control vector
- Florida: ACP heaven; packinghouses, juice plants closing
- Texas: fighting chance; lower RH, higher summer temps; still problematic
- Mexico: WC less issues (lemons and limes); seems like at an inflection point
- Brazil also at tipping point? (indiscriminate frequent sprays proved unsustainable)

Concerns going forward: road ahead for California

- Costs: can it be maintained?
- Some feel-good actions: not always scientifically justified
- Fruit movement: spray and move; shoot limited chemical bullets; sometimes multiple sprays
- Tree removal in residential hotspots: unsustainable (7000 trees over 12 years; high expense; large area to survey; inadequate); reservoir of 18K ha; 6m trees
- Tree removal without vector control (not possible) of limited value
- Focusing more on commercial/residential interface
- $1.5 plus billion dollars spent [Federal, State and Grower spend]: solution box is empty

BUT: water and labor ---- availability and costs are higher concerns to sustaining a profitable industry than what HLB currently presents

Message for Australia?

- Diligence: proactive knowledge gained from other regions can be implemented
- Security of plant material movement
- Border/airport security for travelers, especially from certain regions
- Climate: an ally for most regions (South: hot, low RH, some cold; QLD? May resemble TX; fighting chance)
- Australia will not be overrun by an ACP nor HLB epidemic; your eyes already wide open
- Growers will need to proactively organize: control own destiny
- Be concerned but not paranoid