Huanglongbing management in the United States – Perspectives from Florida, Texas, and California

Megan M. Dewdney, Mamoudou Sétamou, David Laughlin, and Neil McRoberts

University of Florida, Texas A&M, Kingsville, UC Davis

Commonly used abbreviations

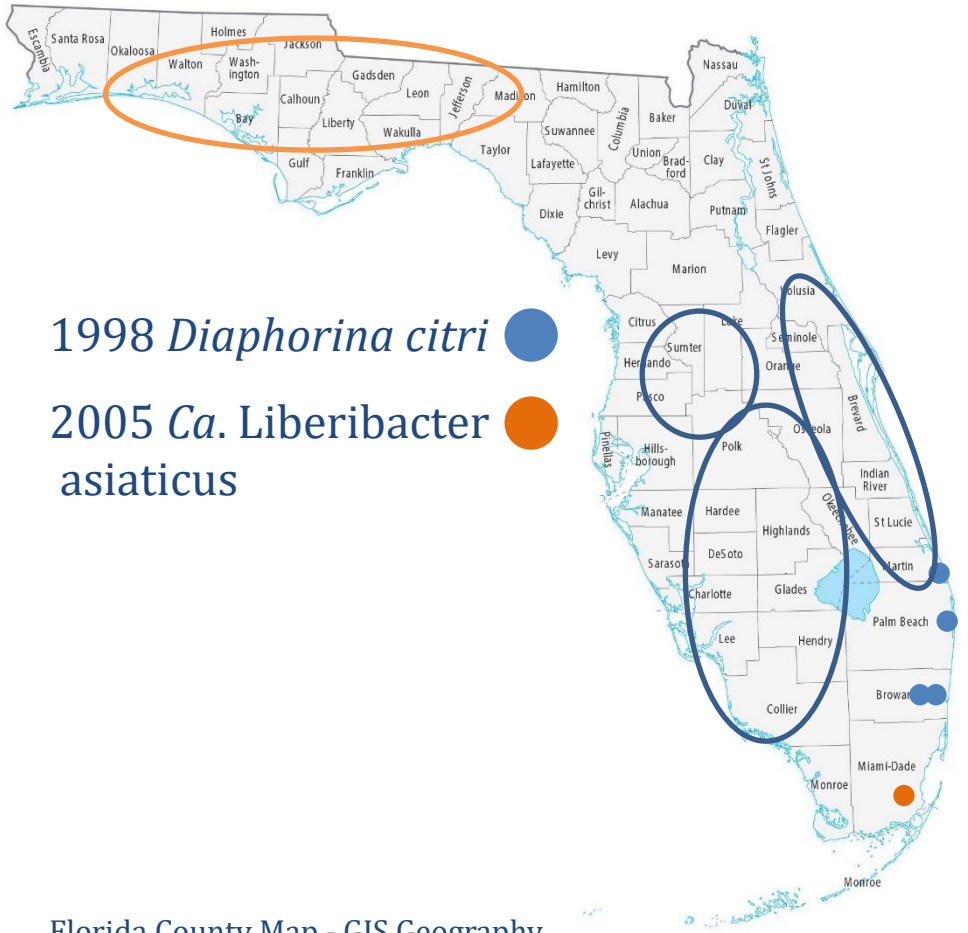
- ACP – Asian citrus psyllid (*Diaphorina citri*)
- HLB – huanglongbing; citrus greening
- CLas – *Candidatus* Liberbacter asiaticus
- IPC – individual protective cover
- CUPS – citrus under protective cover

FLORIDA – MANAGEMENT IN HIGH DISEASE PRESSURE

UF
UNIVERSITY of FLORIDA

Arrival of the vector and disease

- Asian citrus psyllid was first detected in Florida in 1998
  - After initial find, it was found in multiple Southeastern counties
- Huanglongbing was first detected in 2005
  - Initial find was south of Miami
  - Soon detected up east coast to Martin County and to the northwest
  - Entered major citrus production areas before we knew it



Florida County Map - GIS Geography

What has happened in Florida

Production has fallen from a high of 250 million boxes to 16.1 million boxes

Trees near the beginning of the epidemic

Trees 12 years after the discovery of HLB

Initial response to scout and remove trees

- Started scouting commercial groves
  - Found it was widespread in southern regions
- Scouting challenging because trees able to spread disease before easily visible symptoms
- Many growers found this unpalatable
  - Recent failure of canker eradication
  - Perceived as high economic loss

2004 - 2018: Intense ACP chemical management

Neonicitinoid soil drenches for young tree protection

Calendar sprays for psyllids

Taming the beast: ACP management attempt

- Area-wide management
  - Citrus Health Management Areas (CHMA) or area wide management
  - Regional CHMAs throughout state; Required growers to **WORK TOGETHER** for the management of a this highly mobile pest
  - Goals: Reduce population by minimizing movement between groves, slow development of pesticide resistance in psyllids
  - CHMAs would coordinate to apply insecticides during the same application windows
- Good idea, but without full buy in and a solid economic return, it could not last

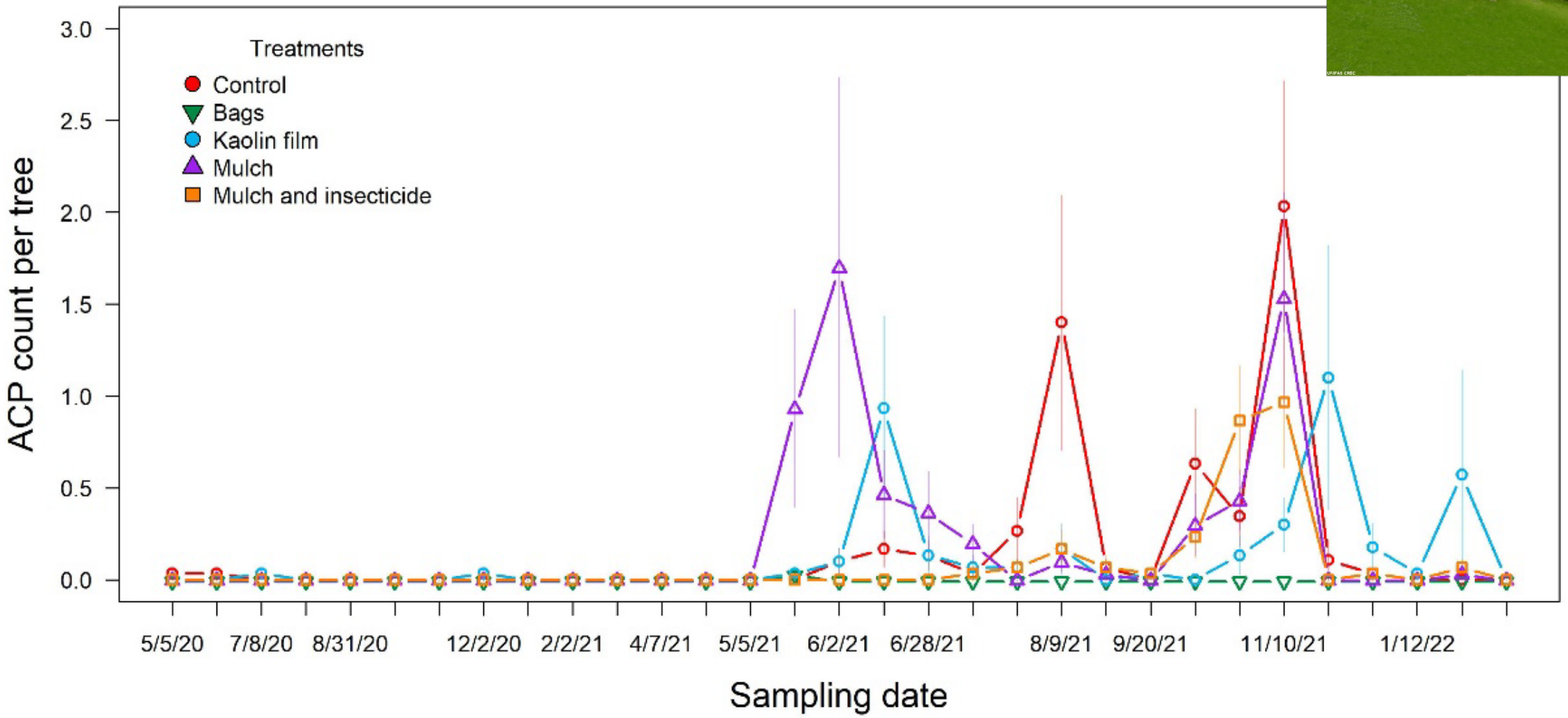
Current ACP management

- Number of sprays and what is sprayed depends on market and individual growers
  - Fresh market is not tolerant of imperfections, need to keep trees clean to have marketable fruit
  - Juice market (most of central FL) tolerates visual imperfections, juice quality is impacted by HLB
- Need to return to IPM
  - See an increase in pests previously managed effectively with biocontrol
  - Need to re-establish natural enemy populations

Young tree protection

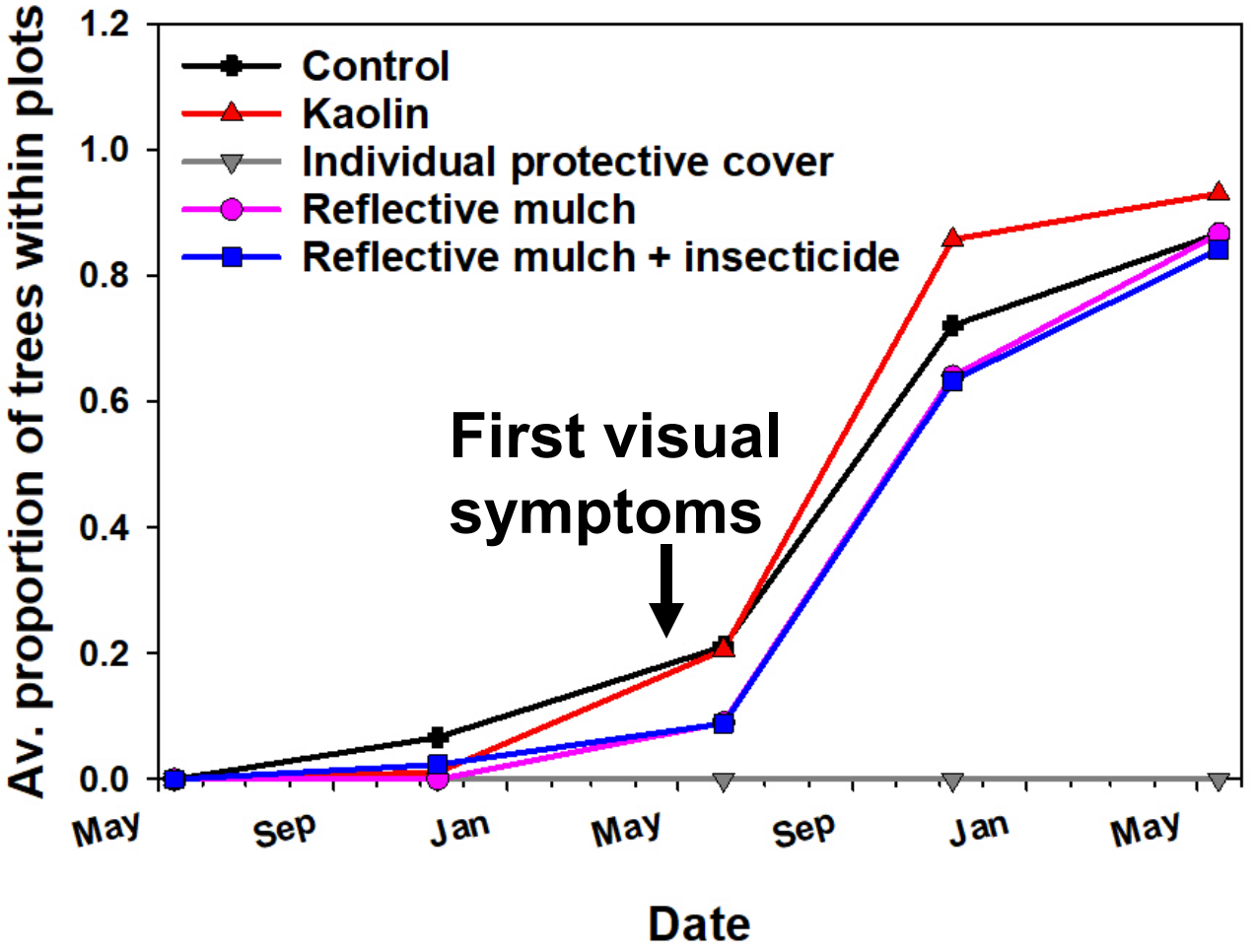
- Experiment comparing
  - IPCs (nets over individual trees)
  - reflective mulch with monthly insecticide application
  - reflective mulch with insecticide applications based on damage
  - red dyed-kaolin clay
  - monthly insecticide (grower standard)

Asian citrus psyllid



Trees with *Ca*. Liberibacter asiaticus

- First PCR detection in December 2020
- Fewer detections in reflective mulch treatments initially
  - Approach control levels by June 2022
- No detection in IPC trees



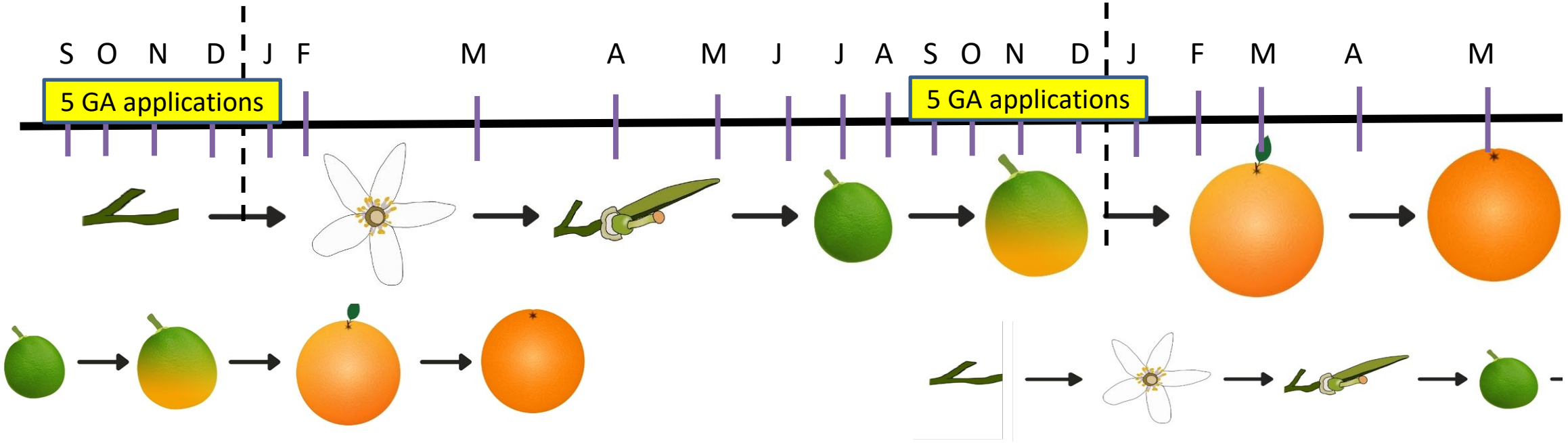
Canopy density

- CLas titer is highly variable within tree and between trees
  - Titer usually found to be unaffected by treatments even if other variables show improvement
- Canopy density recently shown to be good predictor yield
- Can distinguish between levels of tree health
- Associated with fruit drop prediction
- Finding ways to use cell phones or digital cameras to take measurements

Levy et al. 2023

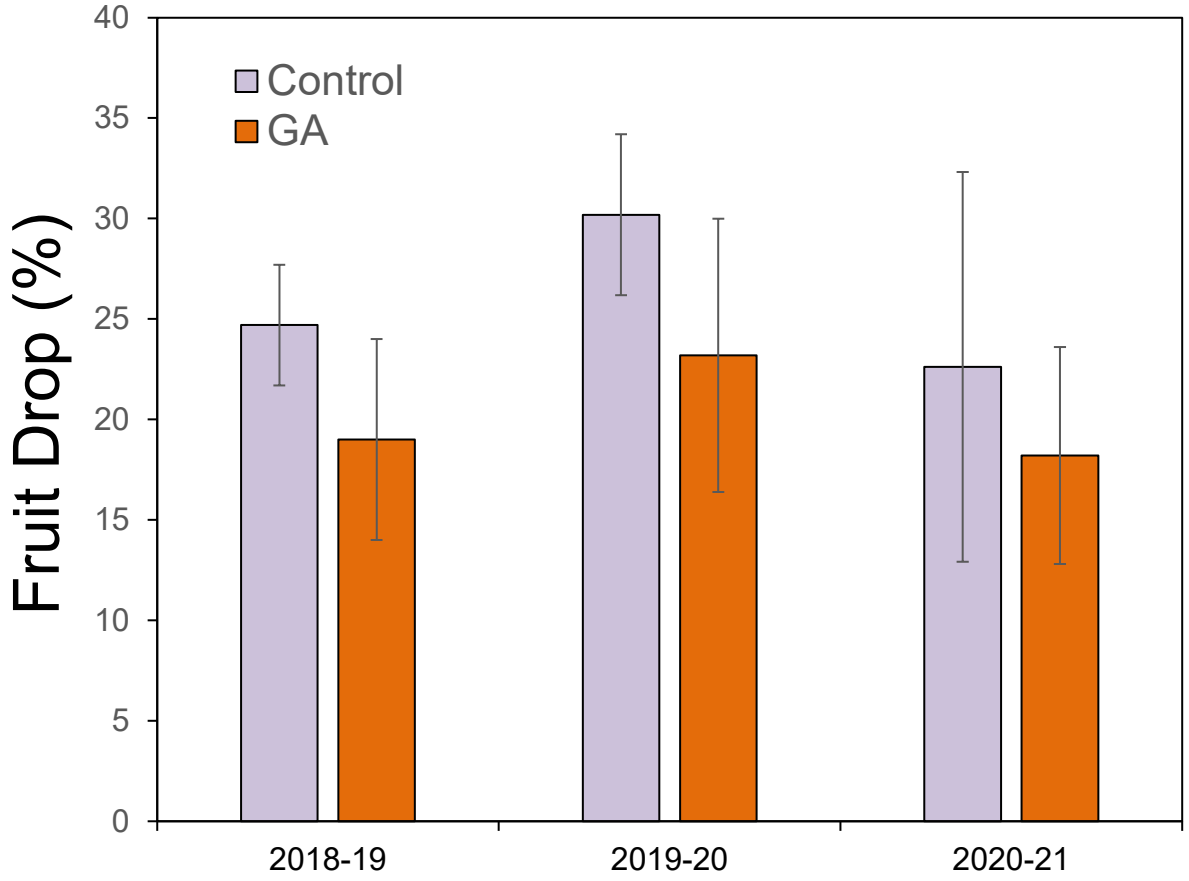
Valencia orange field study (2016-2021)

- 10-year-old ‘Valencia’ on Swingle
- Gibberellic acid applied monthly from September to January
  - 0.72 L per ha (Progibb LV plus) + 0.125% surfactant (Induce)
  - 3.78 L per tree spray volume



Gibberellic acid-treated trees drop fewer fruit

Valencia orange field study (2016-2021)



Gibberellic acid increased fruit yields compared to untreated plots

Due to changes in grove management, soil pH dropped below 5.5

Treatment	Fruit yield (lb/tree) per yea				
	2016-17	2017-18	2018-19	2019-20	2020-21
Control	99	213	209	163	119
GA	**172**	**255**	**282**	**207**	**169**
p-value	0.2	0.15	0.02	0.10	0.07

Increase in number of GA applications

Trees treated with multiple Gibberellic acid applications produced more fruit

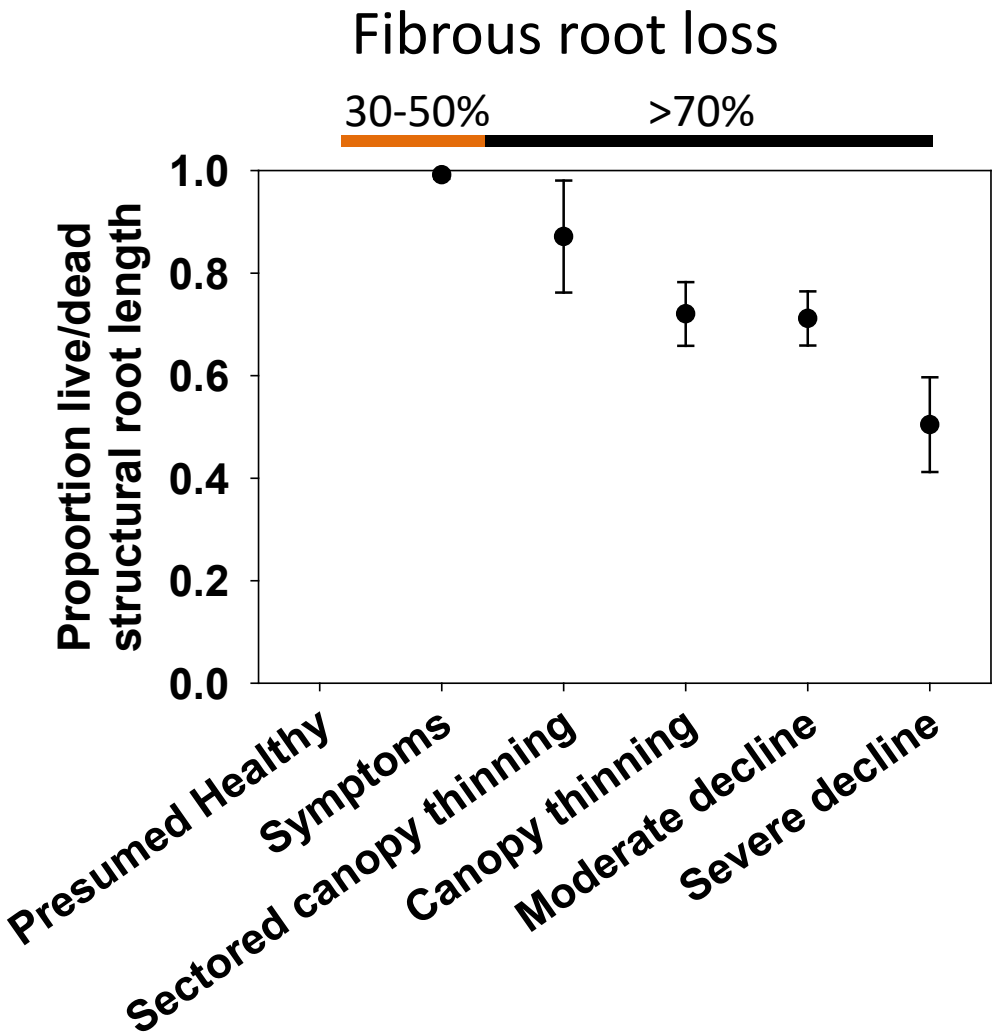
4-year average

	pounds/tree	Boxes per tree	p value
Control	176 b	1.9	0.06
GA	228 a	2.5	

Extrapolation
(150 trees/acre)

	Boxes per acre
Control	293
GA	380

HLB Structural root loss



Ridge root system

30-50% root loss

>70% root loss

What about nutrition?

- Nutrient use by HLB-affected trees is clearly different compared to healthy trees
  - Difficult to pin down exactly what changes when trees affected because effects are highly variable
  - Would need localized study
- We have found that foliar nutrition does not sustain, must be paired with soil applied nutrients
  - Trees need to have continuous nutrition rather than a few times per year
  - Irrigation needs to be tailored for HLB-affected trees
- Nutrients that have shown to have some effect on tree health include Manganese, Boron, Iron

CUPS production

- Only for fresh fruit
  - Too expensive for juice production
- Structures must be designed for hurricanes
  - Depending on location some still damaged
- Very high-quality fruit produced
  - Find different pest and disease pressures in structures than outside

Oxytetracycline injection

- Registered as injection for the first time this year in Florida
  - Widespread use this spring but no noticeable changes in canopy health so far observed
  - Previously available as foliar application; little discernable effect
- Only reported treatment to improve the Brix/Acid ratio
  - Fruit drop is reduced and fruit size increased
  - Other treatments showing improvement often increase fruit size
- Long term efficacy unknown
- Other countries have tried and stopped because of phytotoxicity within trunks

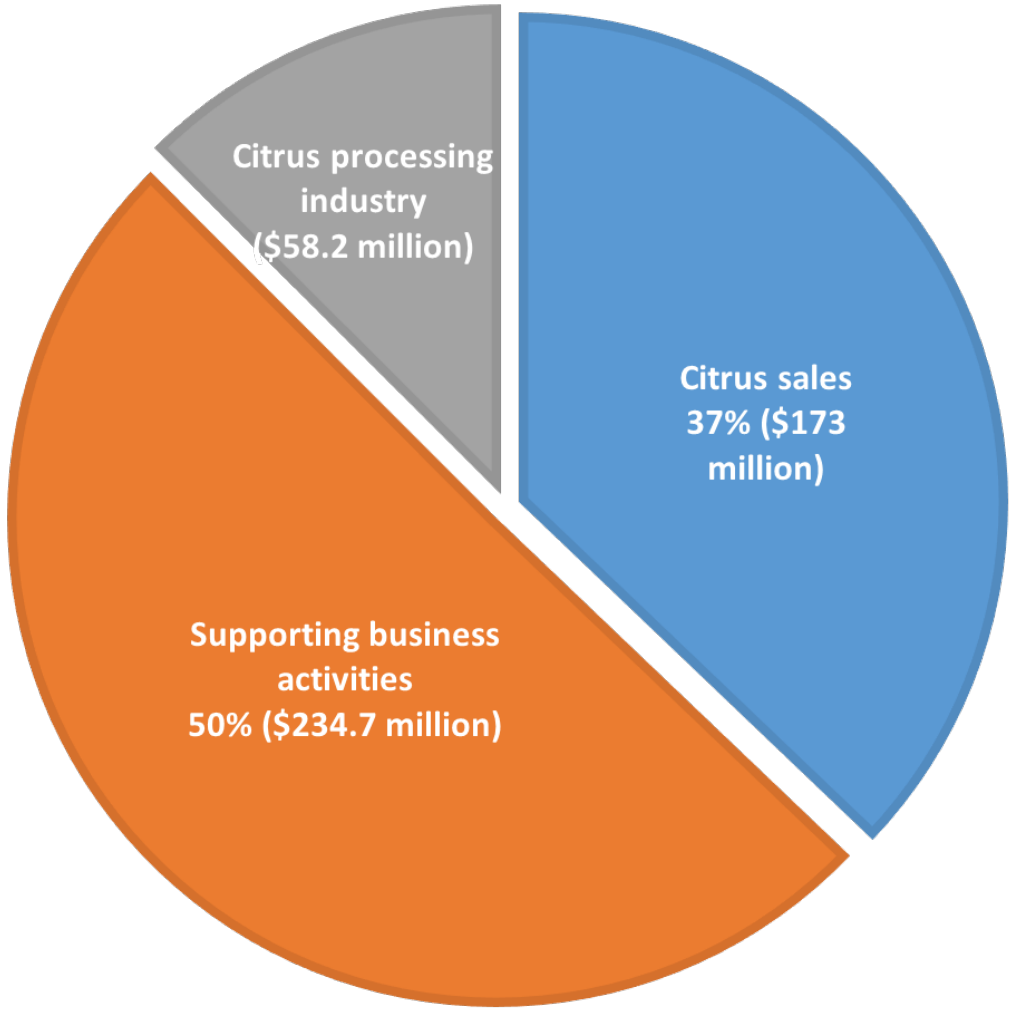
THE HLB SITUATION IN TEXAS – MODERATE DISEASE PRESSURE

Mamoudou Sétamou and David Laughlin
mamoudou.setamou@tamuk.edu;
david.laughlin@tamuk.edu

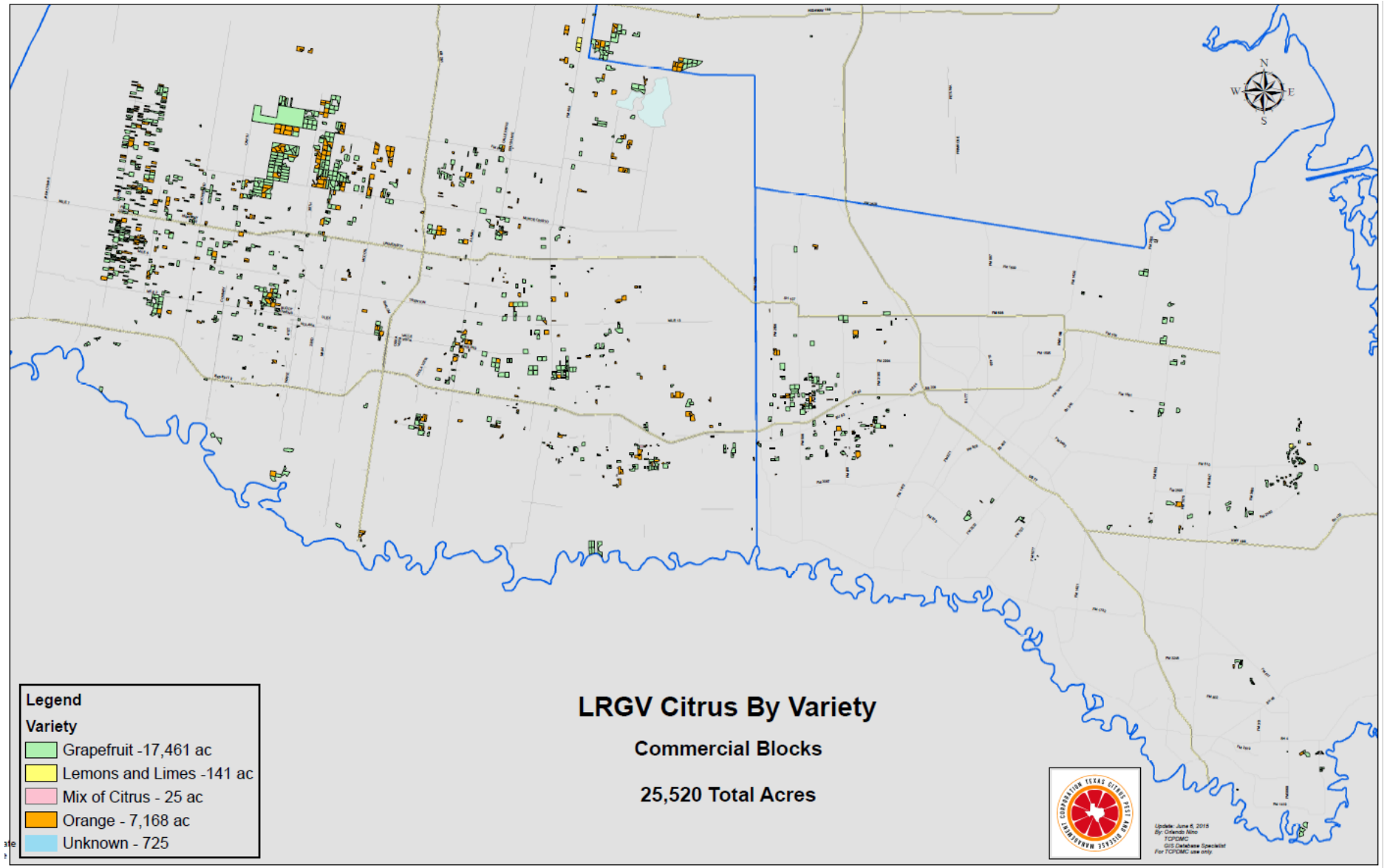
TEXAS A&M UNIVERSITY KINGSVILLE®

The Texas citrus economic value

- Acreage
  - 10.3K ha (Pre-freeze in 2021), ~8.9K ha now
- Composition
  - 65% grapefruit
  - 30% oranges
  - 5% other spp.



The Texas citrus production zone



Background: Timeline of HLB epidemics and management in Texas

ACP detection in Texas

2001

Area-wide control program for ACP

2010

HLB detection in citrus trees

2012

Enclosed nursery regulation

2014

HLB endemic in bearing groves

2020

2006

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

2011

First CLas-infected ACP

HLB BMPs:

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

2017

- Voluntary tree removal in bearing groves
- Young grove program

2021

Winter freeze

- 3,000+ ac lost
- Recovering groves
- **Novel planting design**

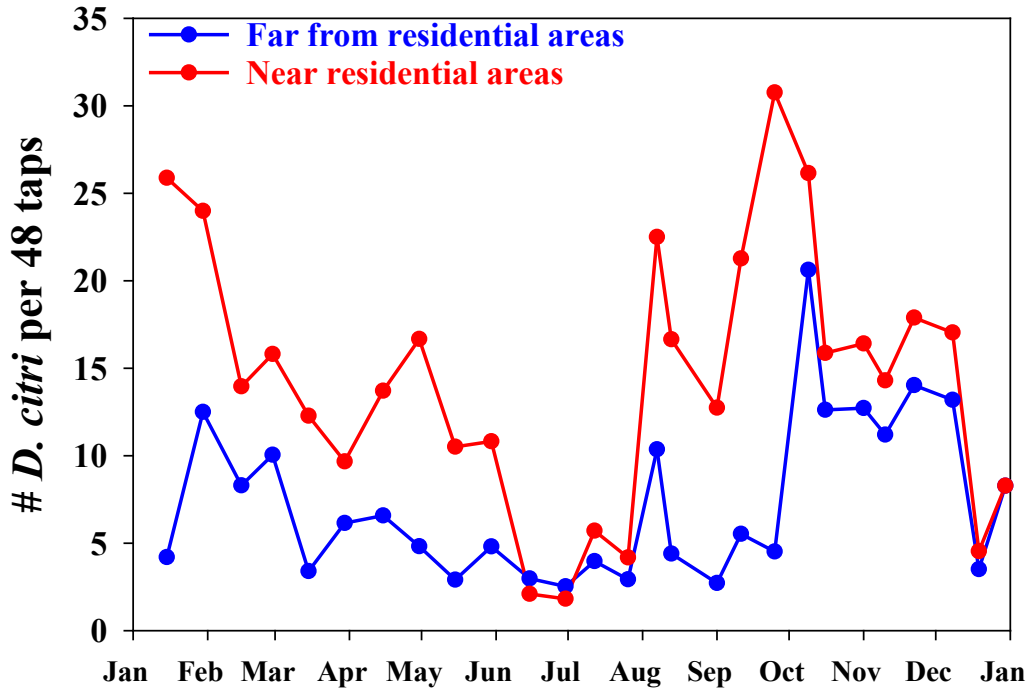
Phase I | **Phase II** | **Phase III**

Cultural aspects of HLB epidemics

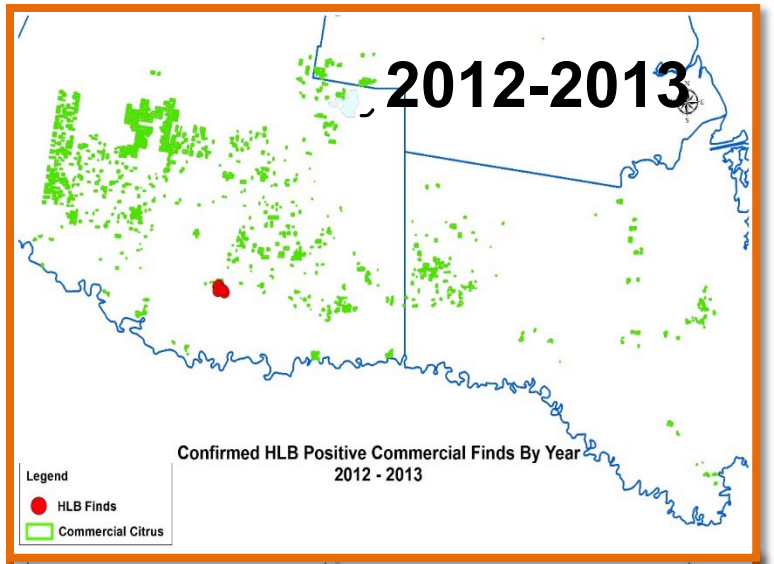
- Urban rural interface
  - A concern around USA
- Residential citrus represents ~25% of commercial trees
  - 1-30 trees per residence; mean = 4
- Residential trees a possible source of CLas and ACP grove re-infestation

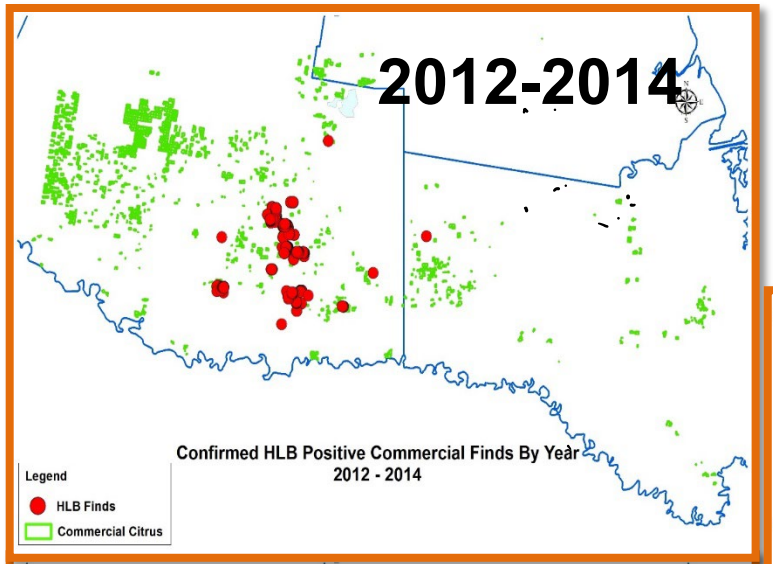
Residential citrus amplify ACP populations in adjacent groves

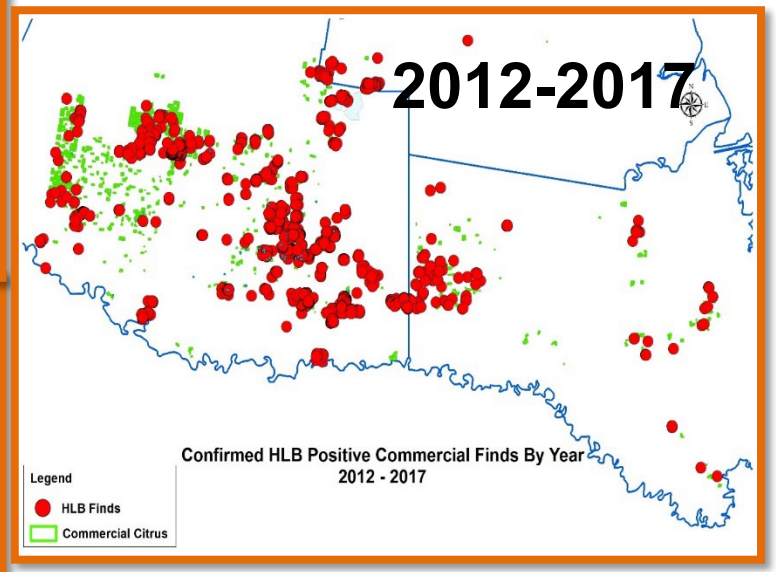
- Groves close to residential citrus had higher ACP populations possibly due to constant re-infestations
- ACP management in groves impacted by residential citrus and unmanaged groves

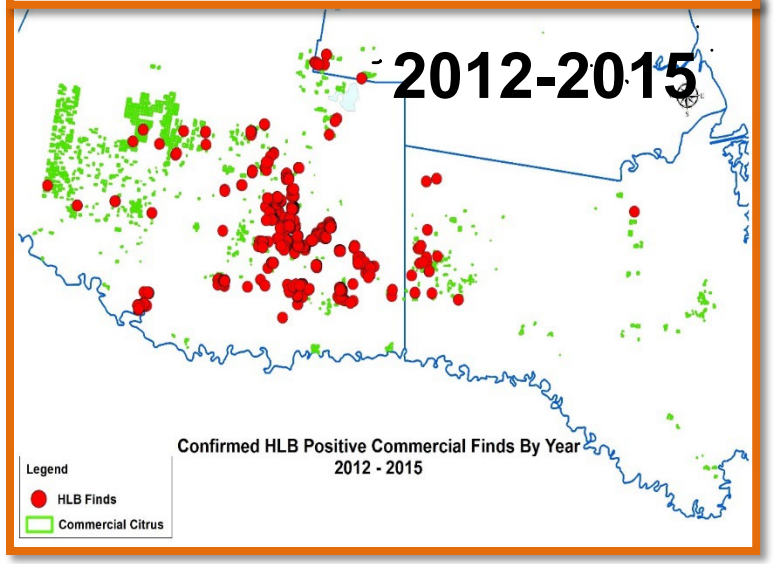


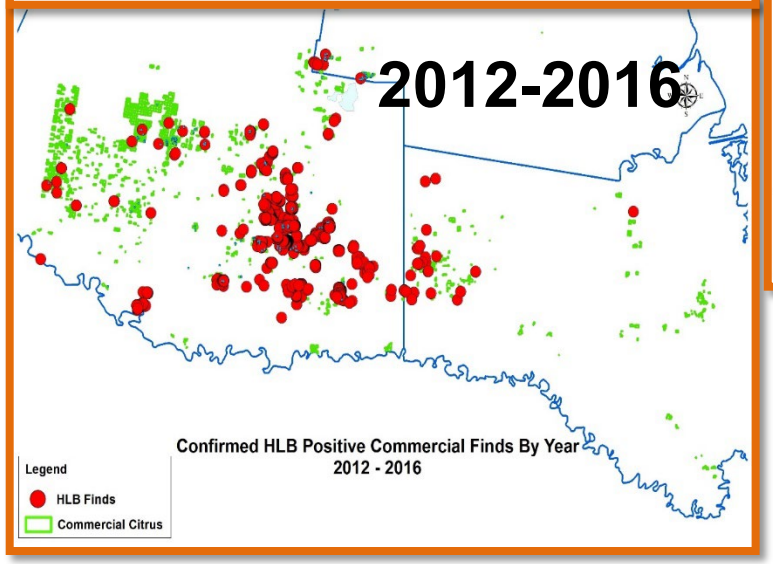
Texas HLB situation: commercial groves





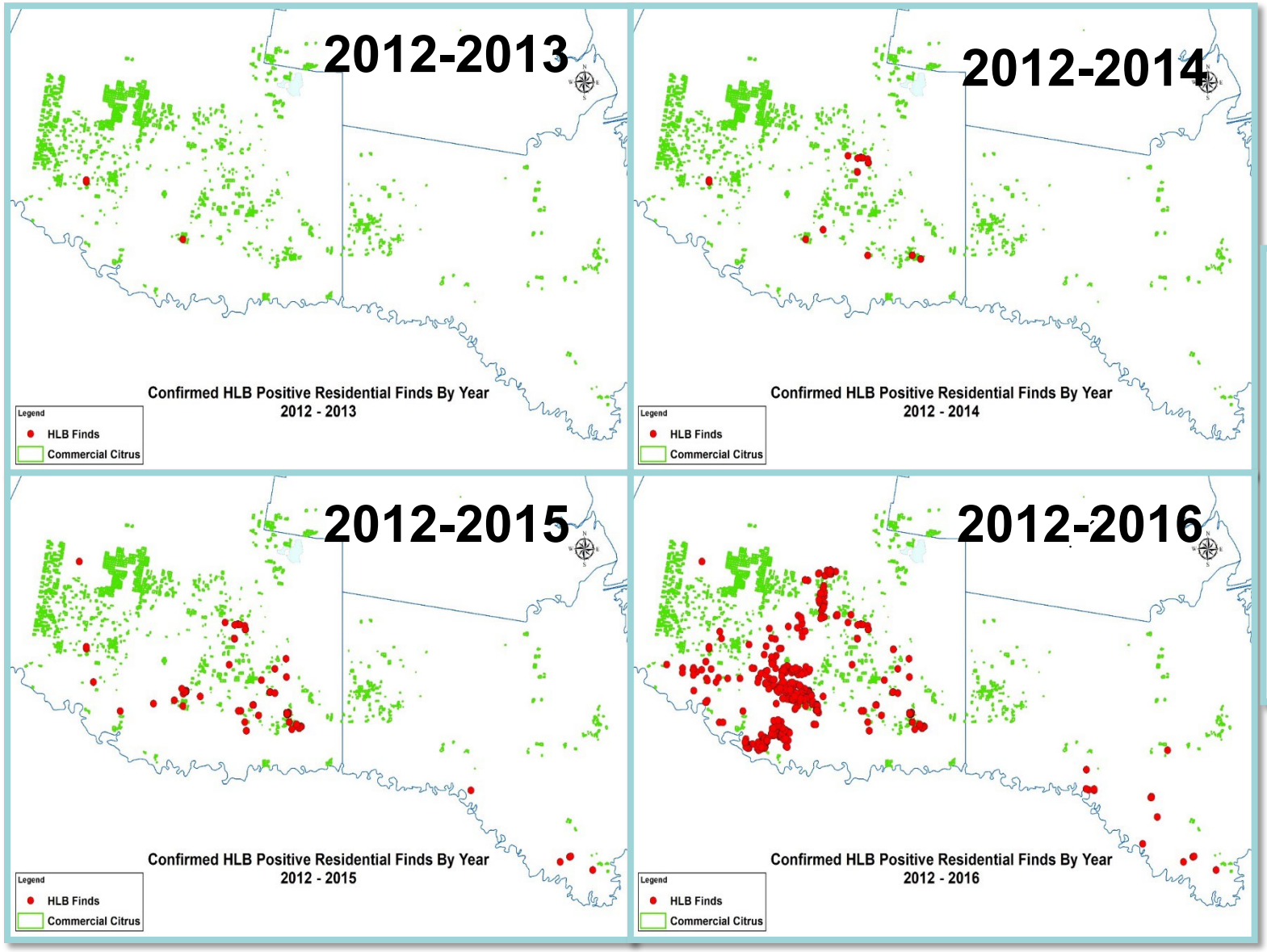


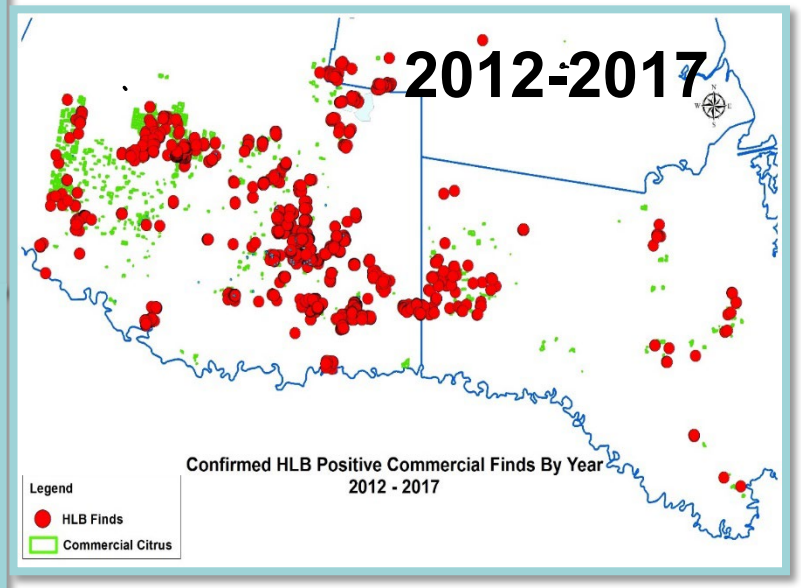




positive sites

Texas residential HLB situation





● positive trees

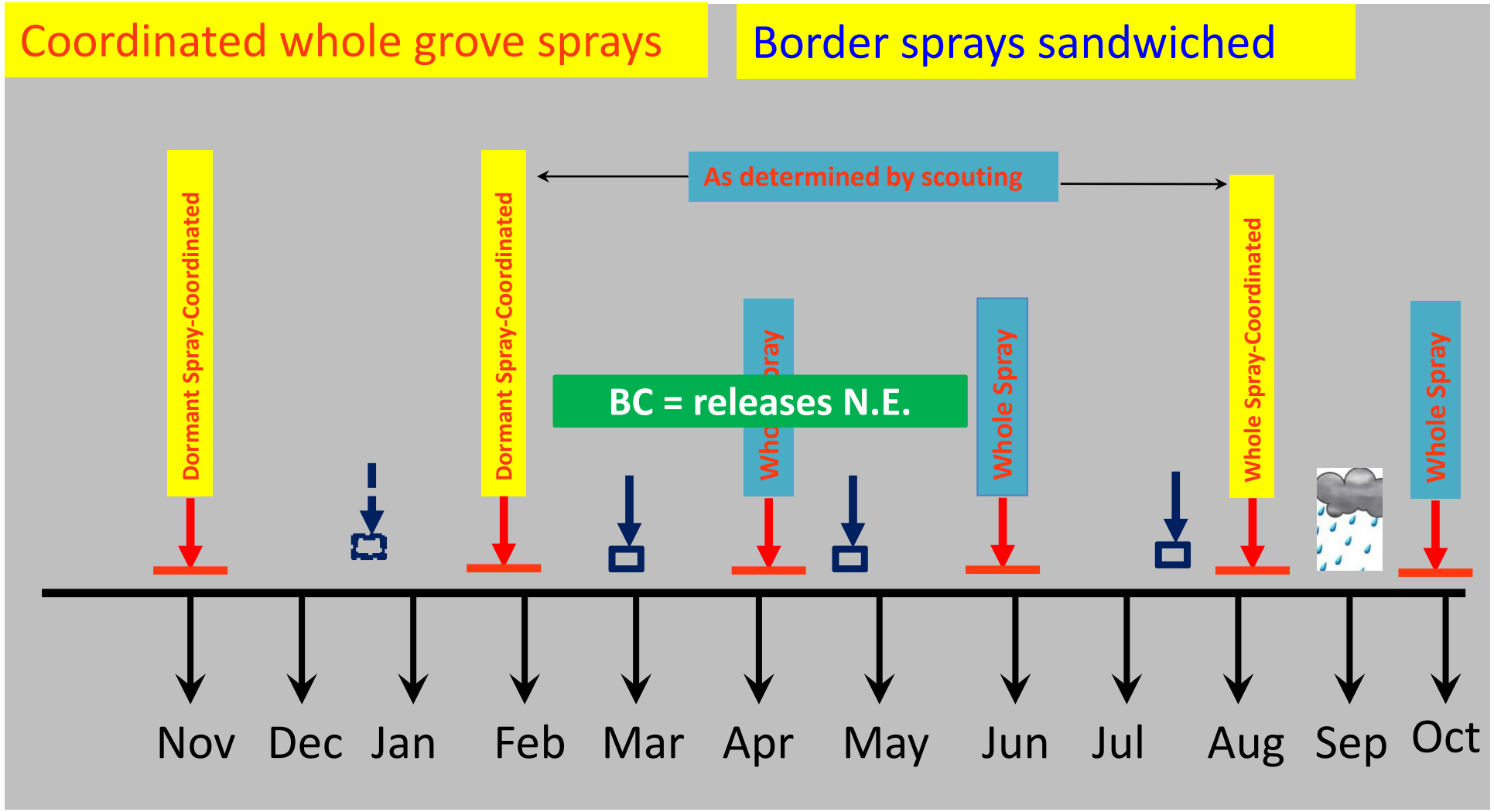
Paradigm change in ACP control

- 2017: Tree phenology and ACP infestation became the trigger for ACP control during the season
- Flush cycles control ACP population dynamics
- Young flush shoots enhance both CLas acquisition and transmission (Hall et al., 1996; Setamou et al. 2016)
- Phenology-based control achieved same level of control as threshold-based in our field experiments

Implementation of phenology-based management of ACP

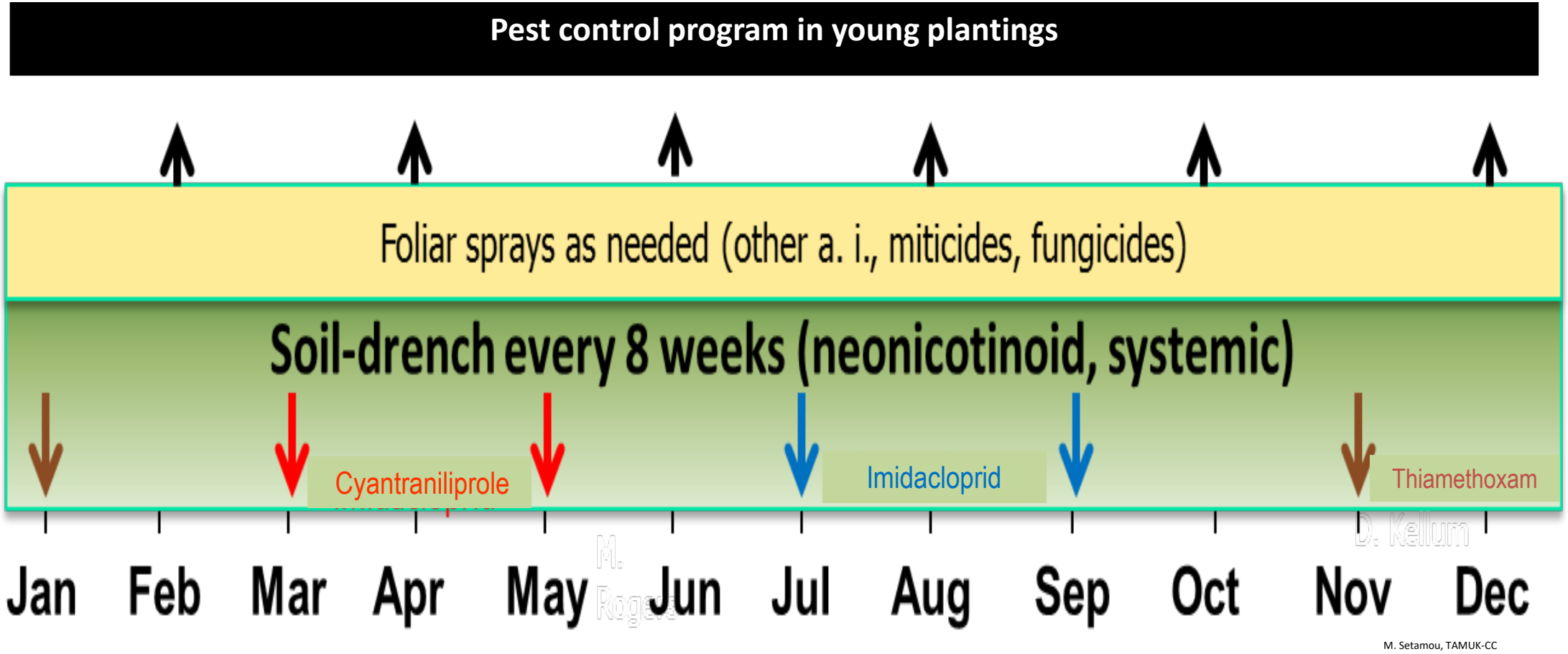
- Two coordinated dormant sprays
- One coordinated proactive sprays before the peak season of ACP population
- Spray before each major flush cycle (as determined by scouting)
- Border sprays between flush cycles (if needed)

Phenology-based ACP control

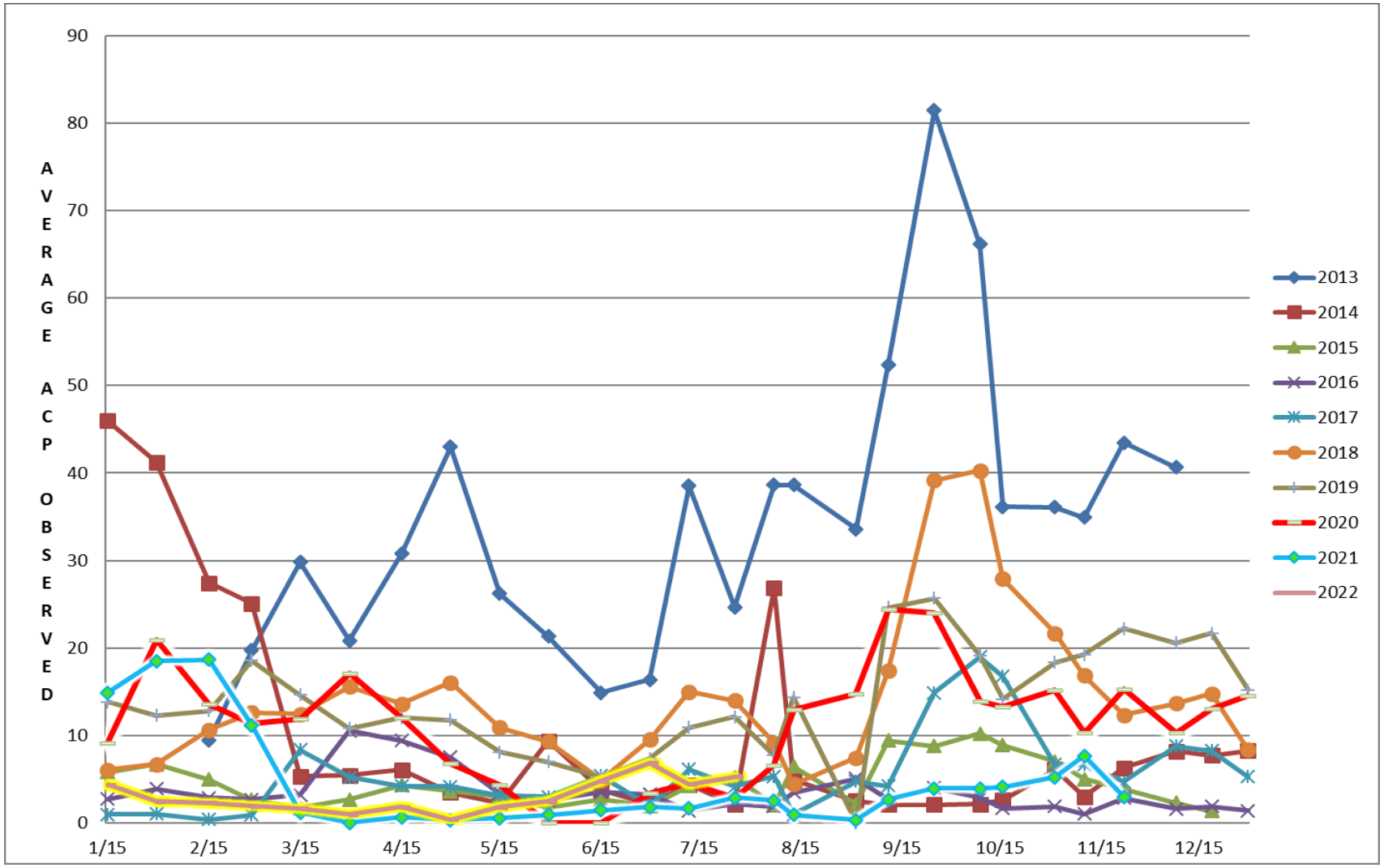


Whole grove sprays are generally for multiple pests

Mandatory ACP control program in young plantings (0-4 yr.-old)



Successful area wide management of ACP in Texas



Texas Citrus Budwood

- To maintain and provide a source of clean, pathogen-free, true-to-type certified citrus budwood to the Texas citrus industry
- Each state has successfully established good budwood programs and covered nurseries

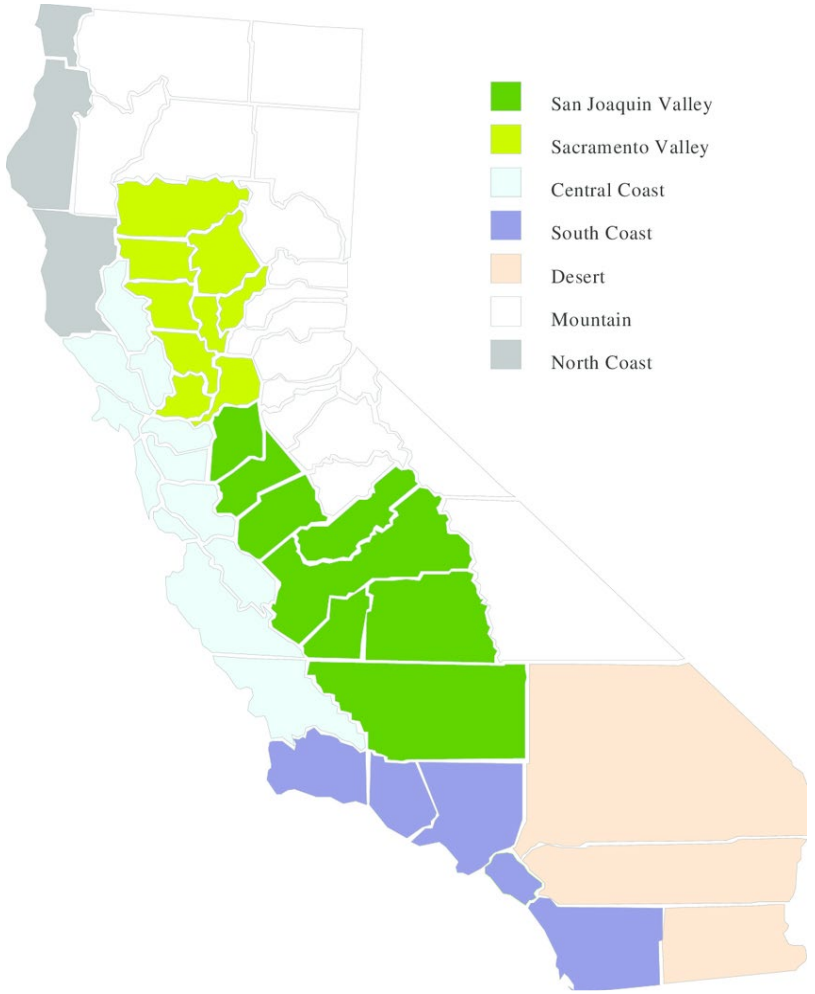
THE HLB SITUATION IN CALIFORNIA – LOW DISEASE PRESSURE

Neil McRoberts, UC Davis
nmcroberts@ucdavis.edu

University of California
Agriculture and Natural Resources

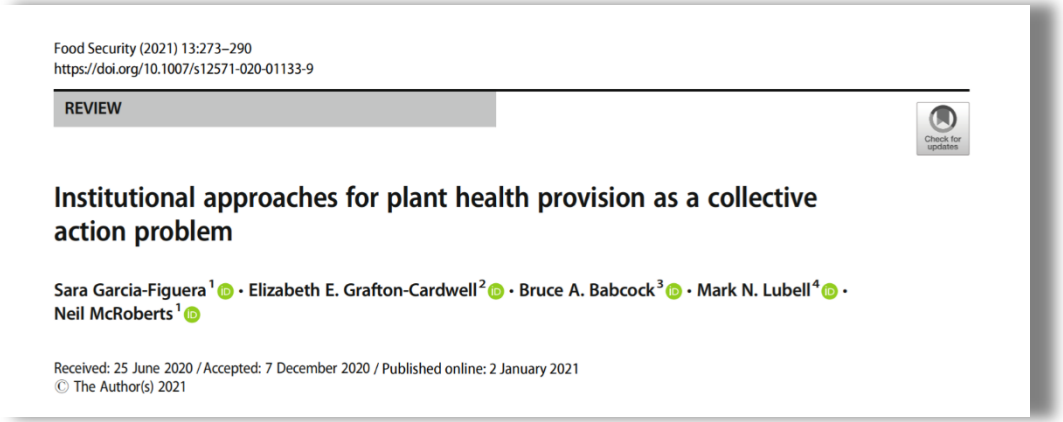
Where is the industry?

- The California industry is 105k – 109k ha
  - Mainly in the Central Valley, but with significant production in coastal and southern desert regions
- Almost entirely a fresh fruit industry, dominated by sweet orange, mandarin, and lemon



Kuminoff, Sumner, and Goldman, 2000

The California response combines top-down and bottom-up features



Food Security (2021) 13:273–290
https://doi.org/10.1007/s12571-020-01133-9

REVIEW

Institutional approaches for plant health provision as a collective action problem

Sara Garcia-Figuera[1] · Elizabeth E. Grafton-Cardwell[2] · Bruce A. Babcock[3] · Mark N. Lubell[4] · Neil McRoberts[1]

Received: 25 June 2020 / Accepted: 7 December 2020 / Published online: 2 January 2021

Our comparative analysis of programs from the Americas suggests that a hybrid program with regulatory and grower participation is the most effective and most sustainable

Growers work in collaboration with state and federal regulatory agencies to run a state-wide disease control program

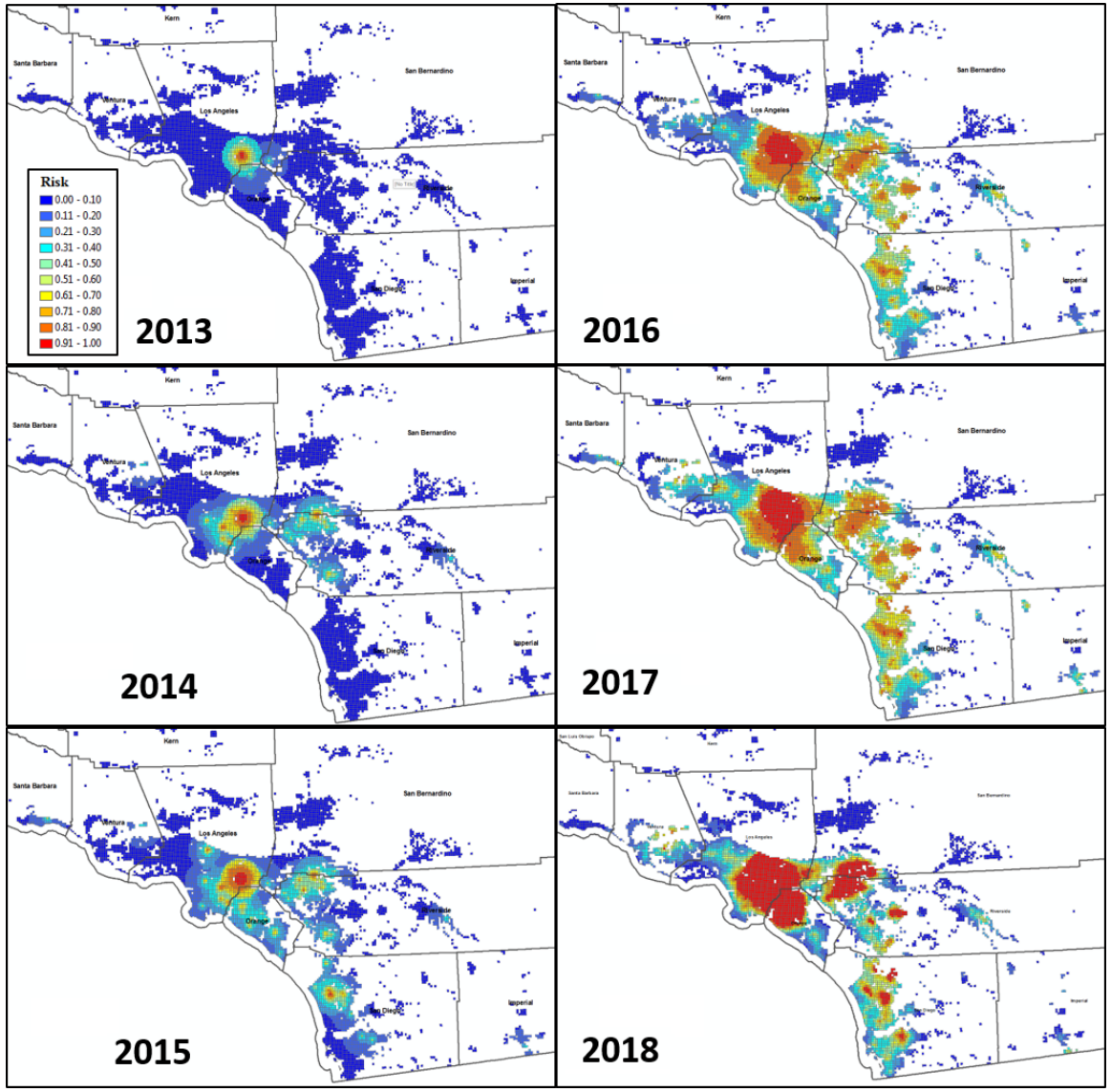
The program is funded from 3 sources:

1. The growers: all commercial citrus production is assessed at 7 cents/carton to combat exotic diseases. The assessment varies with the crop each year, but amounts to $15-20M
2. State general funds of $5M in recognition of importance of industry
3. California's share of the Citrus Health Relief Program (CHRP) federal funds administered by USDA-APHIS; currently $12M/year

Total: $35-40M per year

Surveillance for ACP and HLB

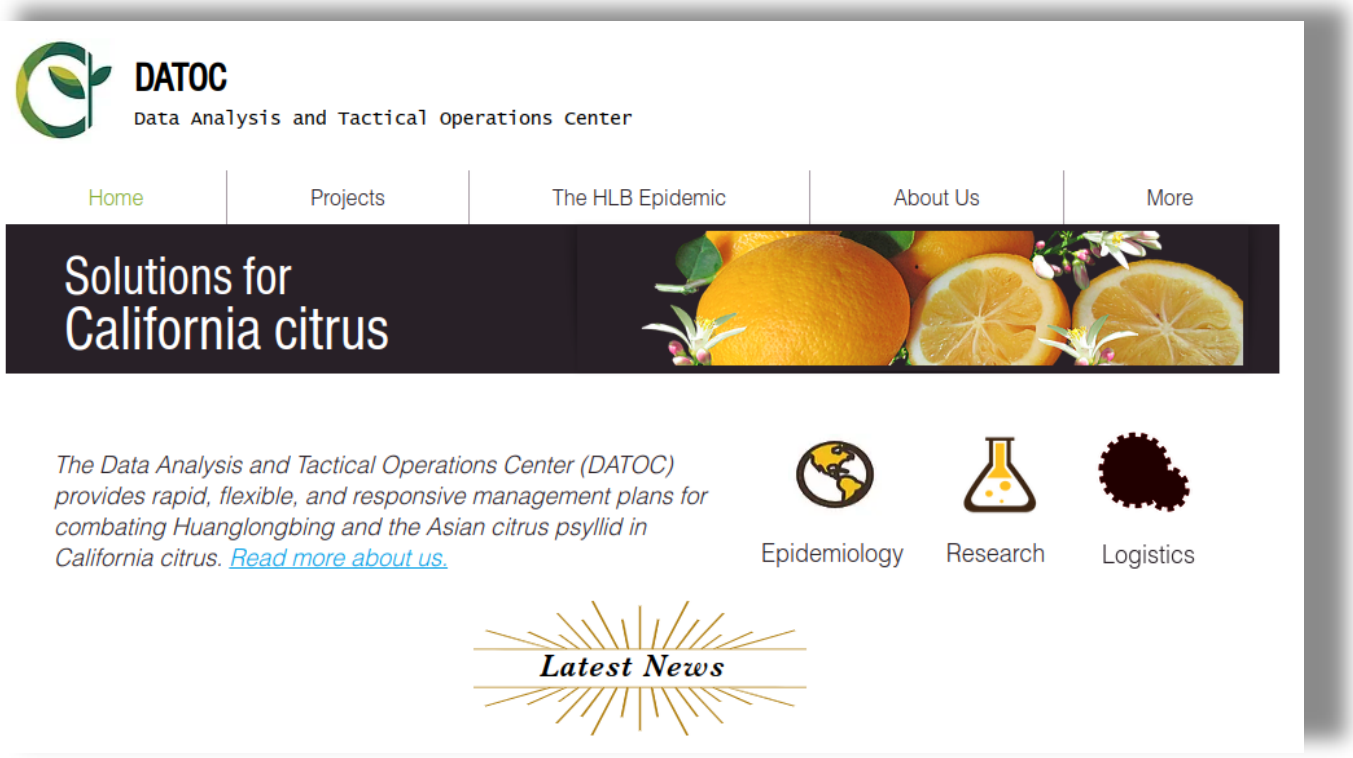
- Focuses on urban areas
  - Commercial citrus is established from certified stock
  - Urban citrus is known to be a point of entry for HLB
- Risk model developed by USDA-ARS and UCD
  - Used to guide the allocation of resources each half-year
- Approx. 2590 km^2 are partly sampled in each cycle
- The risk layer for HLB in southern California over time



Scientific input to the program

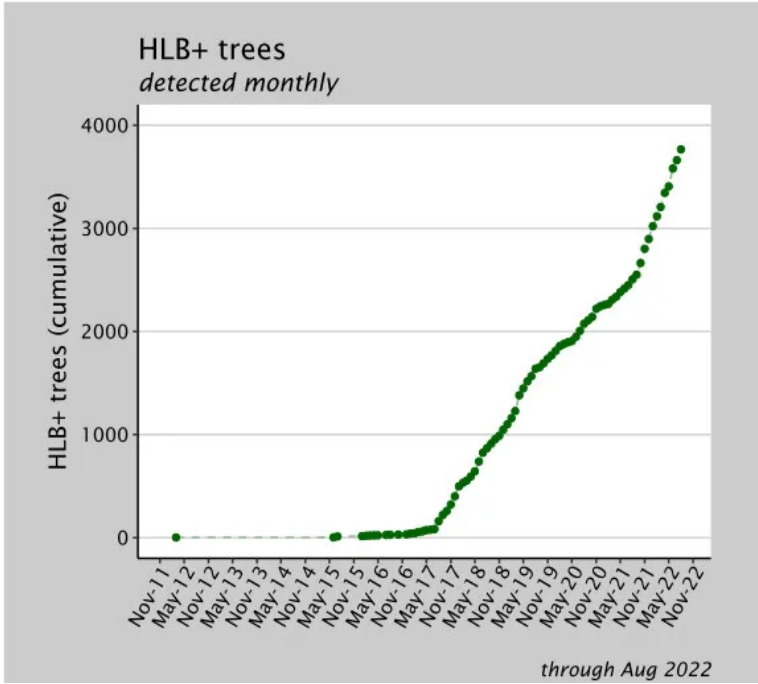
- DATOC - Data Analysis and Tactical Operations Center
- Regular scientific input to Operations and Science sub-committees of CPDC. Decision-making better informed by good science

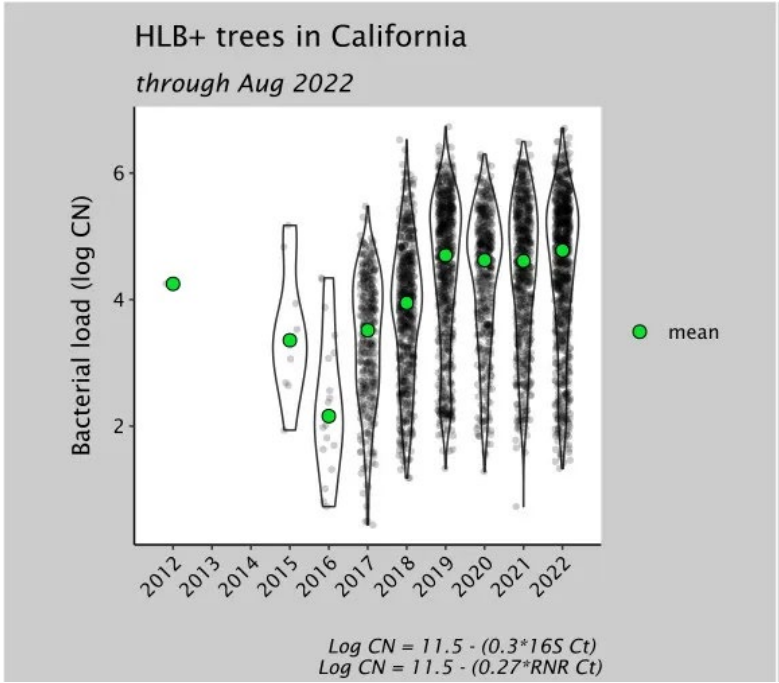
http://www.datoc.us

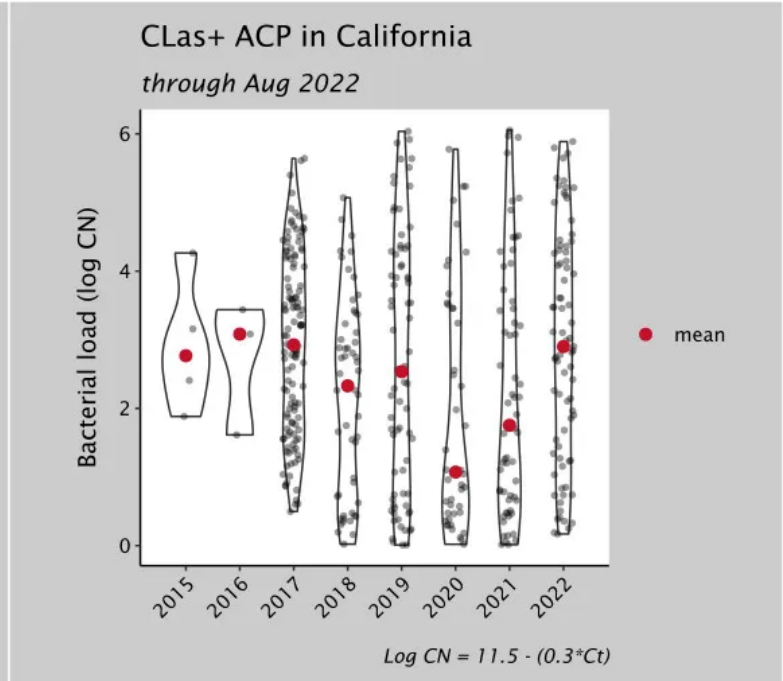


Statistics from California

What does the future hold?







The rate of detection is accelerating

But *C*Las titer levels are not increasing in the ACP or trees where *C*Las is detected

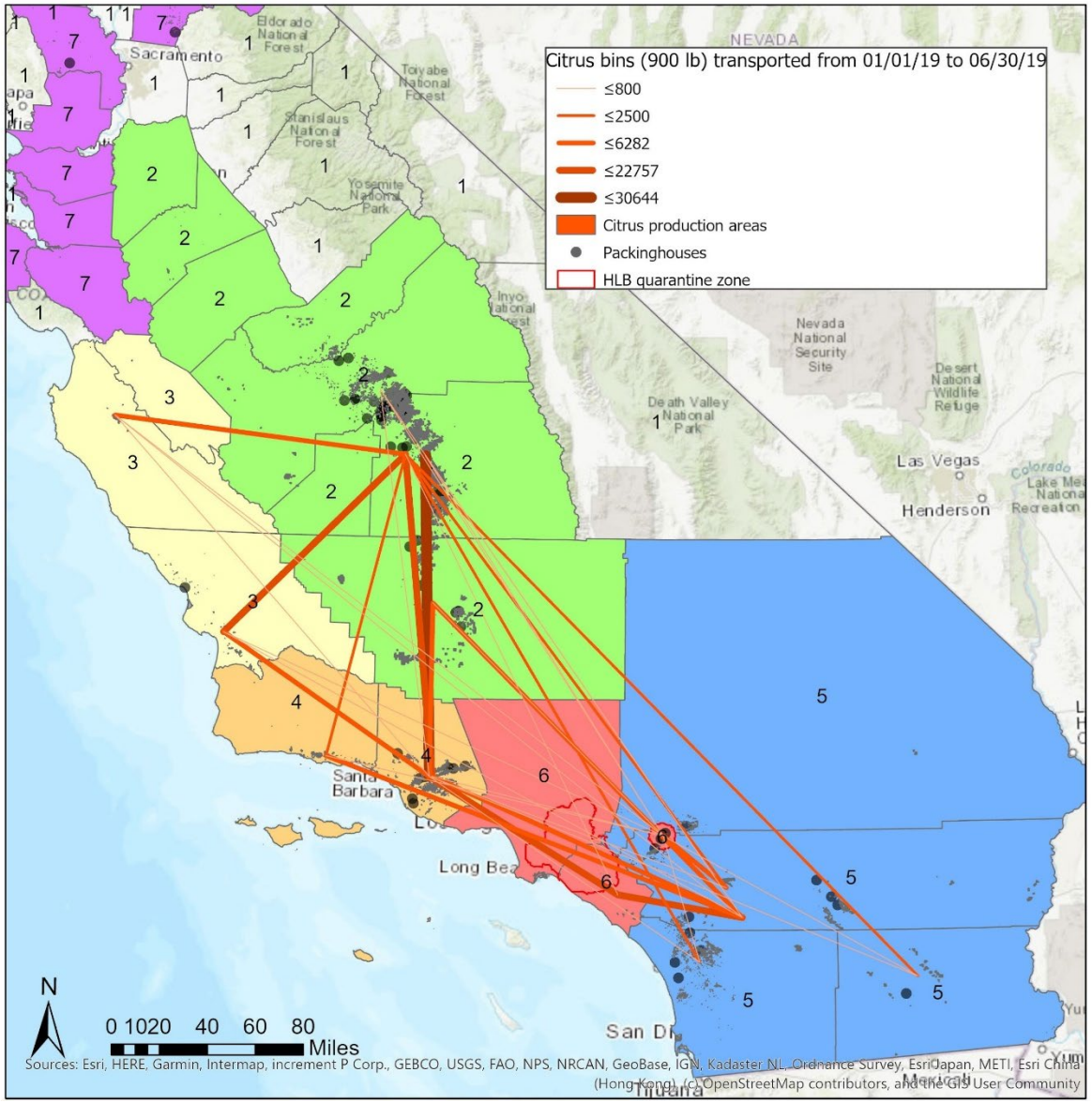
Fruit movement rules key to slowing spread

- In California, citrus fruit harvested and transported in bins to packinghouses
- Evidence from Florida of spread of ACP and CLas with fruit movement (Halbert et al., 2010)
- 2016 ACP detections along transportation corridors
- 2017 Emergency regulation for quarantine zones for the movement of citrus
- 2018 Quarantine regulation active, uniform risk mitigation measures

Halbert, S. E., et al. (2010). "Trailers Transporting Oranges to Processing Plants Move Asian Citrus Psyllids." Florida Entomologist **93**(1): 33-38.

Bulk fruit movement within California

- California was divided into regions
  - Geography is helpful in keeping areas isolated
- Fruit travelling from one region to another needs to be tarped
- Has become standard practice
  - Some grower resistance but has become accepted

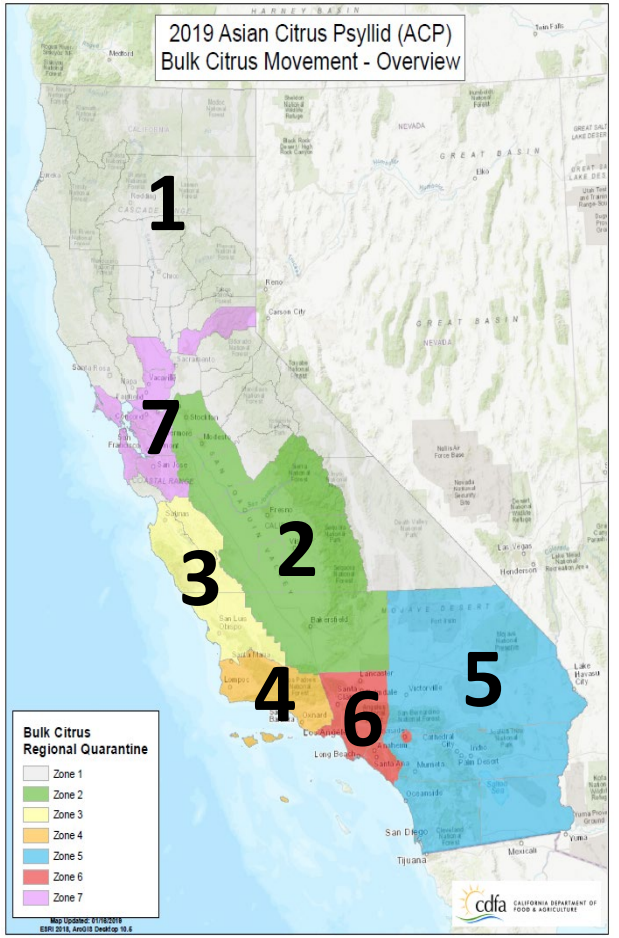


Procedures for fruit movement after HLB

Shipping From	Shipping to a Packer/Processor	
	Within the Same ACP Bulk Citrus Regional Quarantine Zone or into Regional Quarantine Zone 6	In a Different ACP Bulk Citrus Regional Quarantine Zone*
ACP Regional Quarantine Zones 2, 3, 4, 5, or 7	Transport Completely Tarped or in a Fully Enclosed Vehicle	Field Cleaned by Machine **OR** Treatment Option **AND** Transport Completely Tarped or in a Fully Enclosed Vehicle **AND** Complete ACP-Free Declaration Form

Shipping From	Shipping to a Packer/Processor	
	Within the Same Contiguous HLB Quarantine Area	Outside of HLB Quarantine Area OR Different HLB Quarantine Area
HLB Quarantine Area	Field Cleaned by Machine **OR** Spray & Harvest **AND** Transport Completely Tarped or in a Fully Enclosed Vehicle **AND** Complete HLB Pest Risk Mitigation Form	Wet Wash **OR** Field Cleaned by Machine and Spray & Harvest **AND** Transport Completely Tarped or in a Fully Enclosed Vehicle **AND** Complete HLB Pest Risk Mitigation Form

- Risks evaluated for each scenario
- Revised if risks change



CDFA (2018): https://www.cdfa.ca.gov/plant/acp/grower-packer-hauler-information.html, https://www.cdfa.ca.gov/plant/acp/regulation.html

Recommendations

- Ensure that everyone, including for residential citrus, is planting clean trees
- Get education about HLB and plans to coordinate management of ACP to all farmers
  - You are only as strong as the most vulnerable community members
- Monitor how many ACP are carrying CLas, especially outside of quarantine zone.
  - This is the early warning that the disease is moving
- Figure out when ACP are most vulnerable to available management tools and target them

Recommendations

- For eradication, remove identified trees as soon as possible
  - Avoid the temptation to leave trees until harvest
- Determine where ACP lives in between flush cycles and how far it can fly
  - Shown to fly further when infected with CLas
  - Are there management options to be found?
- Coordinate ACP management among farms in regions
- Continue to cooperate among the industry members and educate your population
  - The whole community will need to be involved

MUCHAS GRACIAS

- Tripti Vashisth
- Lauren Diepenbrock
- Davie Kadyampakeni
- Evan Johnson