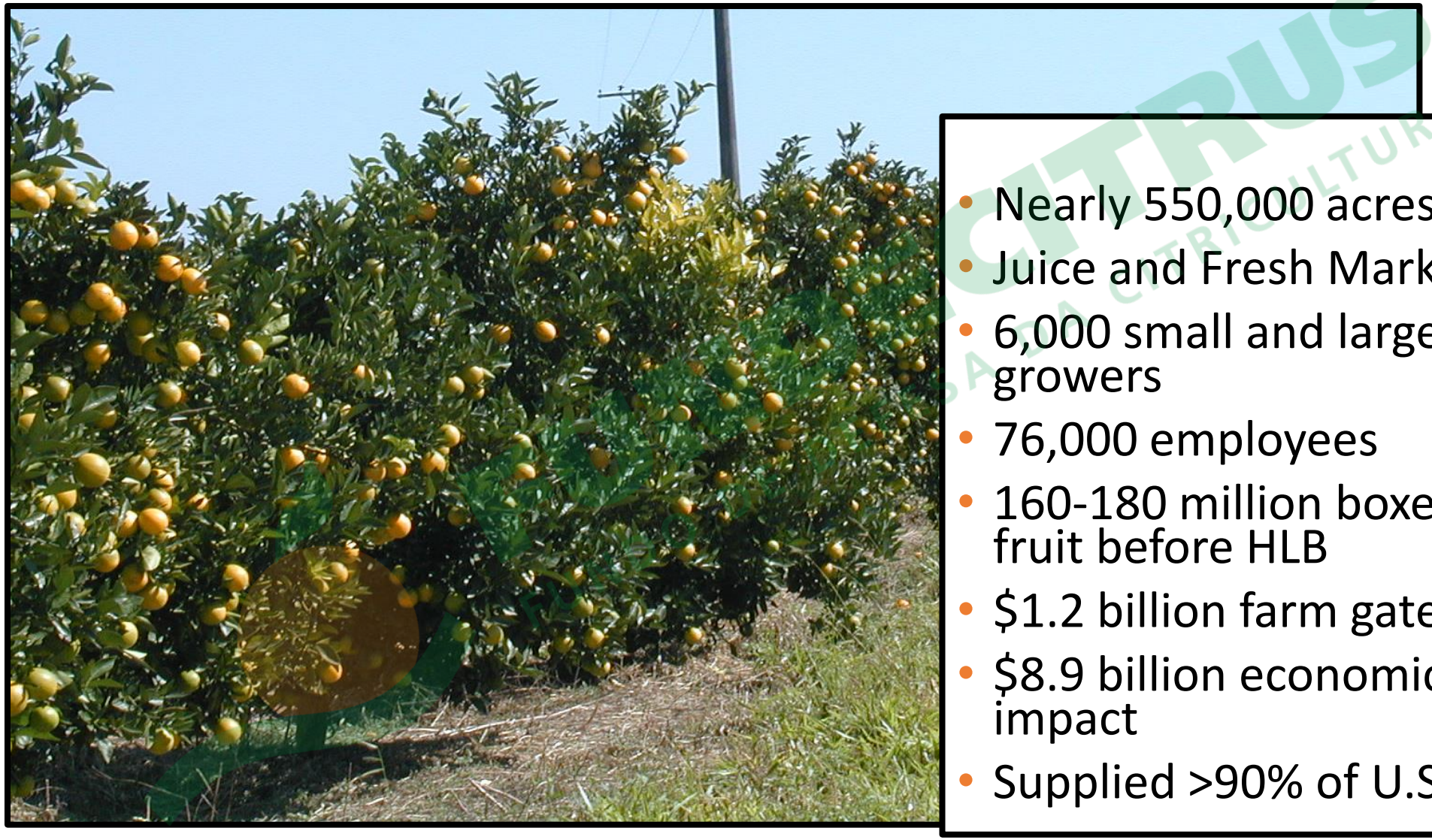
Citrus Disease Solutions
Status of HLB in Florida

FUNDECITRUS Grower Discussion

Harold Browning, Chief Operations Officer

August 20, 2015

Profile: Florida Citrus Industry at Risk

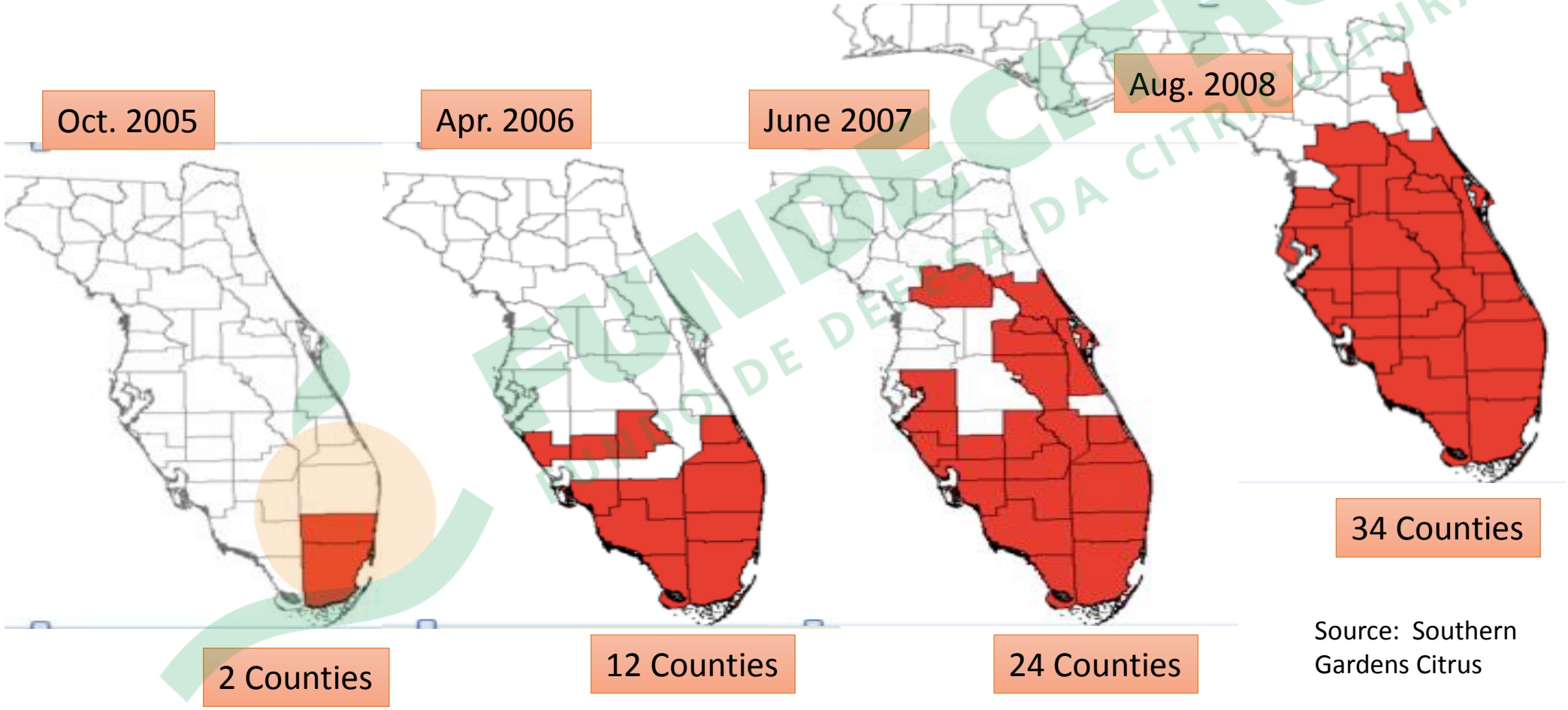


- Nearly 550,000 acres
- Juice and Fresh Marketing
- 6,000 small and large growers
- 76,000 employees
- 160-180 million boxes of fruit before HLB
- $1.2 billion farm gate value
- $8.9 billion economic impact
- Supplied >90% of U.S. OJ

Timeline of Recent Exotic Pests and Diseases

- *Diaprepes abbreviatus* root weevil 1968; spread in 1980's
- Brown citrus aphid, *Toxoptera citricida* – 1980's
- Post-bloom fruit drop, *Colletotricum acutatum* – late 1980's
- Citrus leafminer, *Phyllocnistis citrella* – 1993
- Asian citrus canker, *Xanthomonas axonopodis pv citri* 1995
- Asian citrus Psyllid, *Diaphorina citri* 1998
- Huanglongbing, *Candidatus Liberibacter asiaticus* 2005
- Citrus black spot, *Guignardia citricarpa* 2011

HLB Disease Spread in Florida



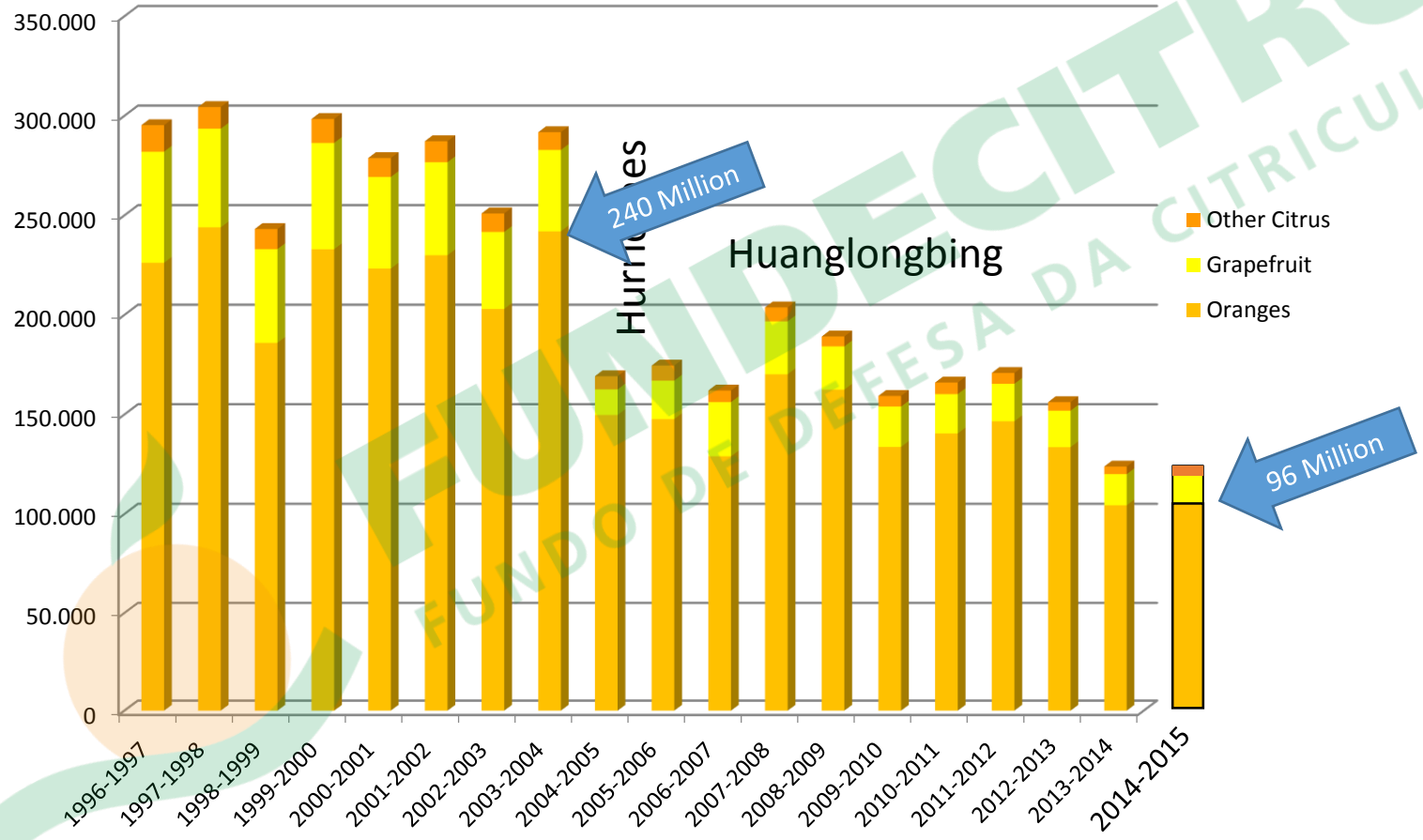
Source: Southern Gardens Citrus

Economic Impacts of HLB

- Increased costs of production (~ $800 U.S. per acre to $2,000)
  - **Psyllid vector treatments and auxiliary disease treatments**
  - **Scouting and tree removal/replacement**
  - **Fertilizer, irrigation inputs must be more timely and efficient**
  - Supplemental materials to overcome tree symptoms and decline
  - Correcting soil, water conditions which are now more important
- Reduced fruit crop through short cropping and early drop
- Losses of efficiencies – managing resets, harvest, etc.
- Uncertainty – reluctance to invest and to replant

CRDF Florida Citrus Production

(Boxes of fruit per type)



Source: USDA, NASS Florida Citrus Statistics

Status of HLB in Florida

Growers Stopped Removing Infected plants

Infection Spread

100% of Groves

~ 70% of trees

Chronic Tree Decline

Significant Fruit Drop

20% Groves Unmanaged

Widespread Inoculum

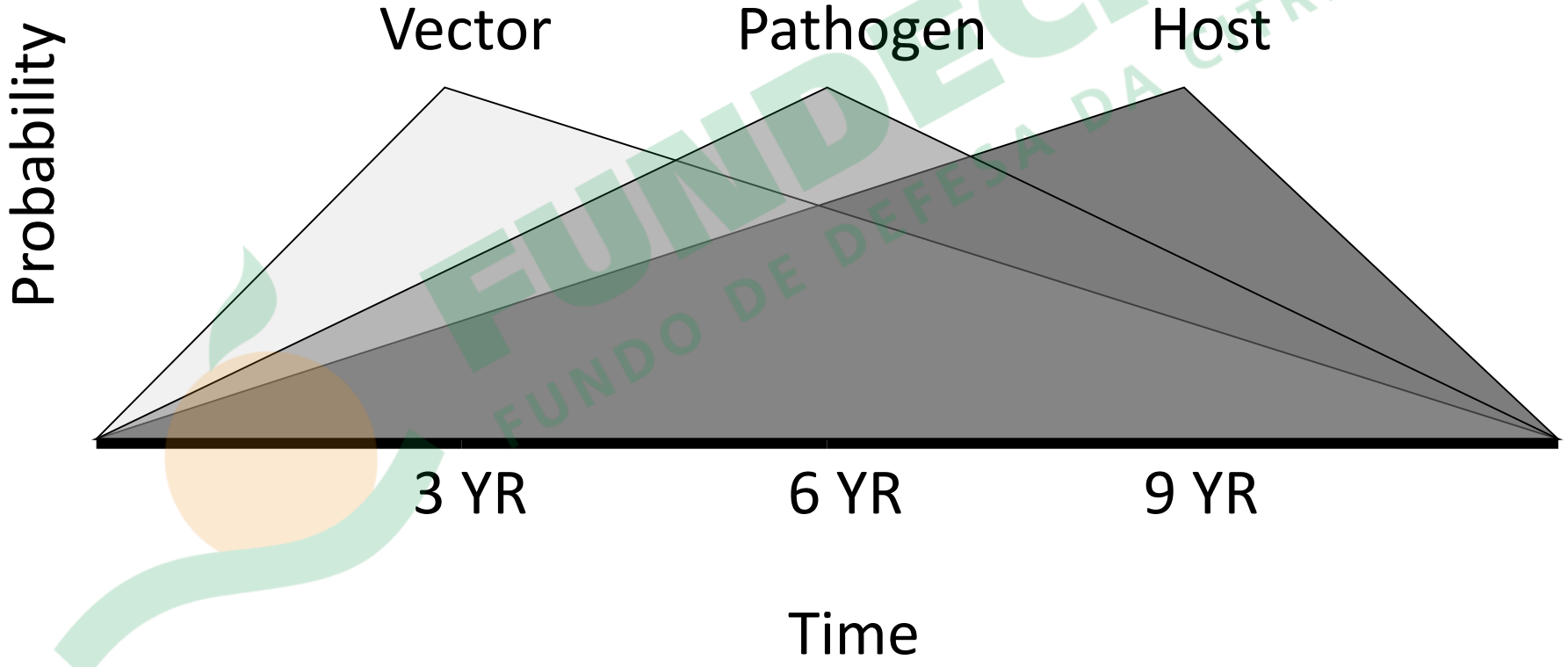
Early Infection of New Plants

Research Goals – Short-Term Delivery

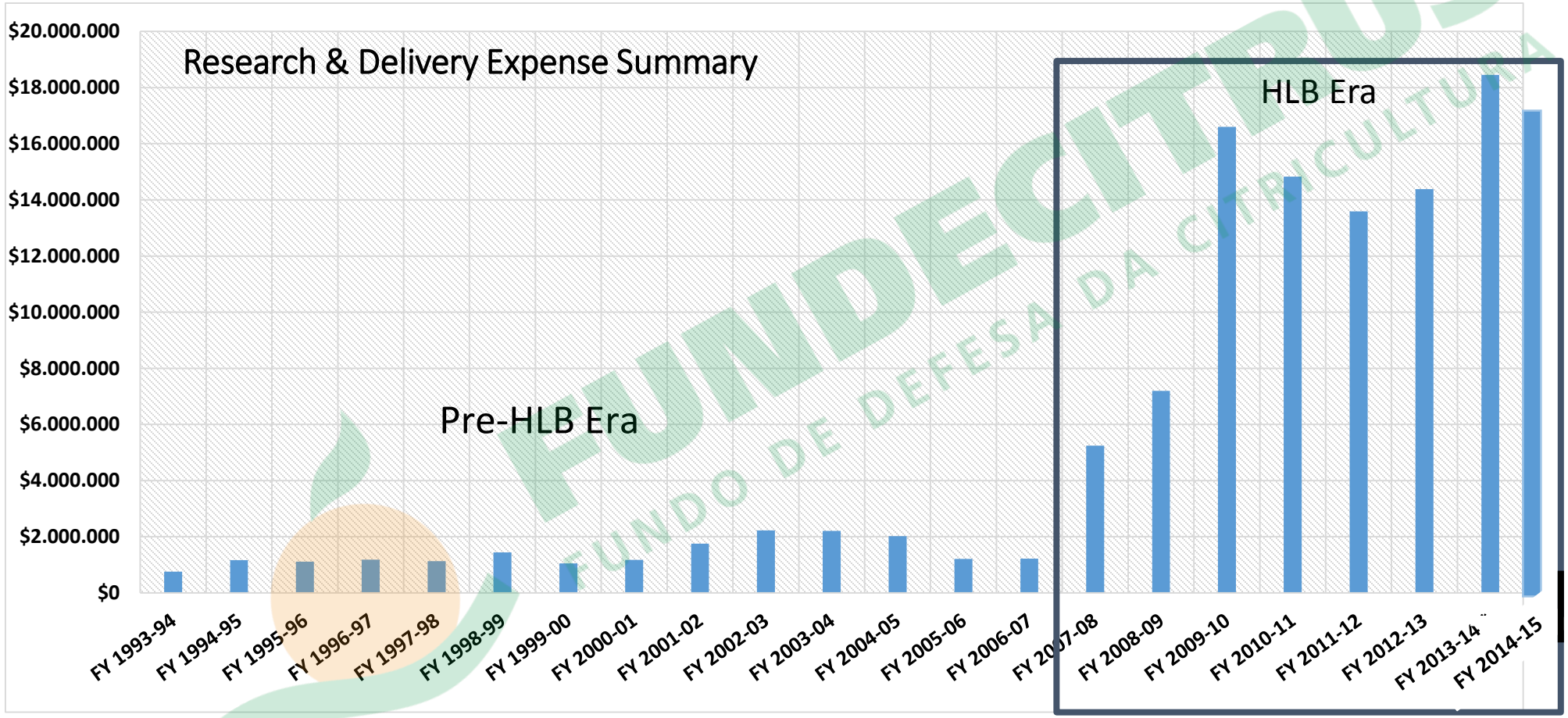
Retain Health of Existing Trees
– Critical for Near-Term Industry Survival

Provide Tools for Success of New Plantings
– Necessary for Stabilizing Loss of Acreage

Time to Market – HLB Solutions



Citrus Industry Research Investments (CRDF)



Approaches to Battle HLB

- Preventing Disease Spread (new plantings and resets)
- Reducing Disease in Infected Trees (remove trees or therapy)
- Sustaining/Improving Tree Health – cultural practices
- Affecting Fruit Drop and Fruit Quality
- Reducing Impacts of other Diseases and Stresses

Project Profile by Topics – CRDF Research

CRDF Research Category	Projects Ending < 7/01/15		Projects Continuing > 7/01/15	
	# Projects	Total Budget	# Projects	Total Budget
1. Consequences of HLB infection	0		1	$ 237,500
2. CLas culture, genomics, molecular	7	$ 1,952,070	4	$ 1,680,137
3. Citrus response to infection	4	$ 304,090	2	$ 496,182
4. HLB pathogen/disease detection	3	$ 583,581	0	
5. HLB epidemiology and mitigation	11	$ 2,459,788	8	$ 2,504,017
6. ACP monitoring and behavior	4	$ 628,470	1	$ 577,703
7. ACP chemical, biological mgmt	7	$ 1,719,149	4	$ 1,127,681
8. ACP trapping and repelling plants	0		0	
9. Citrus genomics and transcriptomics	1	$ 458,000	1	$ 240,000
10. Conventional citrus resistance breeding	7	$ 2,317,621	4	$ 2,052,136
11. Transgenic/ vector mediated resistance	11	$ 2,832,556	6	$ 3,026,921
12. Model systems, inc. screening	2	$ 296,384	3	$ 1,318,803
Non HLB Pest and Disease Research	7	$ 1,356,198	9	$ 3,162,545
Total Research Projects	**64**	**$ 14,907,907**	**43**	**$ 16,423,625**

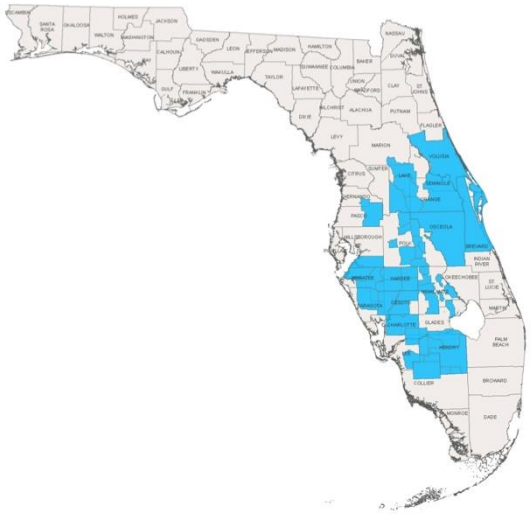
Project Profile by Topics – CRDF Delivery

CRDF Commercial Product Delivery	Projects Ending < 7/01/15		Projects Continuing > 7/01/15	
Program Topic	# Projects	Total Budget	# Projects	Total Budget
Antimicrobial therapy	9	$ 2,567,858	4	$ 506,587
Naturally Occurring Microbes	0		4	$ 468,386
Thermal Therapy	2	$ 467,177	1	$ 105,782
Plant Growth Regulators	5	$ 175,717	1	$ 132,660
ACP Management	3	$ 269,720	0	
Tolerant Rootstock Plantings	3	$ 548,088	1	$ 333,774
Psyllid Shield (RNAi)	1	$ 487,383	1	$ 113,523
HLB Escapes	1	$ 176,000	0	
Non-HLB Pests and Diseases	1	$ 803,126	3	$ 213,333
Total CPD Projects	**25**	**$ 5,495,069**	**15**	**$ 1,874,045**

Integrated Psyllid Management

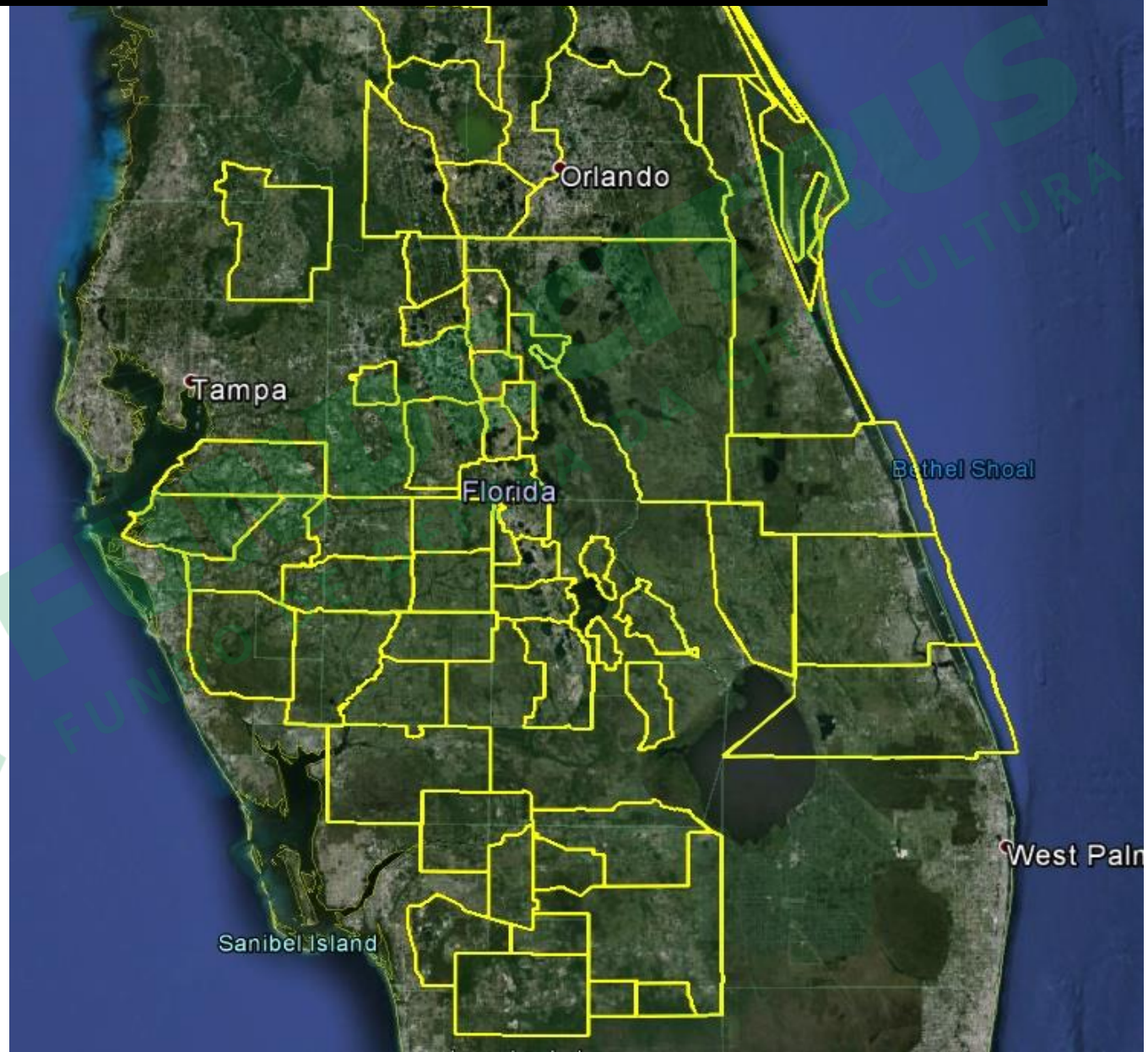
- Measurement of populations and movement of ACP
- Suppression with insecticidal tools
- Manage modes of action to provide sustained activity
- Seasonal timing, application methods and rates
- Balance ACP management with other pests and diseases
- **Don’t let ACP populations get out of hand**
- Implement alternative management strategies as they emerge
- Utilize CHMAs to expand benefit of ACP management

48 CHMAs encompassing 486,000+/- acres of commercial citrus



CHMA

Citrus Health Management Areas



Horticultural Practices to Complement HLB Disease Management

Tools to Prolong Health of Existing Inventory of Diseased Trees

- Chemical and Thermal Therapy to Reduce Bacteria in Trees
- Naturally Occurring Microbial Products
- Plant Growth Regulators - Fruit Drop due to HLB
- Integrated Root Health Practices

These tactics are not expected to affect disease levels but to prolong tree health. This approach should only be considered once tree removal is no longer possible.

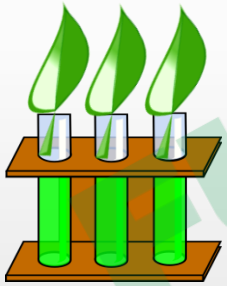
Stepwise Assay System for Bactericides

Increase in biological relevance

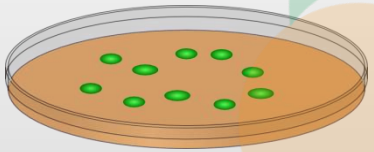
Decrease in throughput

Field Trials/Use

Field trials-tests activity, dose response, phloem entry and mobility, phytotoxicity, application methods, residues, fruit drop and quality



Whole plant (greenhouse) assay-tests phloem entry and mobility, activity against CLas, dose response and phytotoxicity



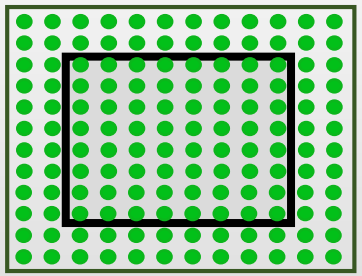
Flush or detached leaf (laboratory) assay-tests activity against CLas, local movement, dose response, phytotoxicity

Liberibacter crescens (laboratory) assay-tests bactericidal activity and dose response

(Slinski 2015)

Field Trials of Bactericides

- Best Candidates Progress from Assays to Field Trials
- Small-scale Field Trials of Candidates
  - Dose Response and Phytotoxicity
  - Formulation and Application Methods
- Multi-Year Field Evaluation of Commercially Available Materials
  - Bactericides/Fungicides & Naturally Occurring Microbe Products
- Large-plot Grower Trials of Promising Candidates
- Full-scale Field Trials Conducted by Registrants
  - Multi-site Evaluation of Activity, Dose, Application, Residues



Thermal Therapy

- Solar tent and supplemental heat with steam or hot water
- Thousands of trees treated
  - Time/temperature refinement
  - Evaluation of *CLas* reduction and tree response
- More growers treating small trees with tents
- Commercial scale-up

How to Succeed with New Plantings of Citrus?

- Widespread inoculum in managed and unmanaged citrus
- Psyllid vectors moving into new plantings from unmanaged groves
- Increased costs
- Citrus Nurseries all protected and regularly inspected for HLB, citrus canker
- Most growers do not have geographic separation from neighbors

Success in new plantings is the key to survival of Florida citrus. It is a very difficult challenge with the level of unmanaged citrus around the farms that are replanting.

Current IPM Practices for New Plantings

Asian citrus psyllid control

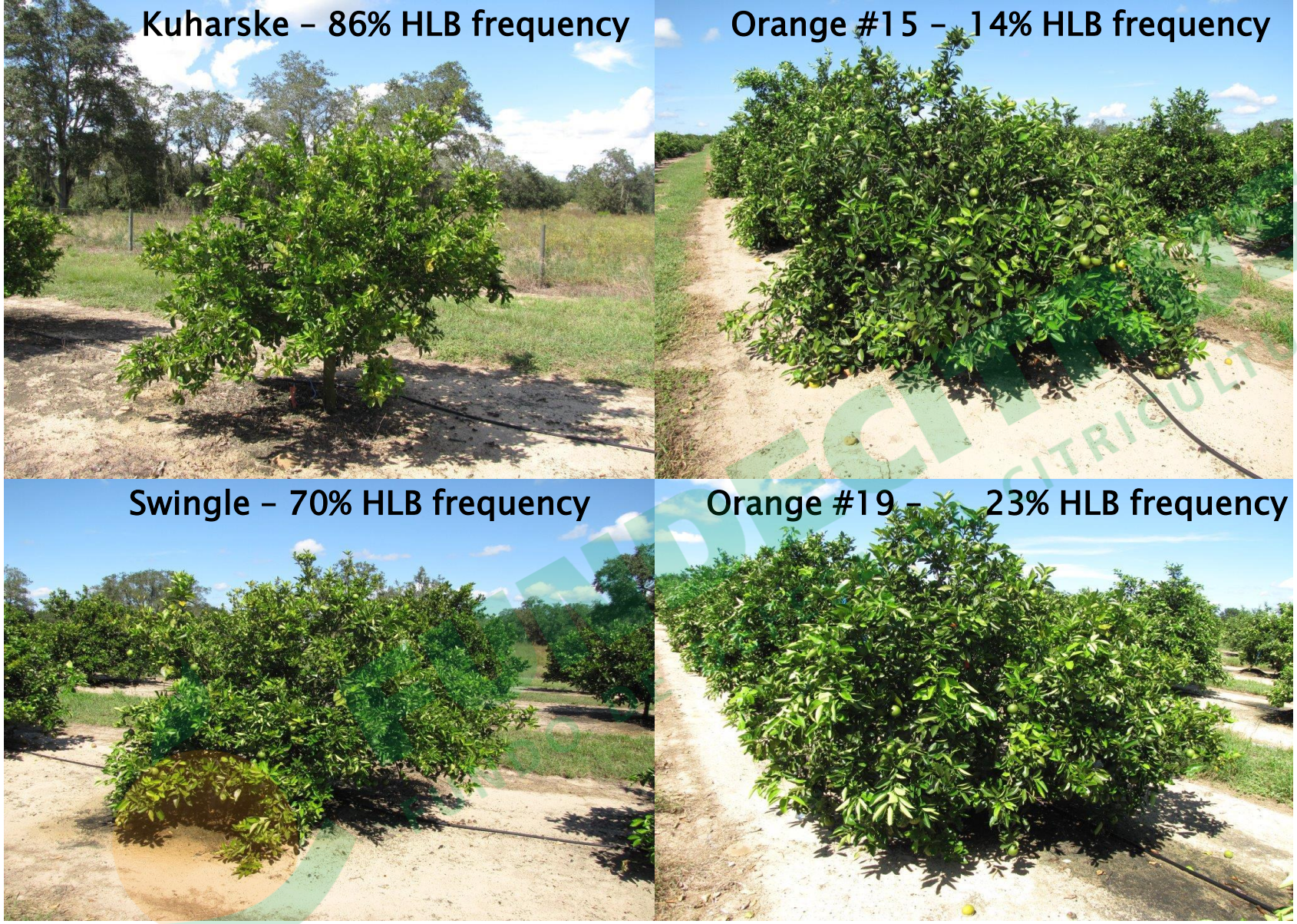
- Neonicotinoid soil drenches to protect trees up to 3-5 years of age
- Organophosphates, carbamates, pyrethroids, neonicotinoids
- 10-12 or more foliar applications required to suppress psyllids in addition to soil drenches in young plantings
- Citrus Health Management Areas (CHMAs) coordination of sprays
- Biological control with *Tamarixia radiata* in untreated areas

HLB Infection Rates in New Plantings

Groves ~2 years of age (2014)

Psyllid pressure	HLB infection range	Average infection rate	# of groves
1 - low	0 – 4.05%	1.02%	20
2 – medium	1.73 – 65.6%	17.7%	20
3 - high	0 – 36.9%	20.96%	21

Premier Grapefruit Rootstock Trial – Fort Pierce



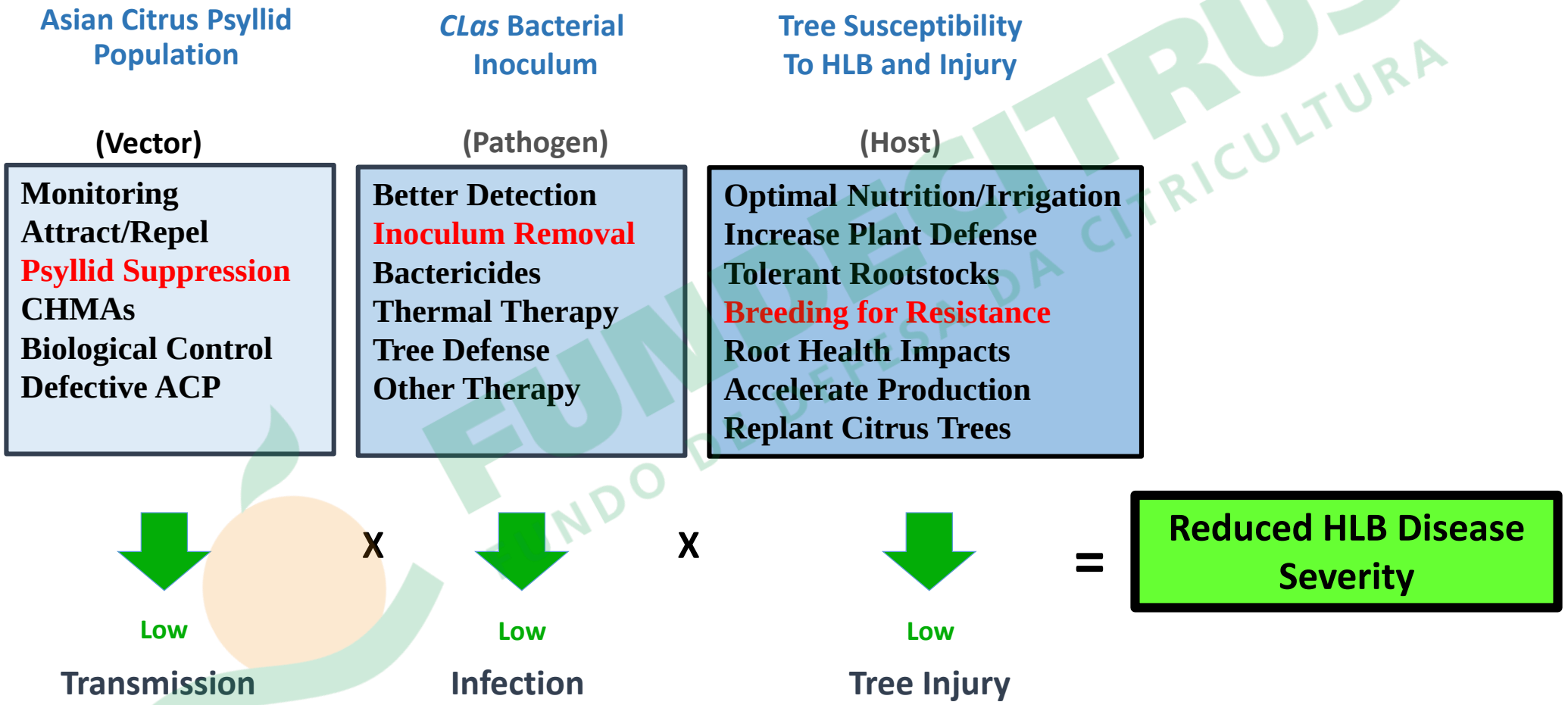
HLB-infected trees in the St. Helena Project
–differences in infection frequency & disease severity

Commercial Scale Field Trial of Tolerant Rootstocks

Long-Term Disease Management Practices

- Remove unmanaged citrus - reduce inoculum and psyllid pressure
- Field trials of conventional breeding progeny
  - Poncirus trifoliata, lime, pomelo, kumquat sources of variation
  - Rootstock and scion development
- Field trials of engineered resistance to HLB
  - 3 permitted sites in Florida for evaluation of engineered citrus
  - peptides, PR genes, genomic approaches
- RNAi strategies
  - Primarily focused on ACP, but also targeting *CLas*
- Build or select a Psyllid population that cannot transmit *CLas*

Ultimate HLB Management

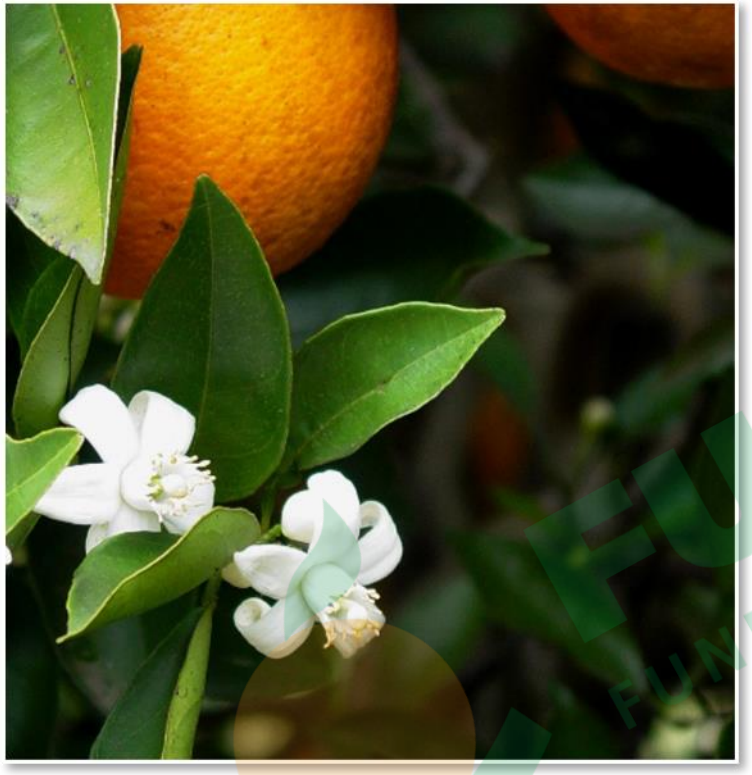


Cooperation

U.S. and Brazil citrus growers and research communities need to cooperate more in discovering, testing and delivering solutions to HLB.

There is much that we can learn from the aggressive management in place in Sao Paulo citrus farms. It is working and is based on sound disease management principles. Unfortunately, Florida growers were slow to adopt this strategy and now we have a big challenge.

Thank you for your hospitality!



CRDF is proud to provide support to the Florida citrus industry