Integrated Pest Management of California Citrus

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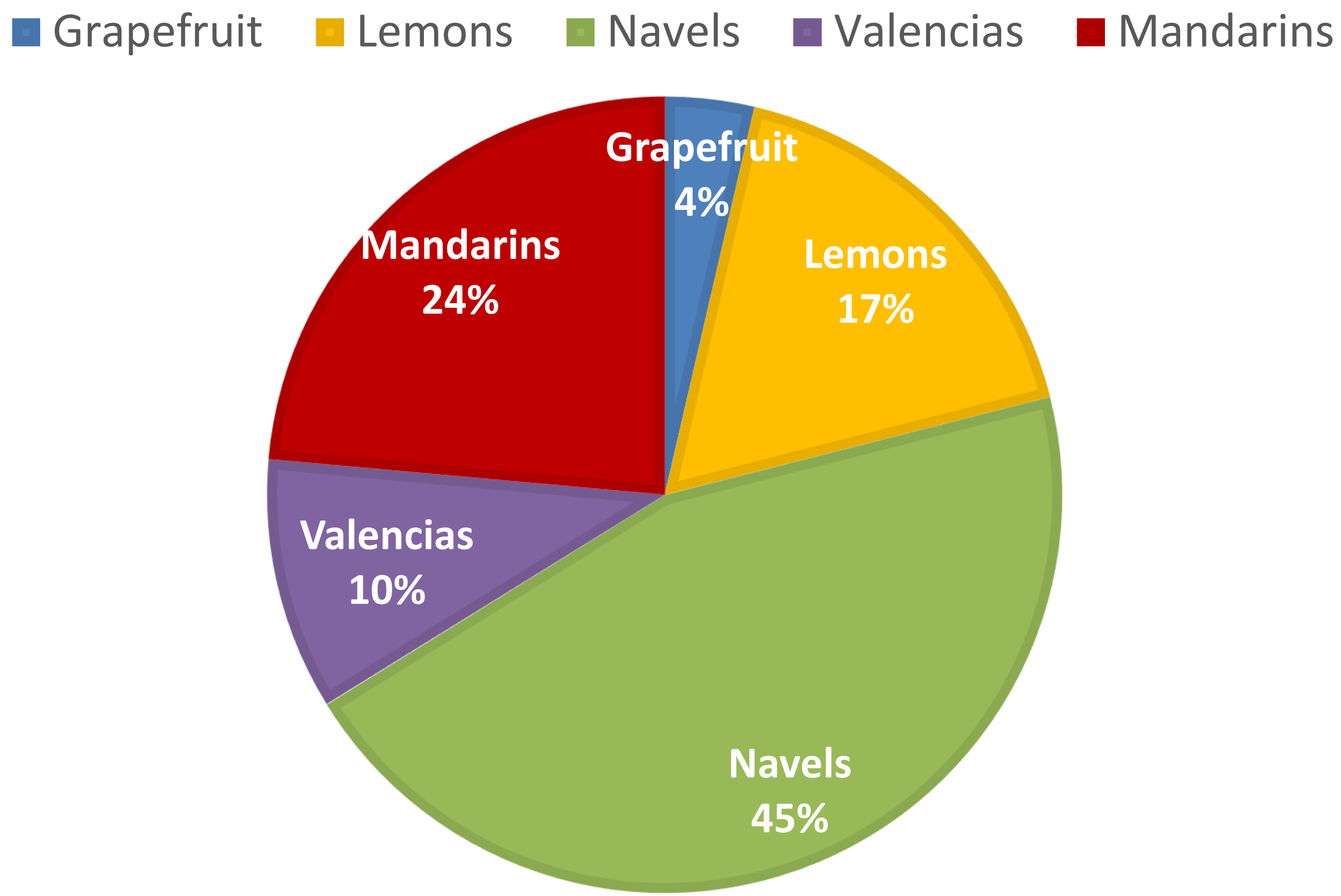
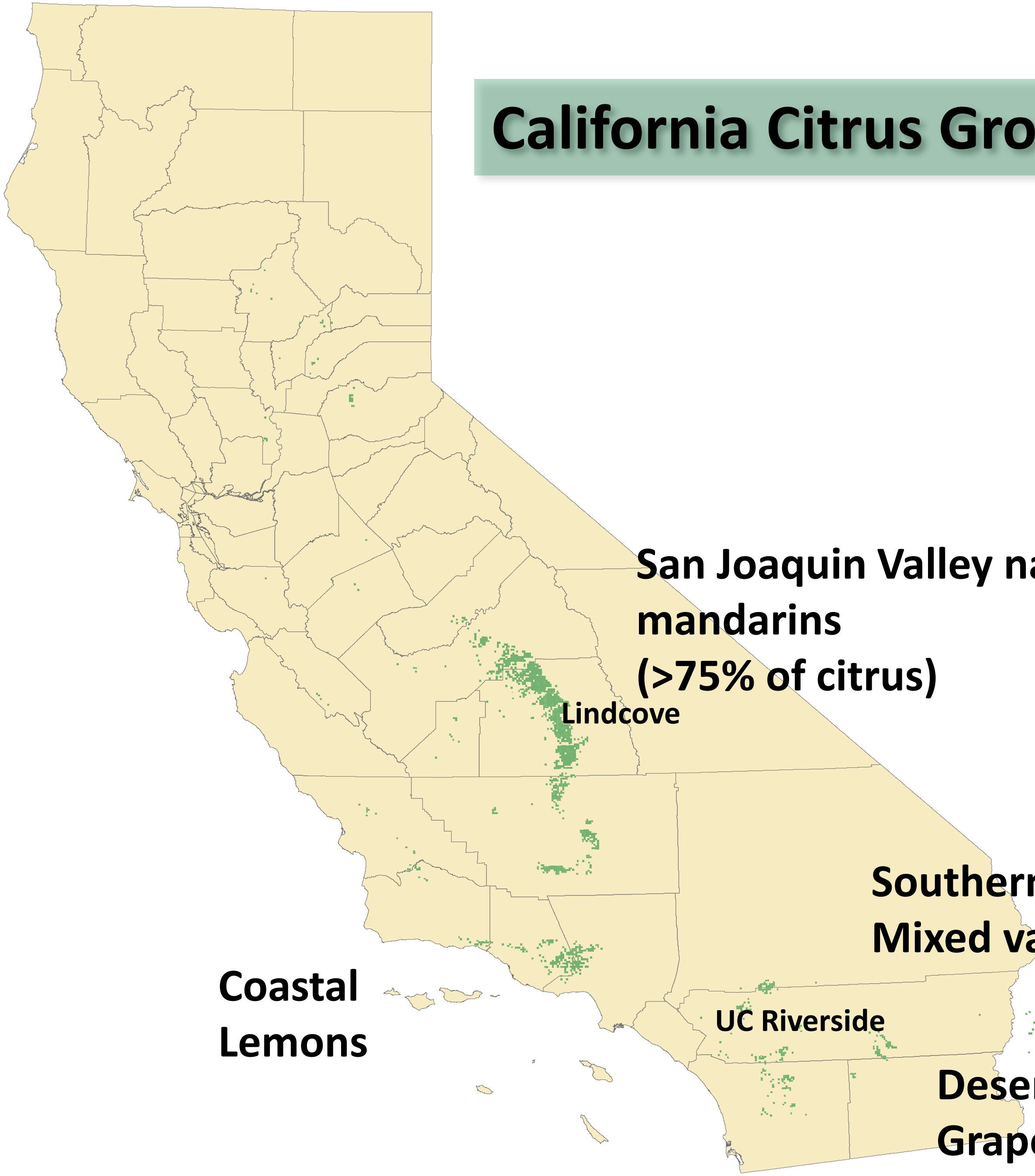
University of California
Agriculture and Natural Resources

CALIFORNIA CITRUS ACREAGE 2018
262,700 ACRES (106,310 HA)



California Citrus Growing Regions

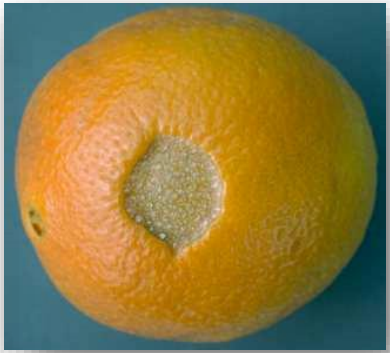


Fresh fruit market

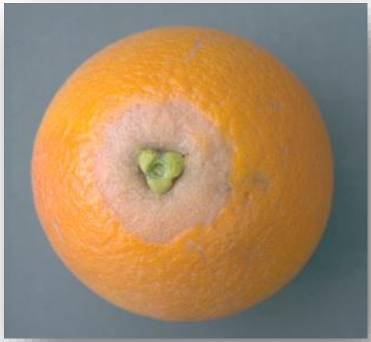
<u>Export markets</u>
Japan
S. Korea
China
Australia
New Zealand
Canada

Cutworm/Earwig

Katydid

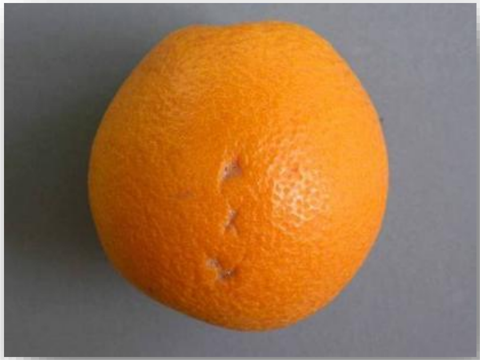


Thrips



Equipment

Hail



Wind/sand

Branch rubbing

Price per box	Juice	Choice	Fancy
Navels	$1.50	$13.13	$25.30
Valencias	$1.60	$12.50	$20.50
Mandarins	$0.28	$17.50	$29.70

These numbers vary from year to year, as the season progresses and for different citrus varieties

San Joaquin Valley Citrus IPM

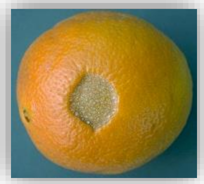
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

UC IPM Guidelines for Citrus

Citrus Red Mite

Citrus Thrips

Katydid



Citricola scale

California red scale

Citrus Red Mite, *Panonychus citri*

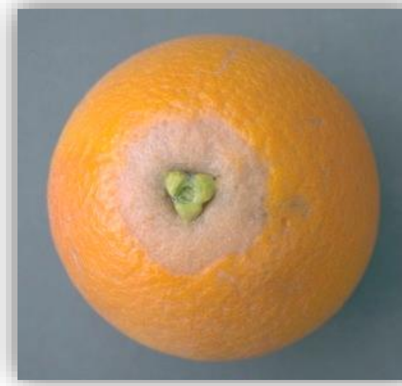
Fairly easily controlled by natural enemies and soft pesticides such as oils and miticides

Predatory mite,
Euseius tularensis

Summer heat
+ virus

Rind damage
Lower yield
Threshold: 8 adult mites/leaf

Citrus Thrips, *Scirtothrips citri*



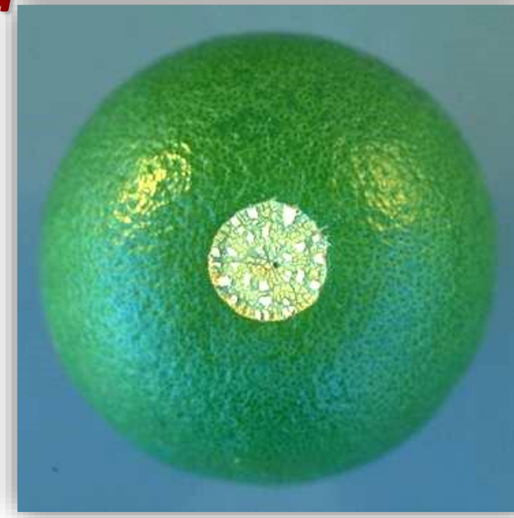
Rind damage

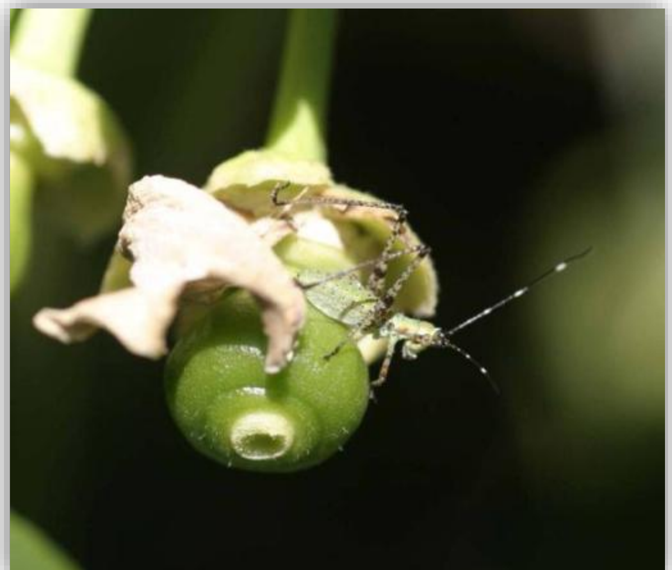
Natural enemies help, but don't bring scarring below an economic threshold.

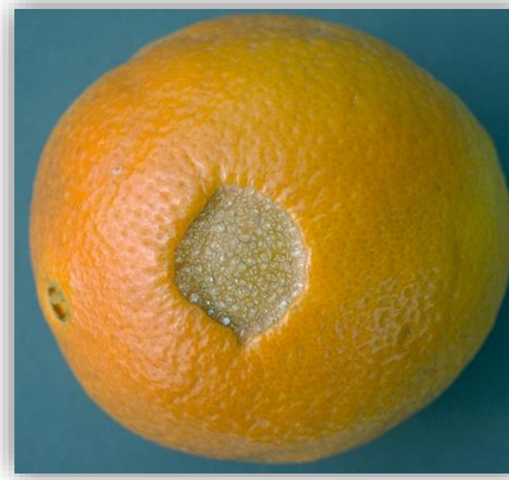
Treatments are applied from petal fall until the fruit is 2.5 cm in diam.

Forktailed Bush Katydid, *Scudderia furcata*

Rind damage







Biological control is minimal and damage is heavy = pesticides are necessary

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

San Joaquin Valley Pest Management Navels & Mandarins

Citrus Red Mite — Oils, miticides

Bloom

Citrus thrips + katydids

Thrips: spinetoram, cyantraniliprole, spinosad, abamectin, formetanate

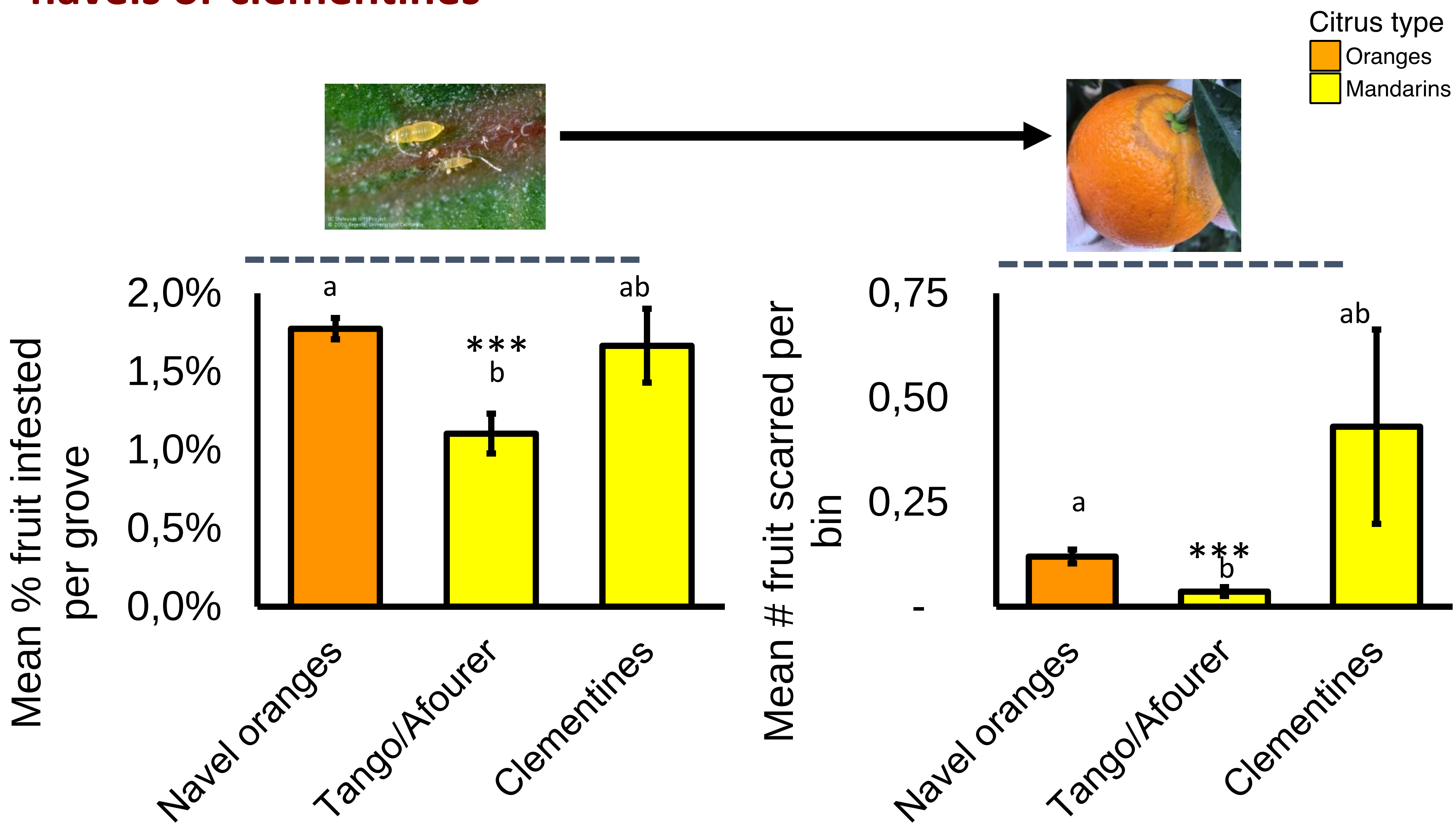
Katydids: pyrethroid, diflubenzuron, kryocide

Broad spectrum

Soft on natural enemies

3-4 insecticides/year

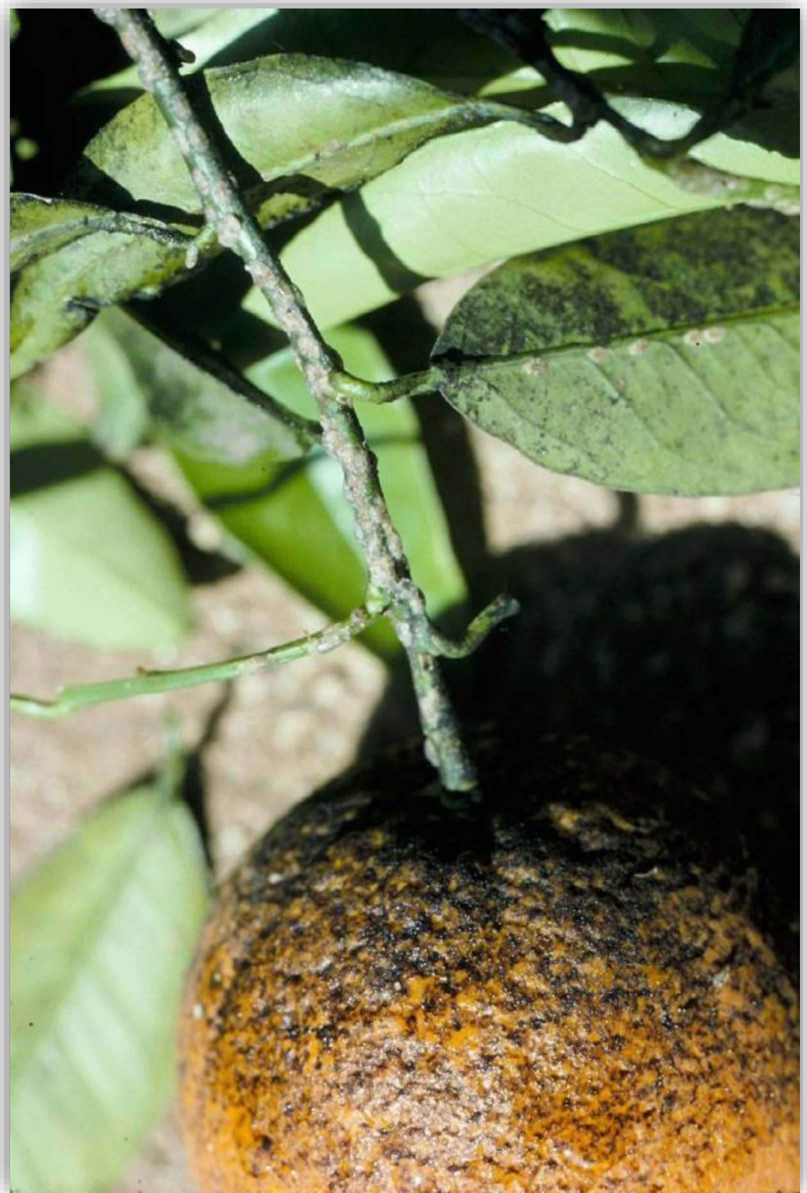
Thrips, katydids and earwigs cause less damage to Afourer than navels or clementines



Mandarins need specific citrus thrips guidelines

Citricola Scale, *Coccus pseudomagnoliarum*

Sooty mold
Yield



Biological control is very poor and broad spectrum insecticides are needed

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Katydids: pyrethroid, diflubenzuron, kryocide

Citricola scale — acetamiprid, thiamethoxam, imidacloprid, buprofezin

Broad spectrum

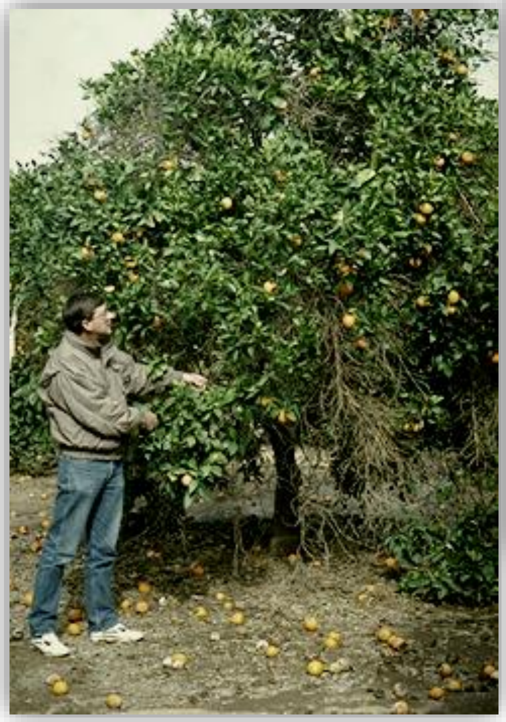
Soft on natural enemies

4-5 insecticides/year

California Red Scale, *Aonidiella aurantii*

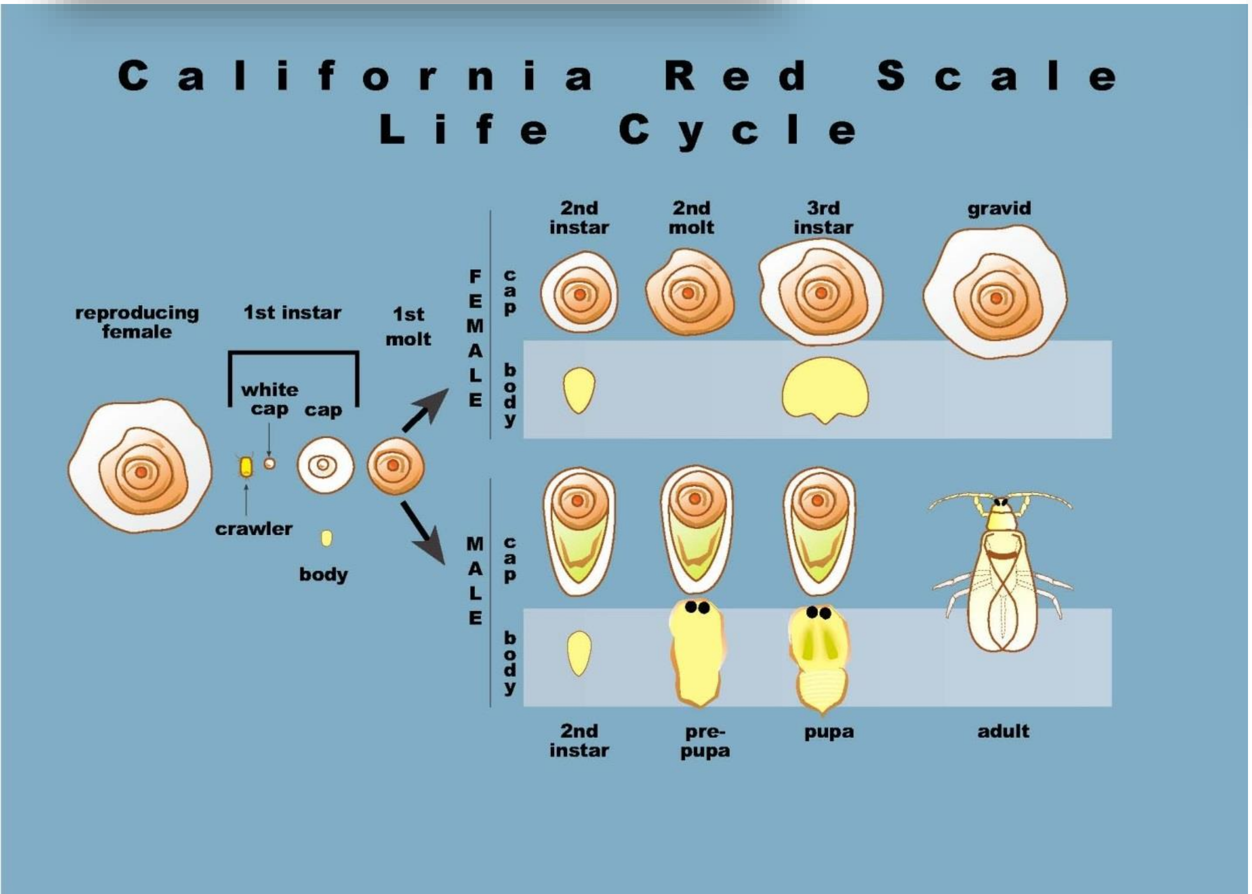
Biological control is very effective if broad spectrum insecticides are avoided and trees are cared for

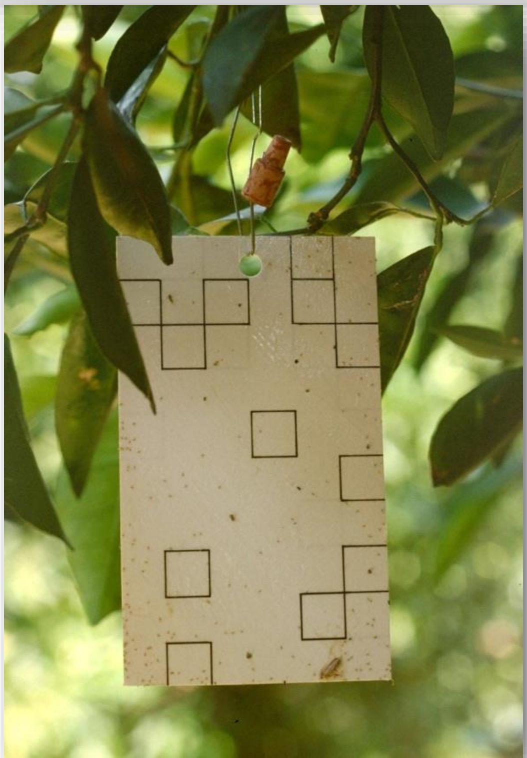
Downgrading of fruit
Yield Loss



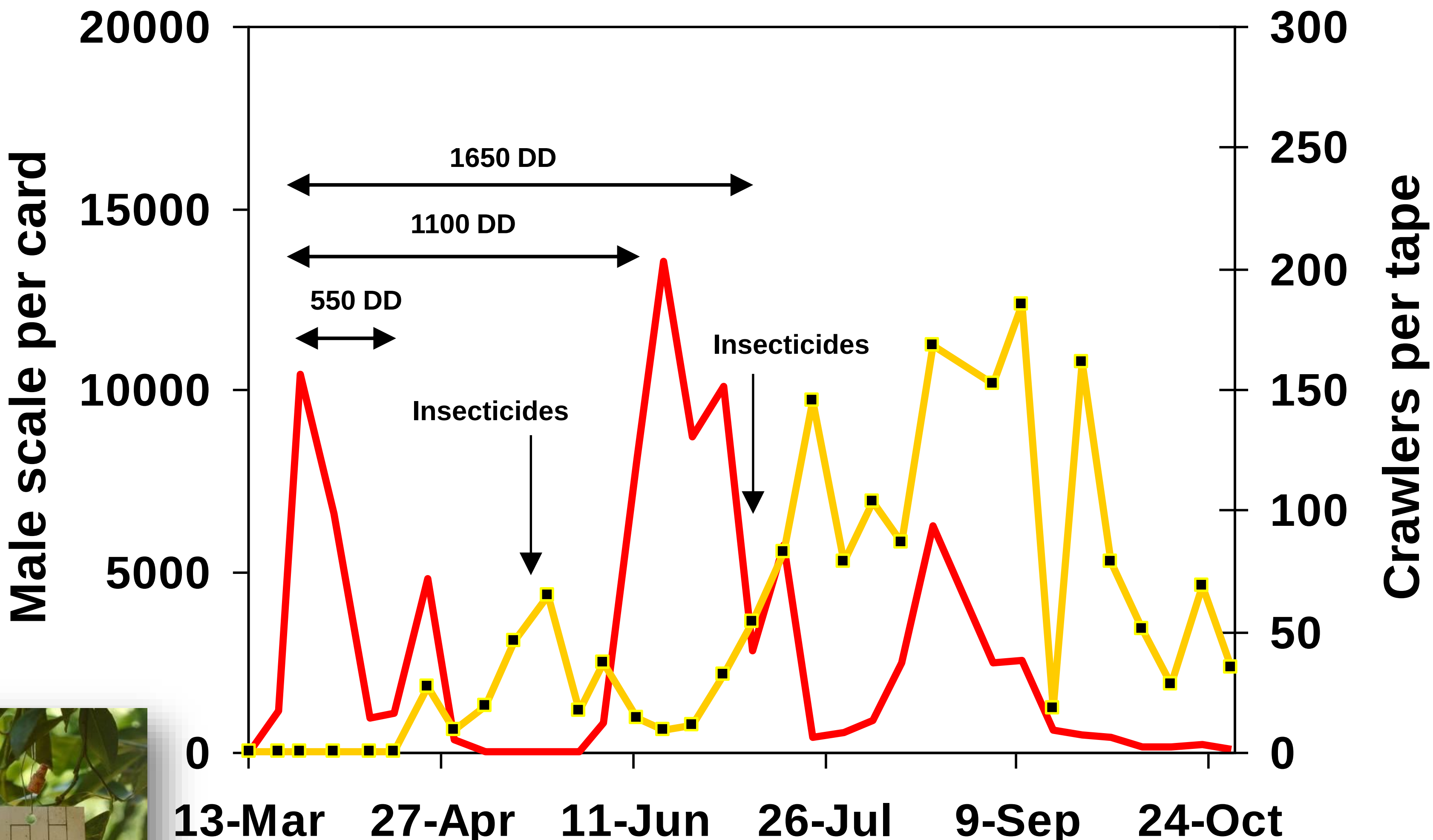
California Red Scale

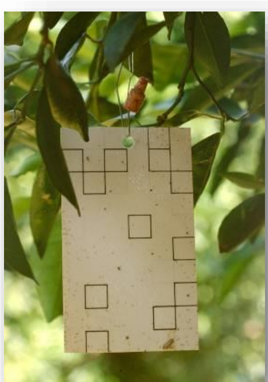
Monitoring: pheromone traps, % infested fruits, crawler tapes





Pesticide treatments timed using degree days = accumulation of the average daily temperature above the lower developmental threshold (53ºF)





California red scale management

Chemical control:

Soft pesticides:

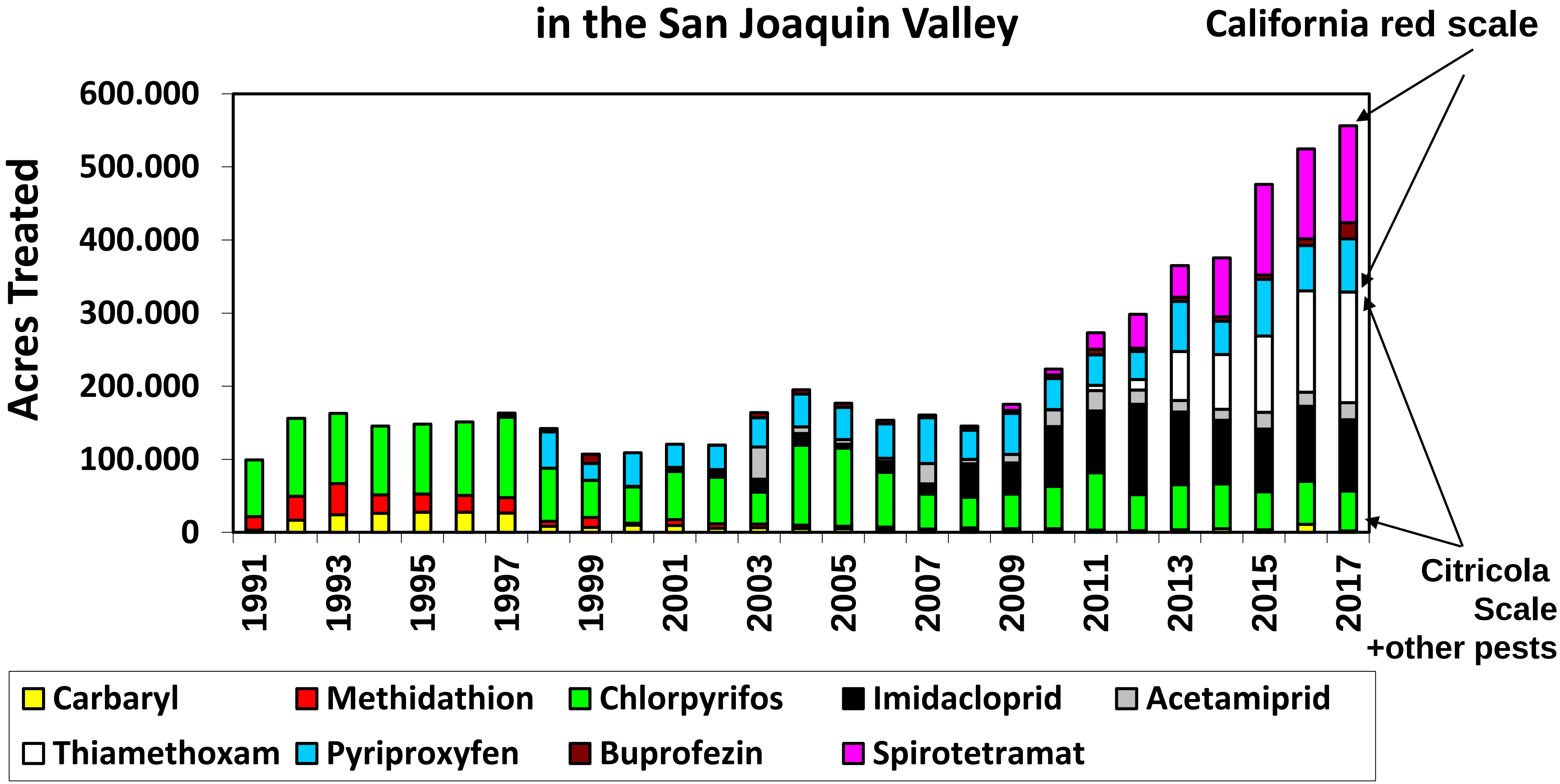
- Oil
- pyriproxyfen* (Esteem) (1998)
- buprofezin (Applaud/Centaur) (1998)
- spirotetramat (Movento) (2008)

Broad spectrum pesticides:

- chlorpyrifos* (Lorsban)
- carbaryl* (Sevin)

*resistant populations

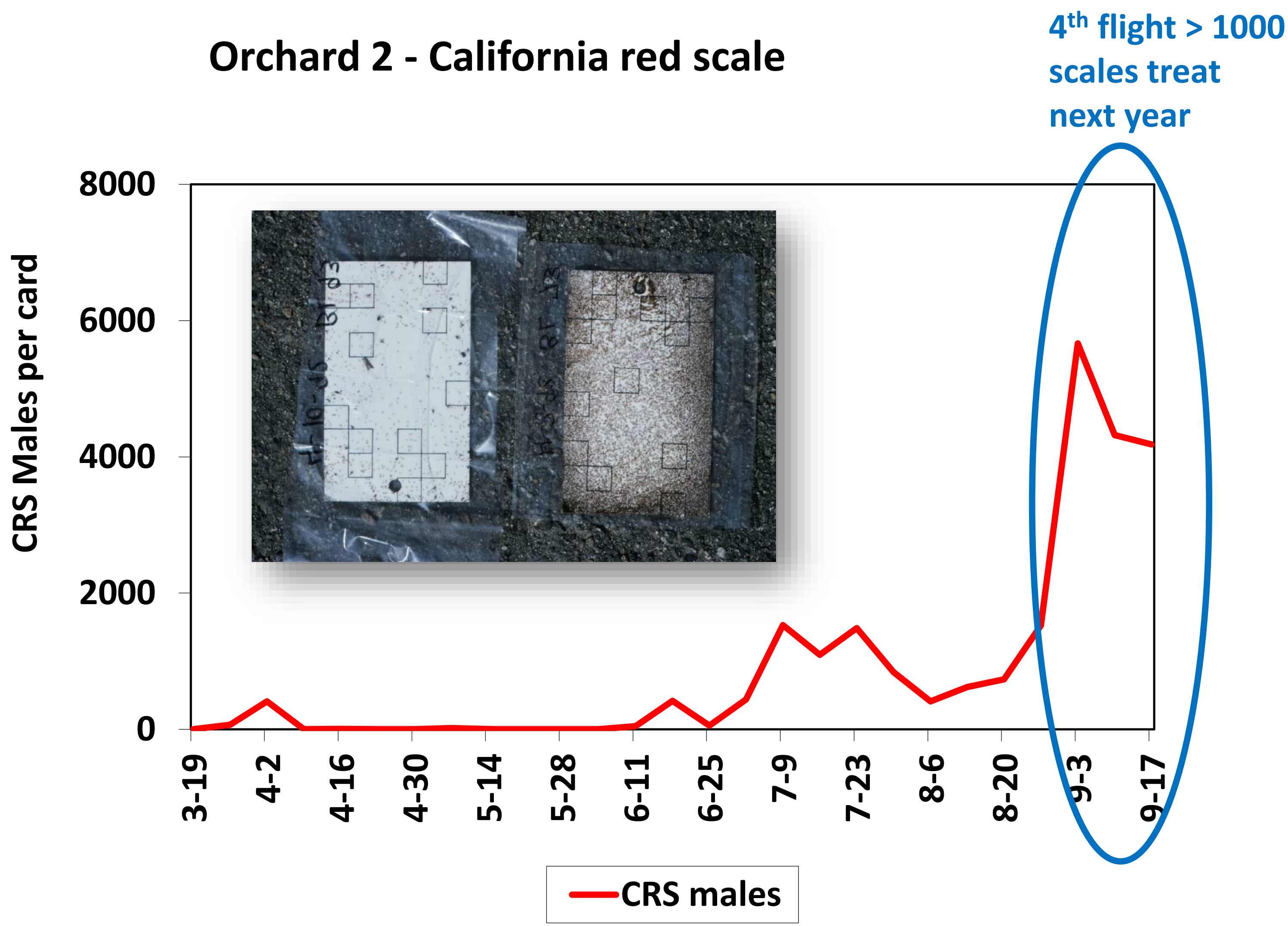
Insecticides Used for Scale Control in the San Joaquin Valley



Chlorpyrifos is also used for caterpillars, katydid, ants, and soft scale pests
Methidathion, malathion, and carbaryl are also used for cottony cushion scale
Imidacloprid and acetamiprid are used for GWSS, but provide some scale control

When to spray: decision making

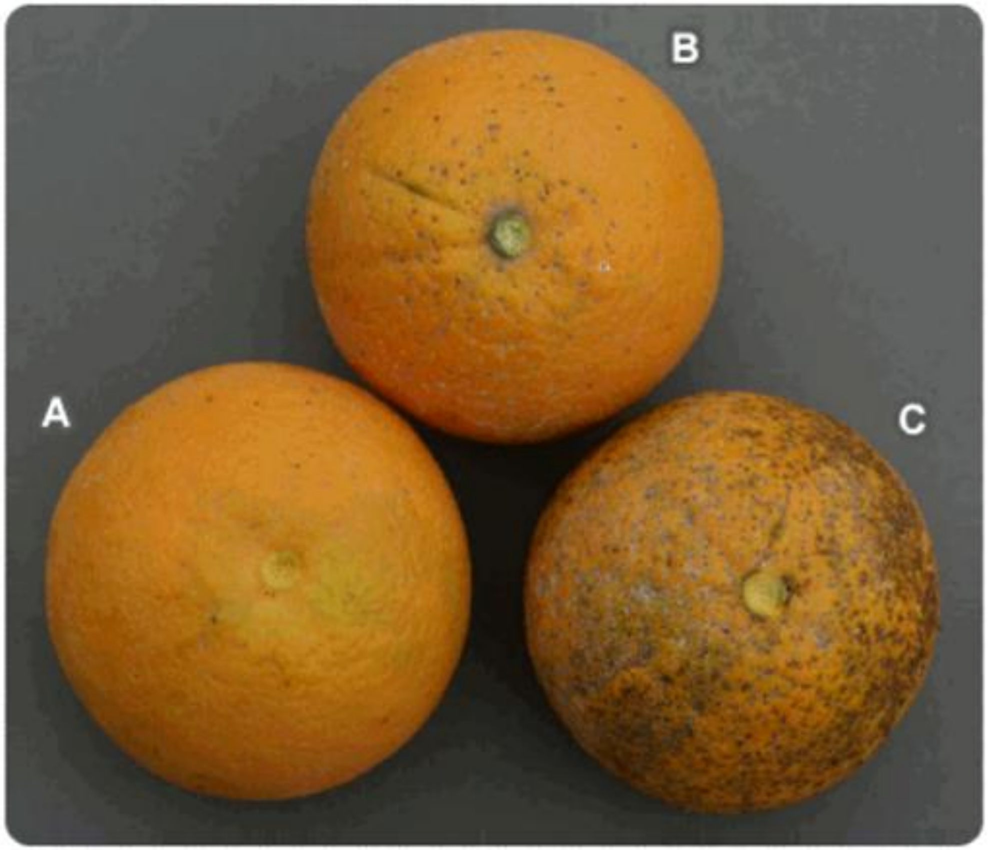
Pest Control Advisors have traditionally used pheromone cards to watch populations on a weekly basis – or put them out during the 4th flight to decide which orchards to spray next year.



During the season: check leaves and twigs and the wood for live scale

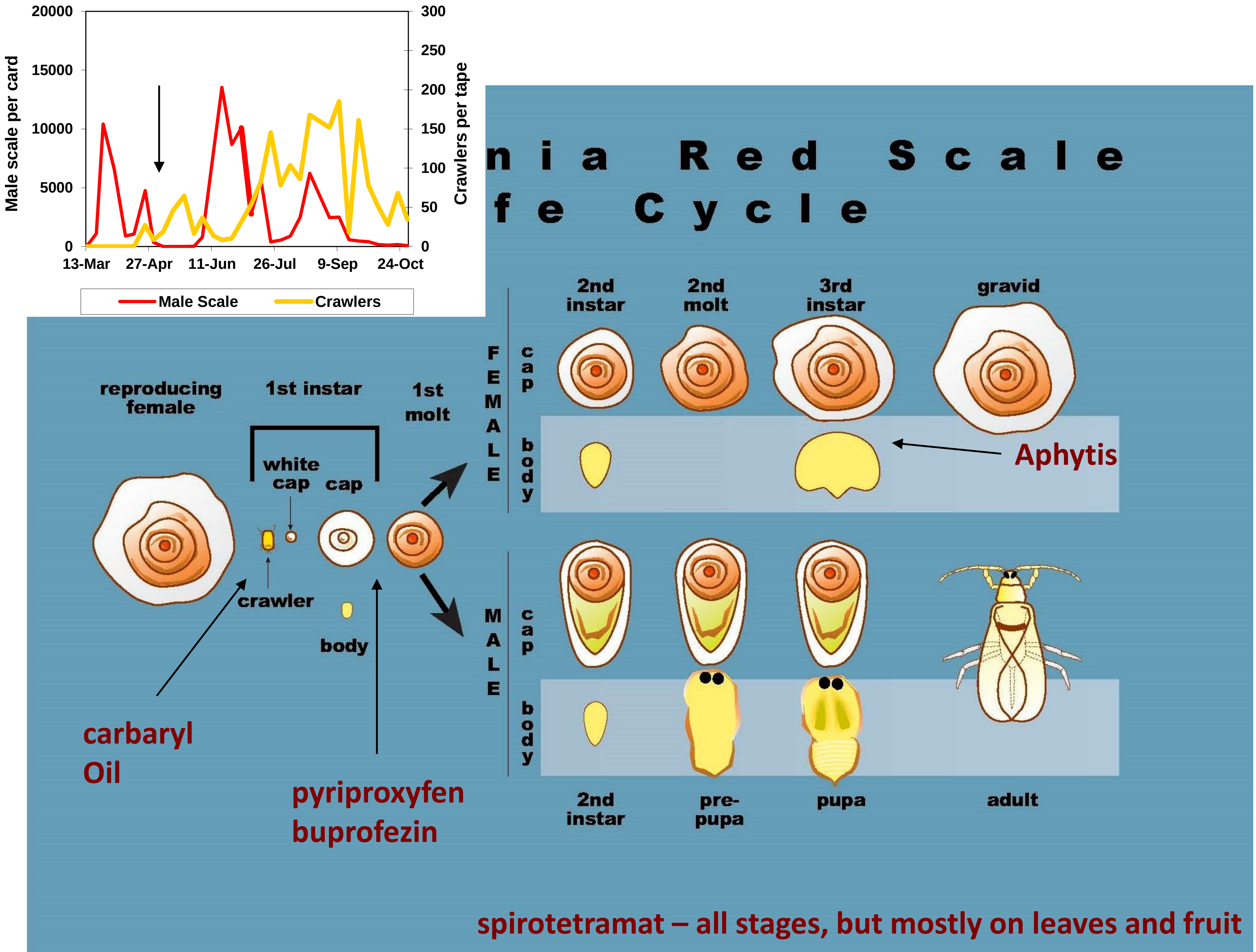
- Is the scale just on the dusty roads or throughout the orchard? (edge effect)
- Look at the interior and tops of the tree to see if scale is building there (improve coverage)
- Rub your thumb lightly over the scales and see if they easily rub off (get to know live vs dead scale)
- One month after treatment, take samples back to the office and look closely at 2nd and 3rd instar scales to see if they are healthy or parasitized (is biological control helping?)

Walk the orchard and check fruit for live scale
At harvest check bins of fruit



Estimate the % of fruit with >10 scales

If you find more than 5% of fruit infested, the block likely needs a treatment next year



Male scale per card
Crawlers per tape
20000
15000
10000
5000
0
300
250
200
150
100
50
0
13-Mar
27-Apr
11-Jun
26-Jul
9-Sep
24-Oct
Male Scale
Crawlers
nia Red Scale
fe Cycle
reproducing female
1st instar
1st molt
white cap
cap
crawler
body
FEMALE
cap
body
2nd instar
2nd molt
3rd instar
gravid
Aphytis
MALE
cap
body
2nd instar
pre-pupa
pupa
adult
carbaryl
Oil
pyriproxyfen
buprofezin
spirotetramat – all stages, but mostly on leaves and fruit

Recommendations for chemical control of California red scale:

- **Timing: treat the stage that is most sensitive**
- **Treat generations 1 or 2 when the scale population is uniform in stage (exception is spirotetramat, which seems to work in fall)**
- **Use the selective insecticides that allow natural enemies to survive when you can**
- **Rotate products to avoid resistance**
- **Good coverage: 750-1500 gpa (7000-15000 l/ha) (spirotetramat 2500-5000 l/ha)**
- **Drive slowly! < 1.5 mph (2.4 kph)**

Aphytis melinus parasitoid releases

Release 5,000 wasps/acre every two weeks, every six tree in every sixth row from March 1 to October 31 = 100,000/acre for the entire season

California red scale management

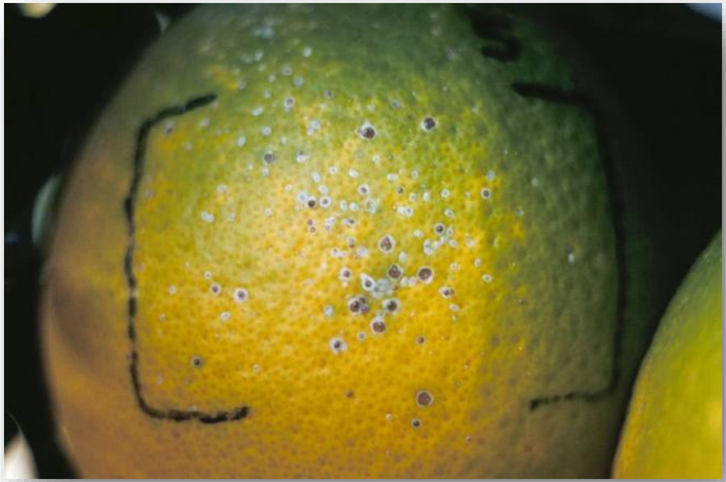
Cultural Control:

Reduce dust, prune trees, high pressure washer, minimize broad spectrum insecticides

Biological Control:

***Aphytis melinus*: Release 5,000/acre every two weeks from March 1 to October 31 = 100,000/acre (250,000/hectare)**

Cost: $.85/1,000 wasps = $85/acre ($200 USD/hectare)



*resistant populations

Issues that are game-changers for citrus IPM

- **Weather**

Dry hot years promote these pests :

***California red scale

Citrus red mite

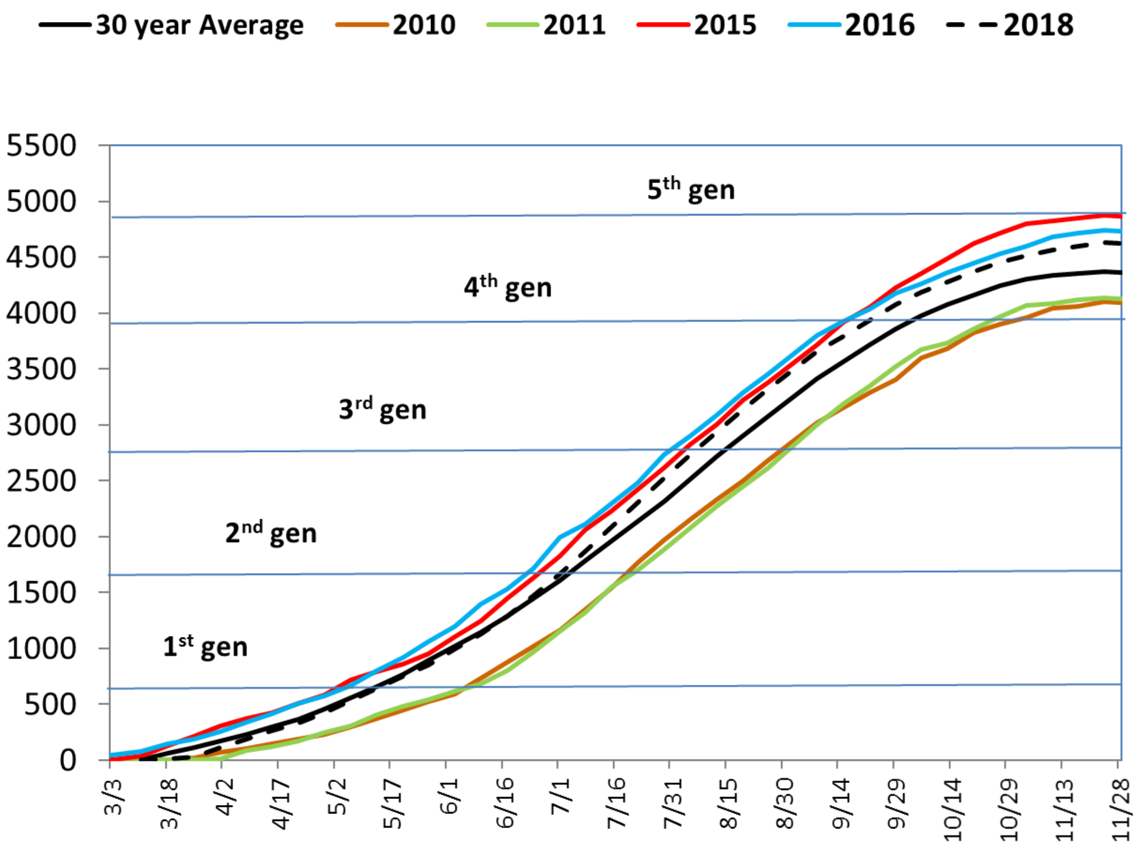
Citrus thrips

Cool wet years promote these pests:

Citricola scale

Snails

California Red Scale Degree Days
Lindcove Research and Extension Center



Factors that caused red scale problems to escalate in 2012-2019?

1. Heat = fast development of scale, more generations and the parasites don't keep up
2. Warm winter = scales of all stages developing at all times, less overwintering mortality
3. In season drought – dusty, stressed trees have more scale, parasites don't work as well
4. Insecticide treatments only last about 1 generation – forcing growers to treat more often
5. Some insecticides don't control scales on wood (imidacloprid, spirotetramat)

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

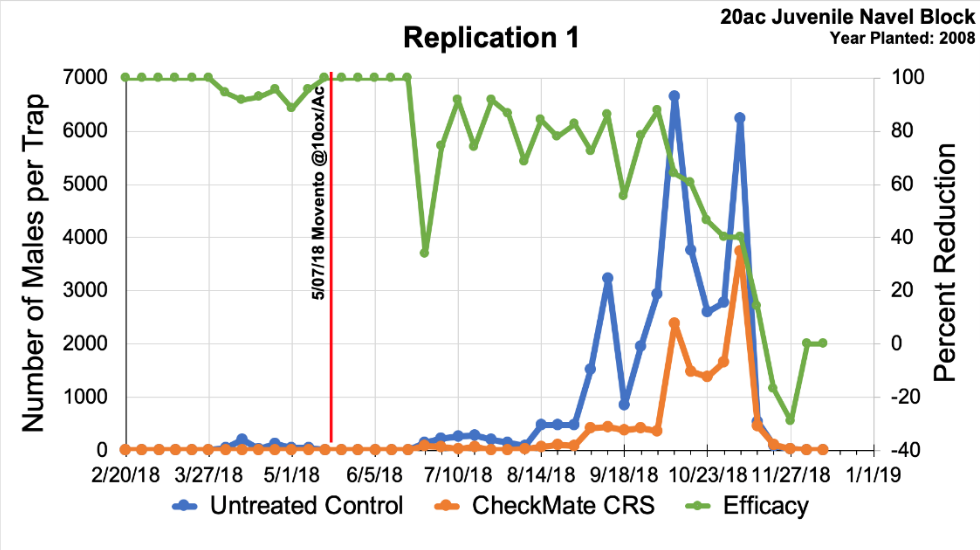
Citricola scale — acetamiprid, thiamethoxam, imidacloprid, buprofezin

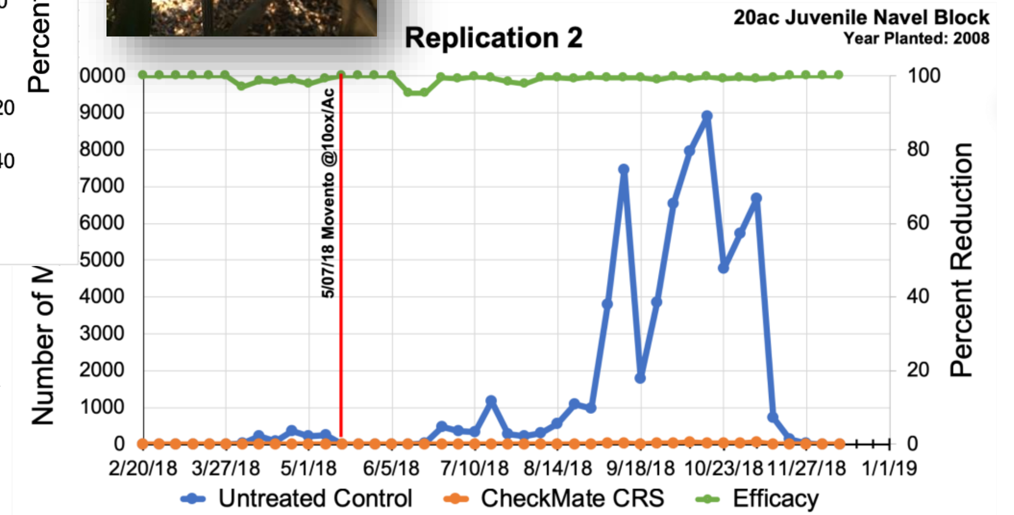
California red scale — pyriproxyfen, spirotetramat, carbaryl, oil — X 2-3

Broad spectrum

Soft on natural enemies

6-7 insecticides/year





- **5 orchards**
- **10-20 acre (4-8 ha) plots**
- **Split control/pheromone *Checkmate CRS lures***
- **180 dispenser/acre**
- **Deployed February 16th 2018**

Treatment Rep	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
	% Fruit with >10 Scale				
Date	Dec 7th, 2018	Dec 3rd, 2018	Dec 8th, 2018	Dec 10th, 2018	Dec 11th, 2018
Untreated Control	6.62	11.63	2.09	0.63	5.03
Suterra pheromone dispenser	7.23	0.18	0.19	0.01	0.28
Percentage Reduction	0	98.4	91.1	98.7	94.5
Chemical Application (In Both Control & Treatment)	5/07/18 Movento @ 10oz/ac	5/07/18 Movento @ 10oz/ac	5/07/18 Movento @ 10oz/ac	No	5/21/18 Movento @ 10oz/ac

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San Joaquin Valley Pest Management Navels & Mandarins

Citrus Red Mite — Oils, miticides

Citrus thrips + katydids

Thrips: spinetoram, cyantraniliprole, abamectin, formetanate
Katydids: pyrethroid, diflubenzuron, kryocide

Citricola scale — buprofezin, acetamiprid, thiamethoxam, imidacloprid

California red scale — pyriproxyfen, spirotetramat, carbaryl, oil + pheromone

Broad spectrum

Soft on natural enemies

4-5 insecticides/year

California Red Scale and its Natural Enemies

A study of the biology and management

https://campus.extension.org

next »

Beth Grafton Cardwell

Dept. of Entomology, University of California Riverside

Issues that are game-changers for citrus IPM

- Weather
  - Dry conditions promote red scale and thrips
- Pests of Export Concern and MRLs
  - South Korea
  - Australia/New Zealand

Pests of Export significance – reduction in MeBr use requires in-field treatments

S. Korea

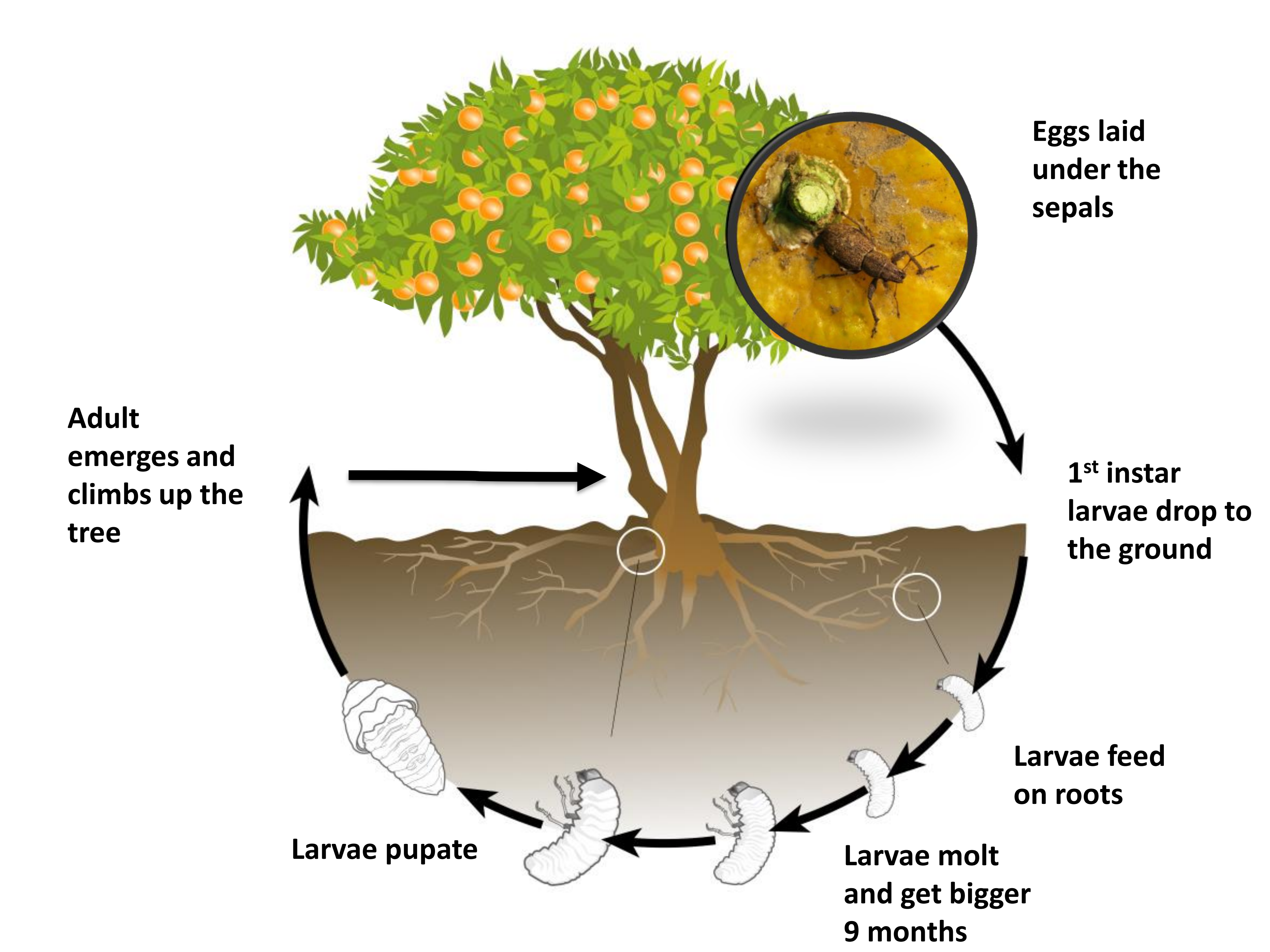
Fuller rose beetle

California red scale

Australia & New Zealand

Bean thrips

Mites


Eggs laid under the sepals
1st instar larvae drop to the ground
Larvae feed on roots
Larvae molt and get bigger 9 months
Larvae pupate
Adult emerges and climbs up the tree

Protocol to ship to S. Korea: Fuller rose beetle

Eggs deposited under the calyx of fruit

Larvae/pupae in the ground.

Adults emerge year round and climb trees

Skirt Prune

2 treatments: foliar thiamethoxam or soil bifenthrin

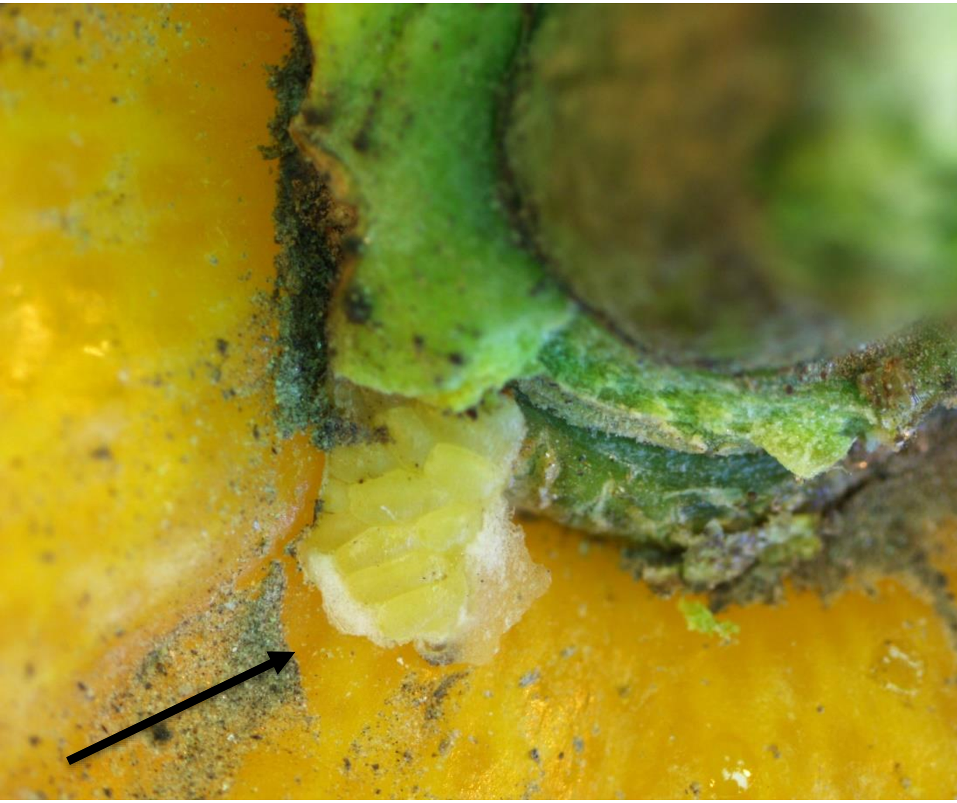
harvest

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

Peak adult emergence

Growers eliminate groves from Korean export if they find high numbers of adult beetles using a beating sheet

Orchards are also checked for FRB eggs prior to harvesting, using a metal tool to lift up the sepals and look for eggs.



Live eggs
– whitish or yellowish and plump

Dead or hatched eggs
– dried out

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

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Citricola scale

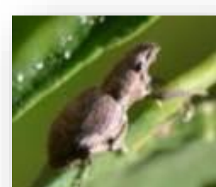
acetamiprid, thiamethoxam, imidacloprid, buprofezin

California red scale

pyriproxyfen, spirotetramat, oil, buprofezin, carbaryl

+ pheromone

Fuller rose beetle



thiamethoxam or bifenthrin x 2

Broad spectrum

Soft on natural enemies

6-7 insecticides/year

Issues that are game-changers for citrus IPM

- Weather
  - Dry conditions promote red scale and thrips
- Pests of Export Concern and MRLs
  - South Korea
  - Australia/New Zealand
- Invasive Pests

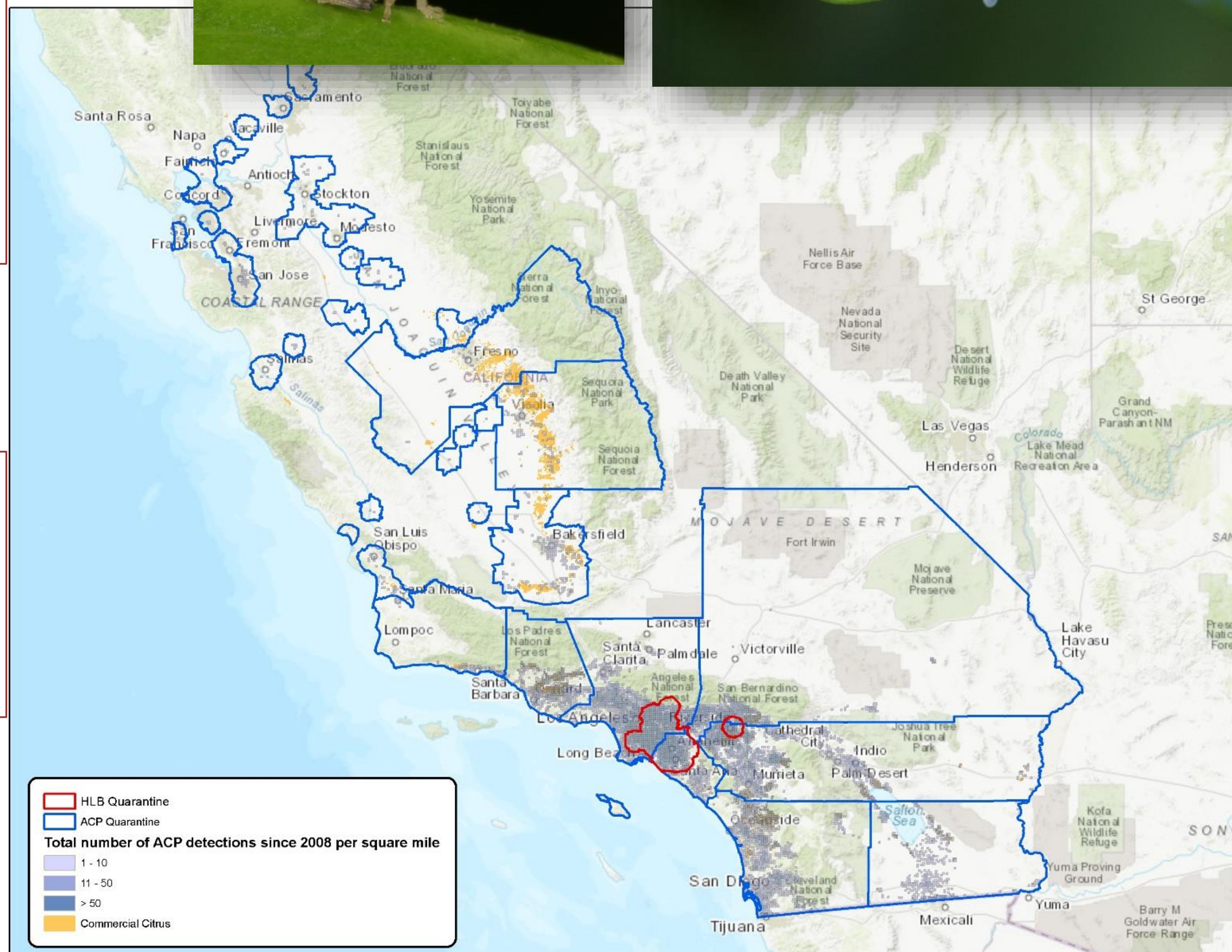
The California Situation

Goal: reduce psyllids to reduce the spread of disease

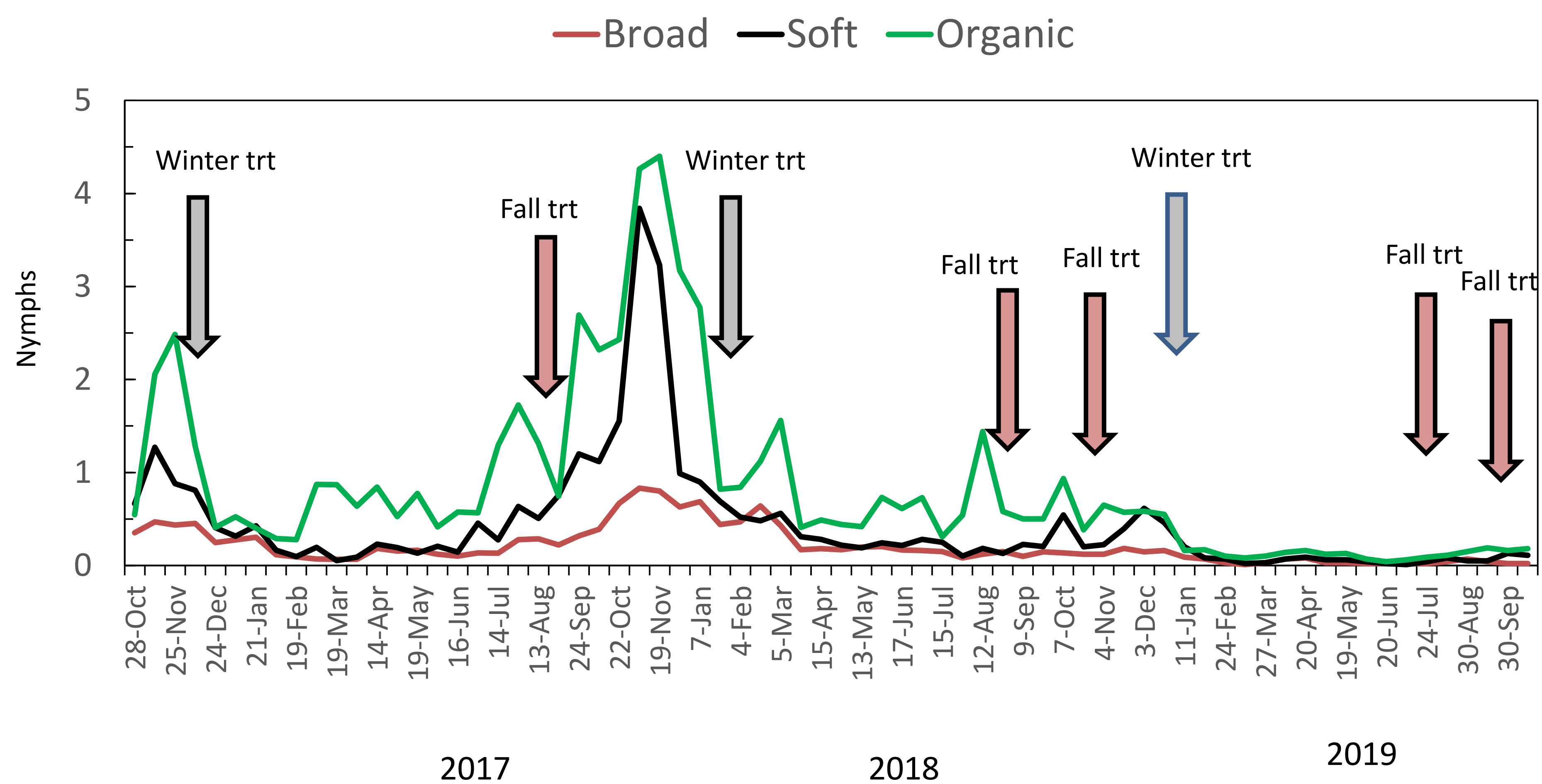
http://ucanr.edu/sites/ACP/

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

Southern California:
<u>Area-wide treatment program</u>
Commercial citrus: Growers treat together over a 2-3 week window (early winter & fall)
Urban: parasites released



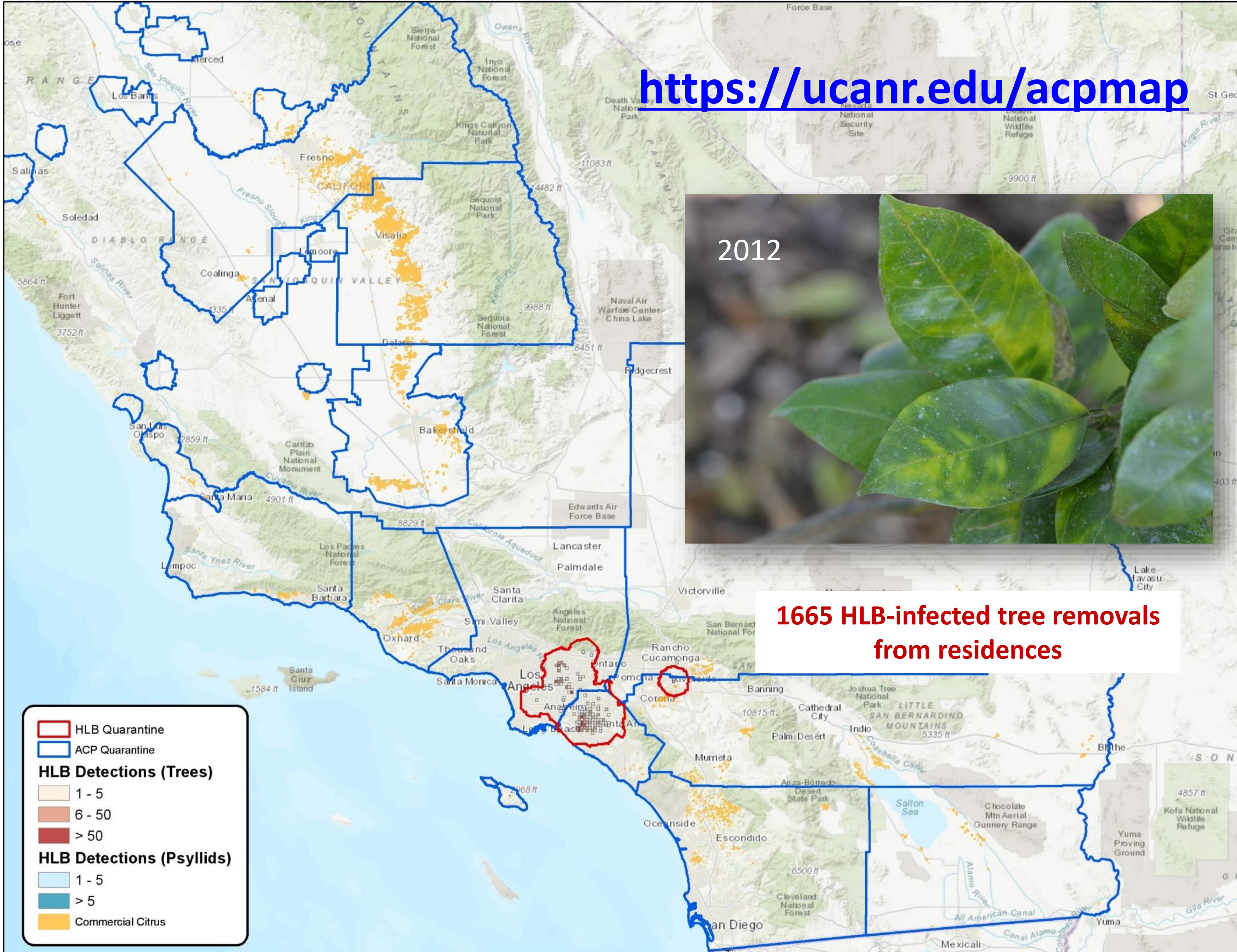
Average of 44 Ventura Sites by Management Strategy
Nymphs per Flush



Broad: pyrethroids, imidacloprid, thiamethoxam, flupyradifurone, OPs

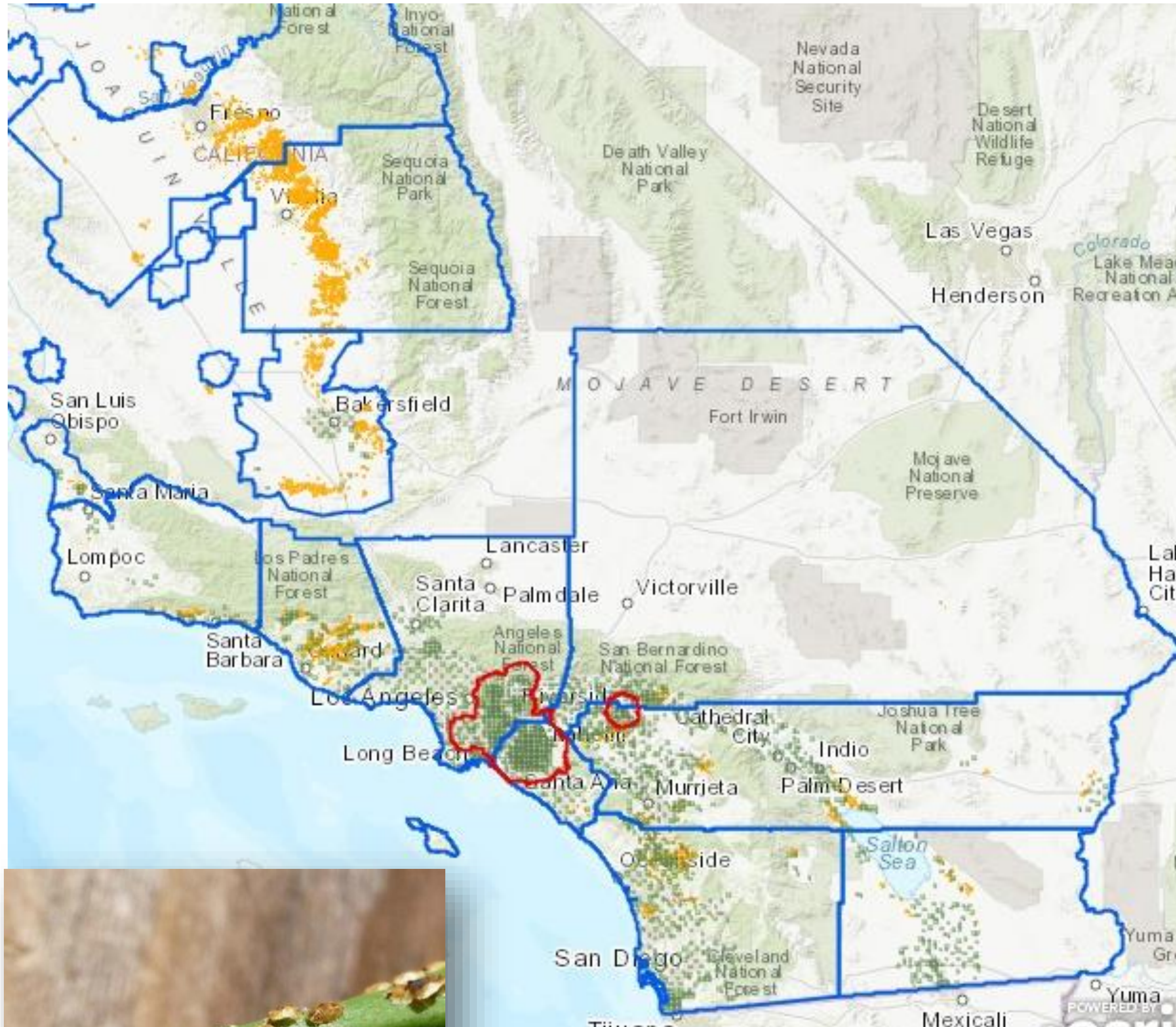
Soft: spinetoram, spirotetramat, cyantraniliprole, abamectin

Organic: pyrethrins, spinosad, Oil, kaolin https://ucanr.edu/acpmap



1665 HLB-infected tree removals from residences

Tamarixia radiata parasite releases



USDA/UC Releases have been successful, the parasites are spreading – however parasitism is not enough to prevent disease spread.

www.ucanr.edu/sites/acp

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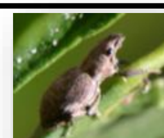
California red scale — pyriproxyfen, spirotetramat, buprofezin, oil, carbaryl

Fuller rose beetle — thiamethoxam or bifenthrin x 2



Broad spectrum

Soft on natural enemies

Asian citrus psyllid

pyrethroid

7-8 insecticides/year

neonicotinoid

https://ucanr.edu/sites/scienceforcitrushealth/

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Goals of California Citrus IPM

Manage pests in a way that is economical and sustainable. Minimize broad spectrum pesticide use to maximize natural enemies. Address pesticide resistance, worker safety, bee health and environmental issues.

Biggest issues affecting the citrus IPM program:

- **Weather changes**
- **Export Issues**
- **Invasive Pests**
- **Availability of pest control tools and pesticide resistance**