Navel orangeworm biology, monitoring, and management

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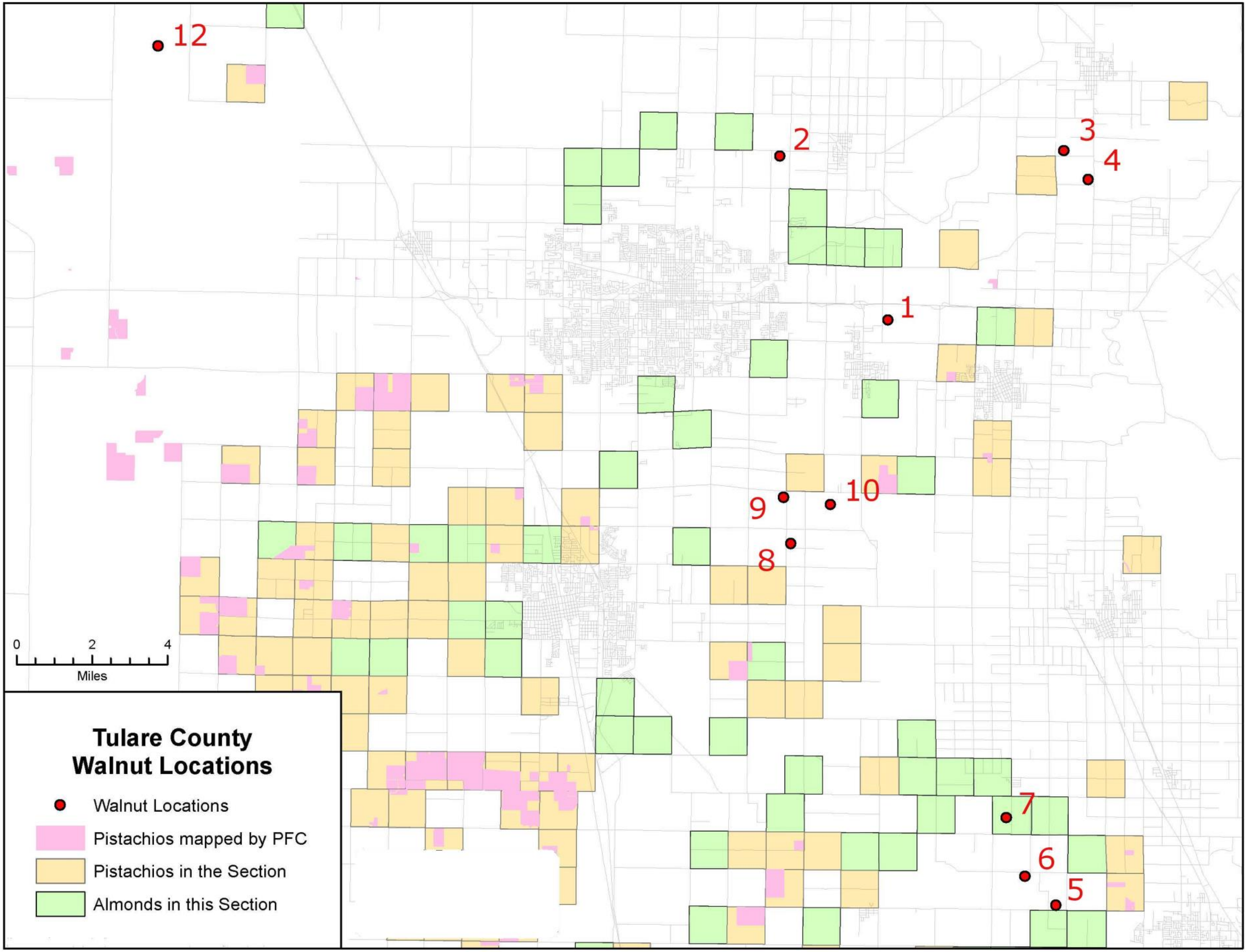
Topics, NOW Monitoring and Management

1) Importance of NOW as a primary cause of damage
2) Source of NOW—resident or immigrant populations?
3) Monitoring tools for NOW—characterization of NOW Biolure
4) Pest management tactics for NOW

Importance of NOW as a primary cause of damage in walnuts



12
2
3
4
1
10
9
8
7
6
5
0 2 4
Miles
Tulare County
Walnut Locations
Walnut Locations
Pistachios mapped by PFC
Pistachios in the Section
Almonds in this Section

Harvest sampling procedures

- 1,000 nuts taken from center of block
- Three sampling times
  - Pre-harvest (poled, end of August)
  - First commercial shake (mid-September)
  - Second commercial shake (early October)
- Expectation: CM damage stable past husk split; NOW increases

Percent insect damage by site and harvest

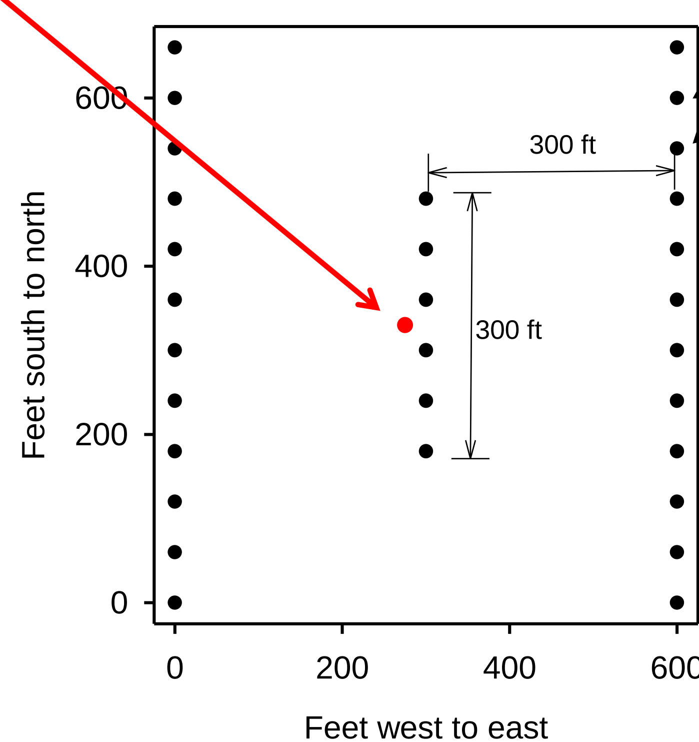
Percent insect damage by site and harvest, 2013

Site	Pre-harvest	Harvest 1	Harvest 2
1	0.2	0.9	3.8
2	0.0	0.0	0.0
3	0.0	0.0	0.3
4	0.1	1.0	1.3
5	0.0	0.1	3.0
6	1.0	17.2	
7	0.0	0.2	
8	0.0	0.1	
9	0.1	1.4	3.4
10	0.9	7.2	

- Significant trend of increasing damage
- Indicates that NOW is the primary cause of damage in these locations
- "Problem blocks" have been consistent (1, 6, 10)
- These are taller blocks

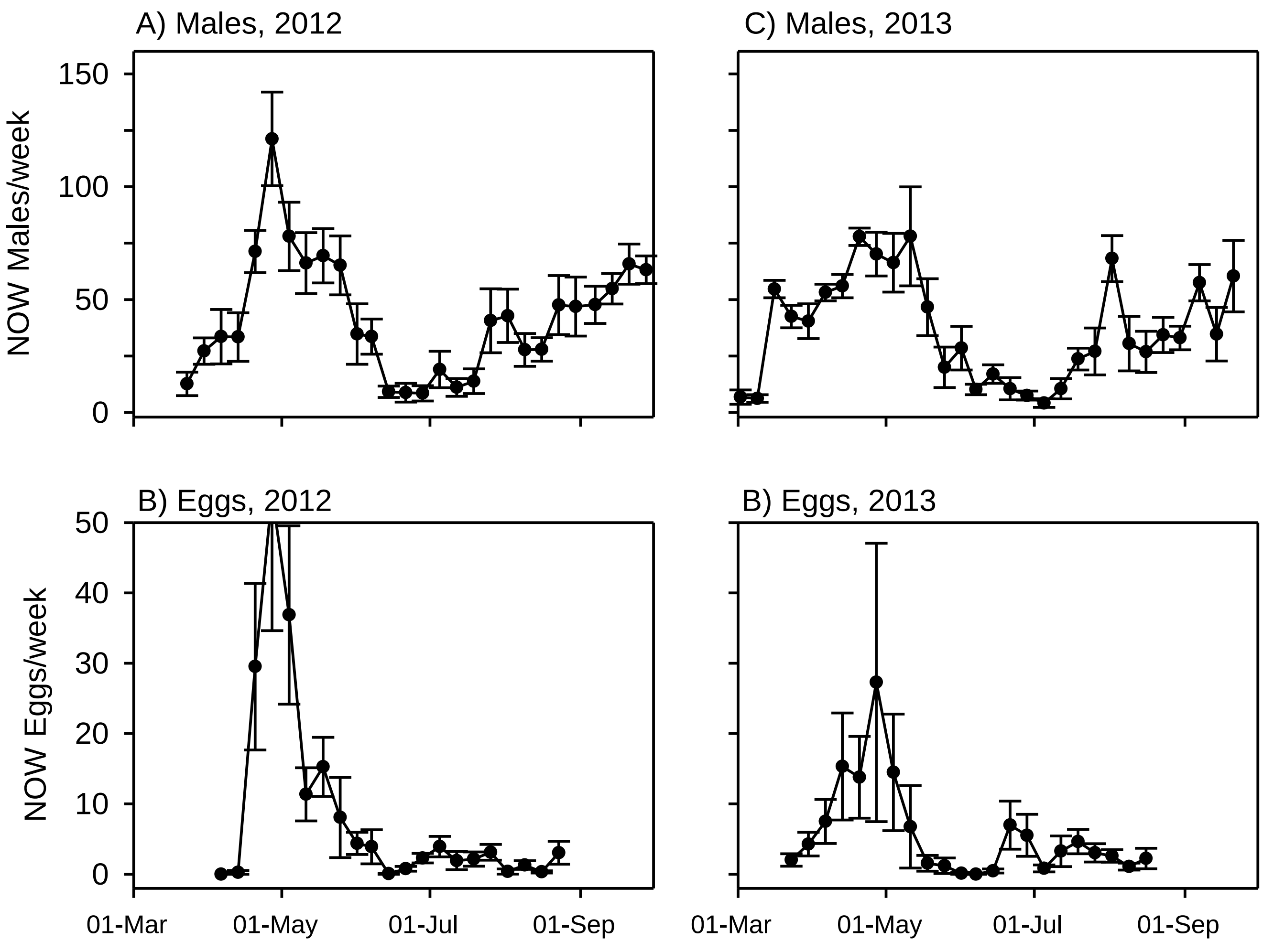
Does NOW damage come from resident or immigrant populations?

Monitoring for seasonal abundance



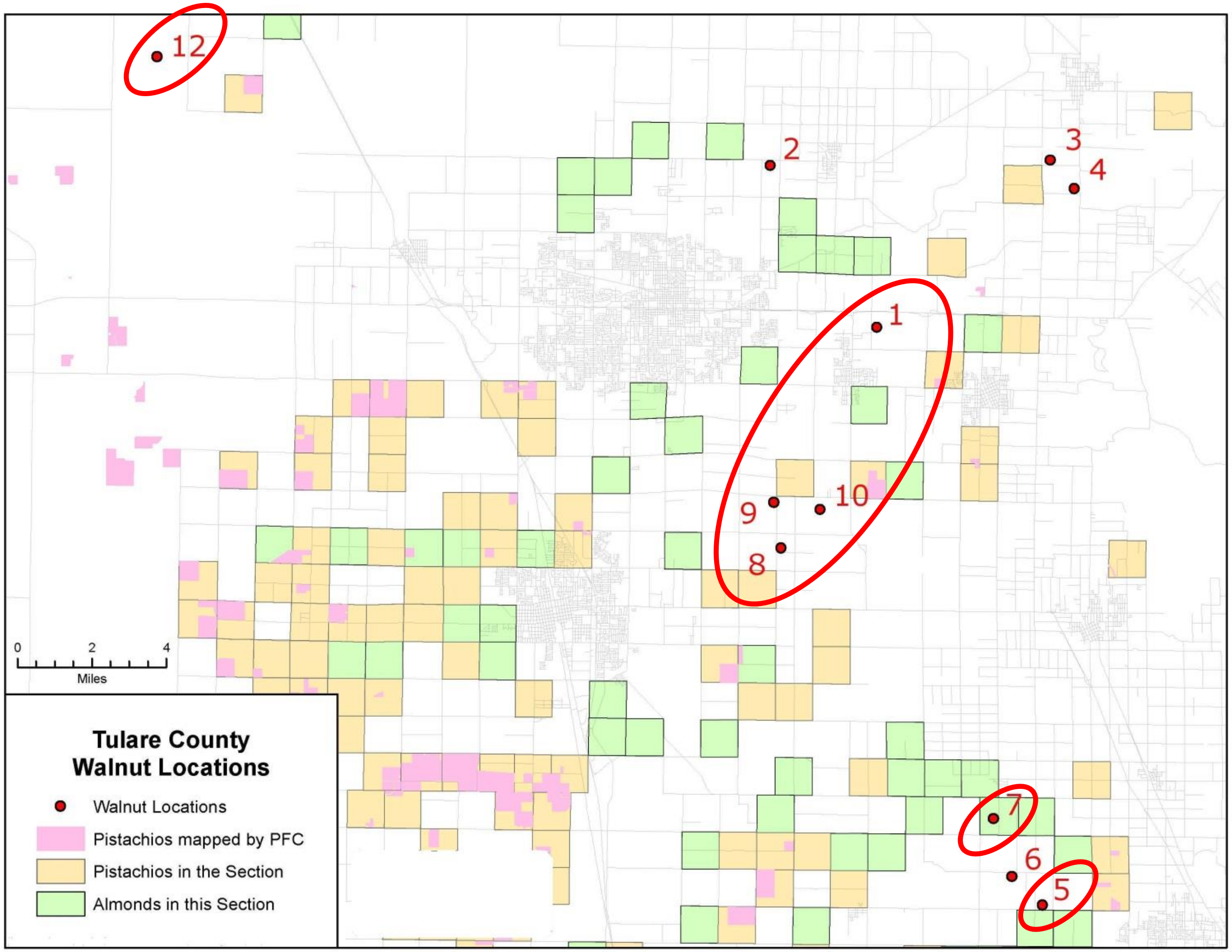
10-acre plots

Seasonal abundance, males and eggs, two years



- Biofix: males usually precede eggs
- Male data show presence throughout the growing season
- Egg detection poor, but showed second flight better than males

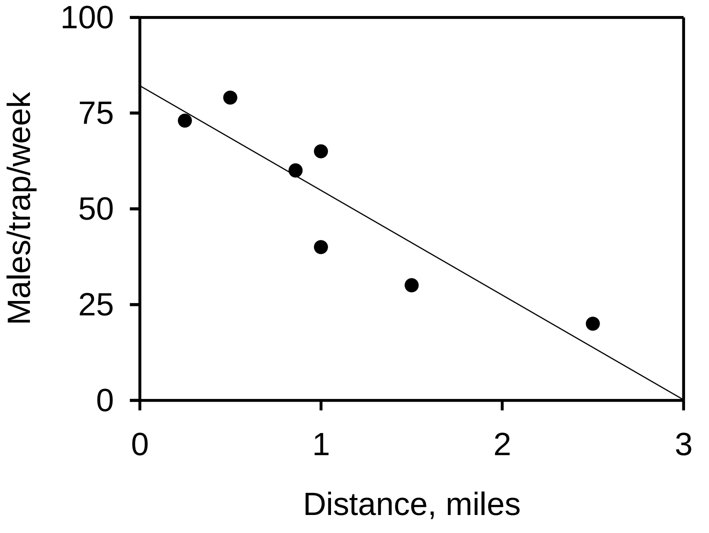
Non-mating disruption sites for NOW dispersal comparison



Non-mating disruption sites for NOW dispersal comparison

Expectation if males come from other nut crops…

Hypothetical relationship between males captured and distance to other nut crops…



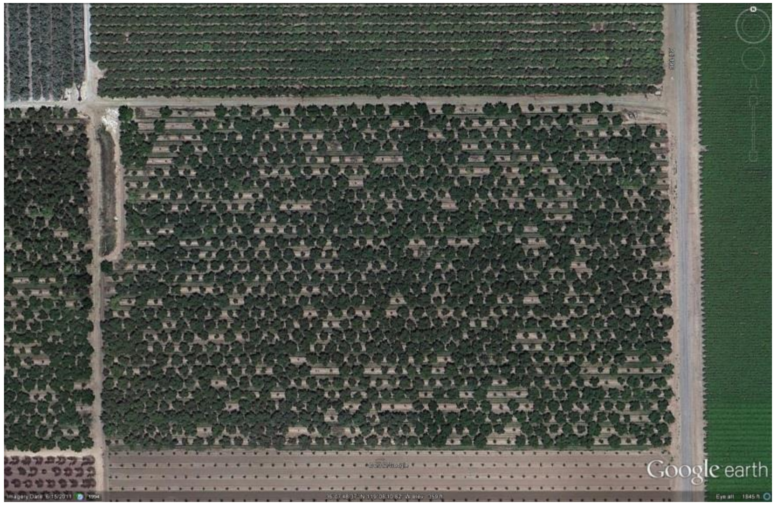
- More males if nearer other nut crops
- Slope and correlation coefficient are negative

No relation between distance from other nut crops and pheromone trap captures

Year	Flight	Spearman r	P
2012	1	0.20	0.67
	2	0.43	0.33
	3	0.43	0.33
2013	1	0.79	0.03
	2	0.58	0.18
	3	0.58	0.17

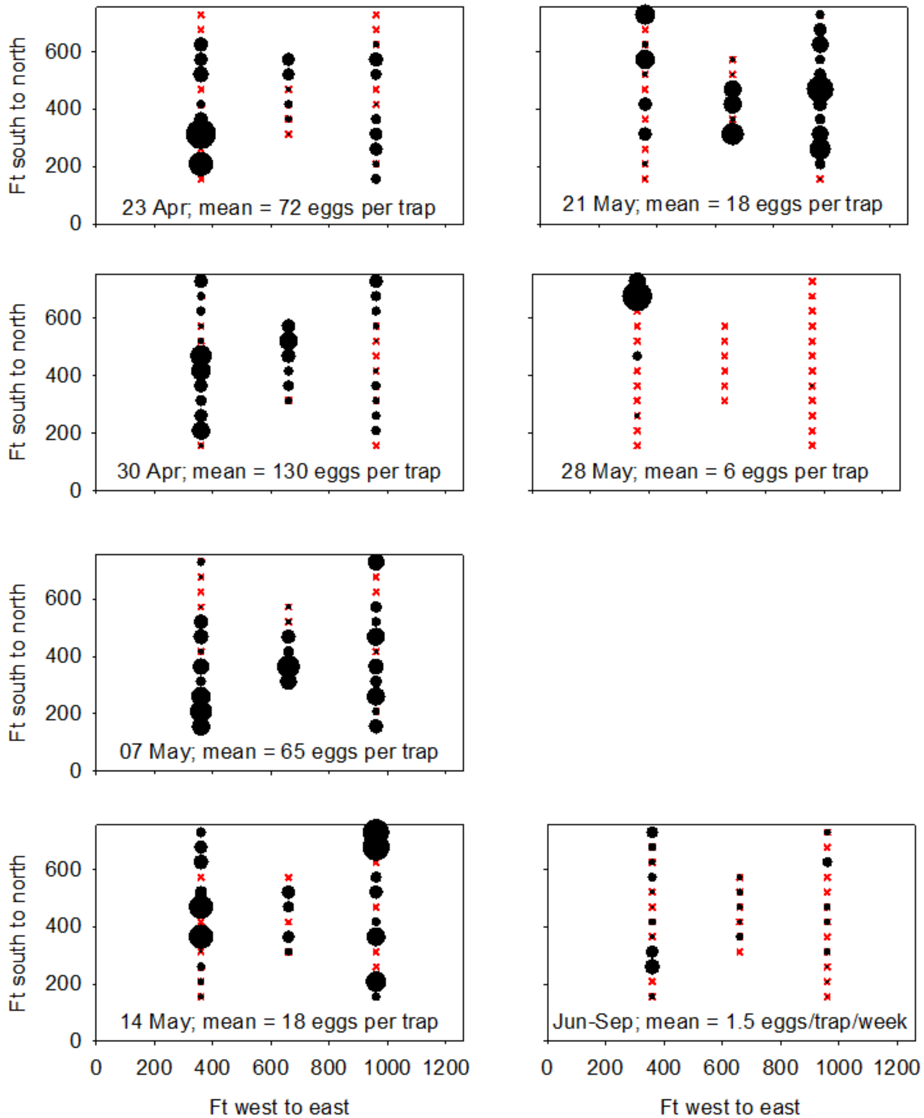
- Observed associations positive (and generally not significant)
- Negative (inverse) relationship expected if other nut crops are sources of NOW infestation in walntus

Distribution of egg on traps in a walnut site next to almonds



- Almonds (Nonpareil and polinator) to the north (above) of a Serr block
- Egg traps are short-range attractants
- Distribution of eggs on grid of 30 traps used to ask whether there are more eggs nearer the almonds than farther away

Distribution of egg on traps in a walnut site next to almonds—2012



- Diameter of black dots proportional to eggs on trap positions (shown with red x
- There were not significantly more eggs in the north half than in the south half of the block

Distribution of egg on traps in a walnut site next to almonds—2013

Flight	Side	Eggs per trap	Kuskal-Wallis H
1	North	68 ± 14	0.0039
	South	61 ± 17	
2	North	0 ± 0	3.2116
	South	6 ± 4	
3	North	27 ± 7	0.5417
	South	28 ± 8	

- Nonparametric statistics used to compare eggs in north (newer almonds) and south (farther away).
- Differences between eggs in the two halves of the field were not statistically significant

Monitoring tools for NOW—characterization of NOW Biolure

Comparison of NOW Biolure and unmated females

Four traps…

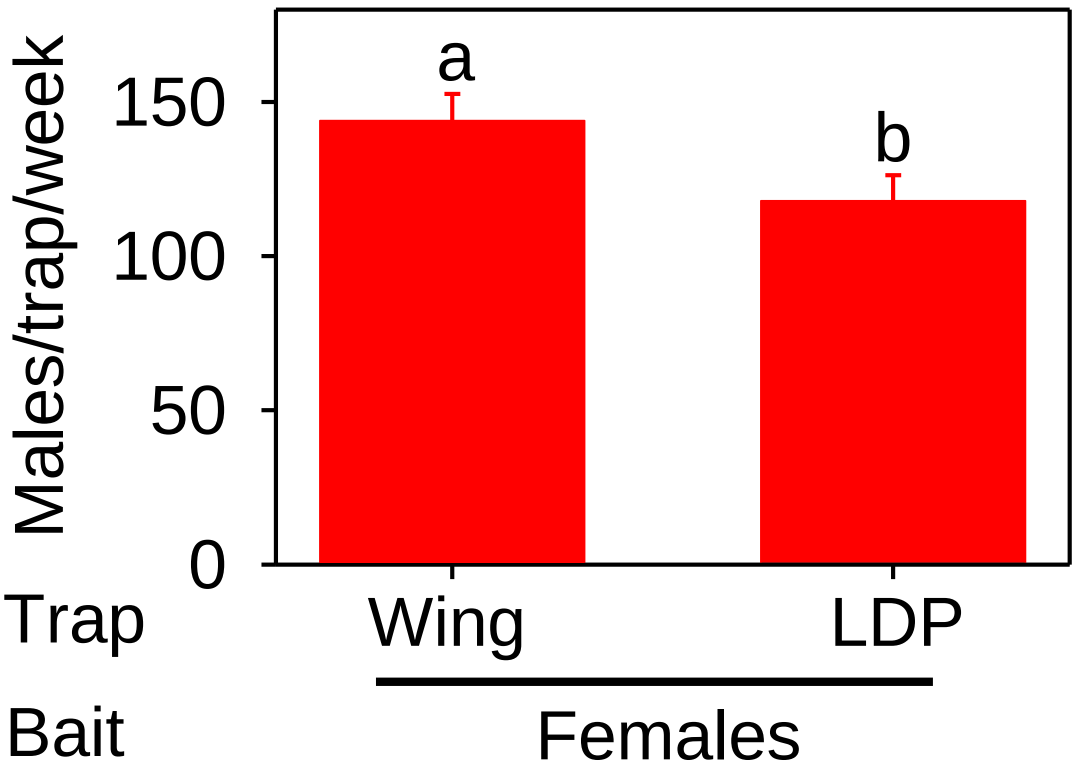



…four experiments

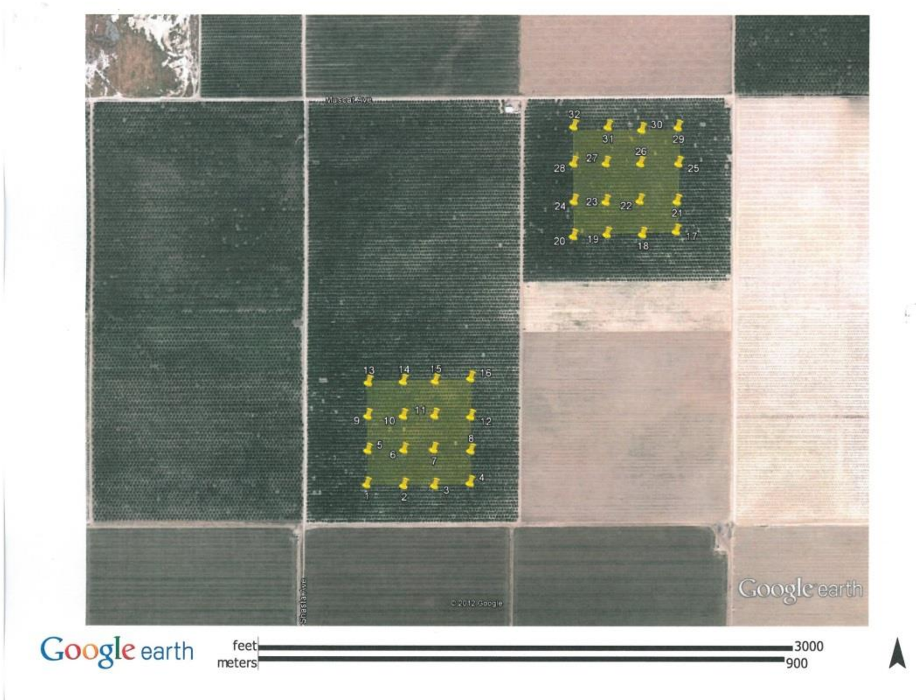
1) Wing vs. delta traps, unmated females only
2) Single-day experiment, almonds
3) Single-day experiment, walnuts
4) Season-long experiment, almonds and pistachios

Wing vs. LDP

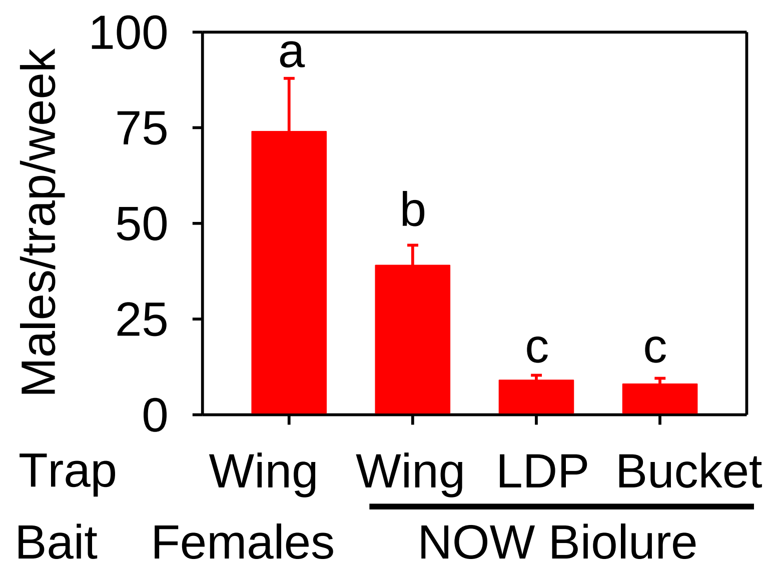
When both are baited with females, capture in wing and LDP traps is proportional to glue area (n = 8)



Four trap types—almonds, 2012



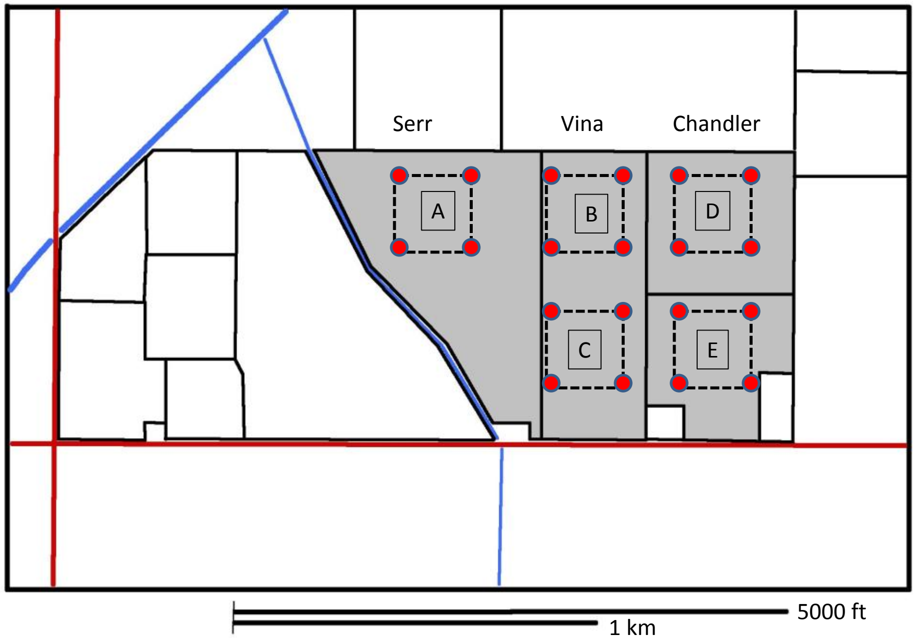
Treatment effects (mean ± SE)

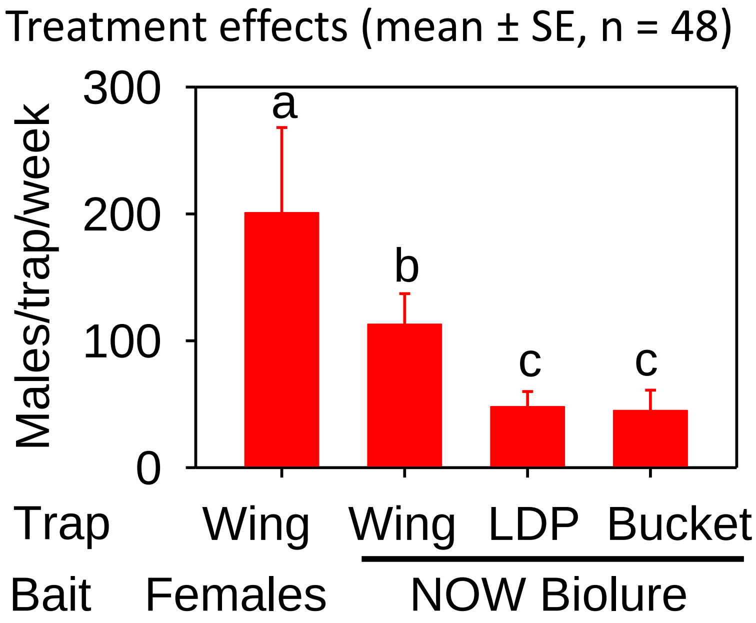


F = 32.2, df = 3,31; $P < 0.0001$

- Replicated 4 x 4 Latin square
- Inter-trap distance 50 m
- 1-day interval
- Repeated measure—14 nights during September 2012

Four trap types—walnuts, 2013



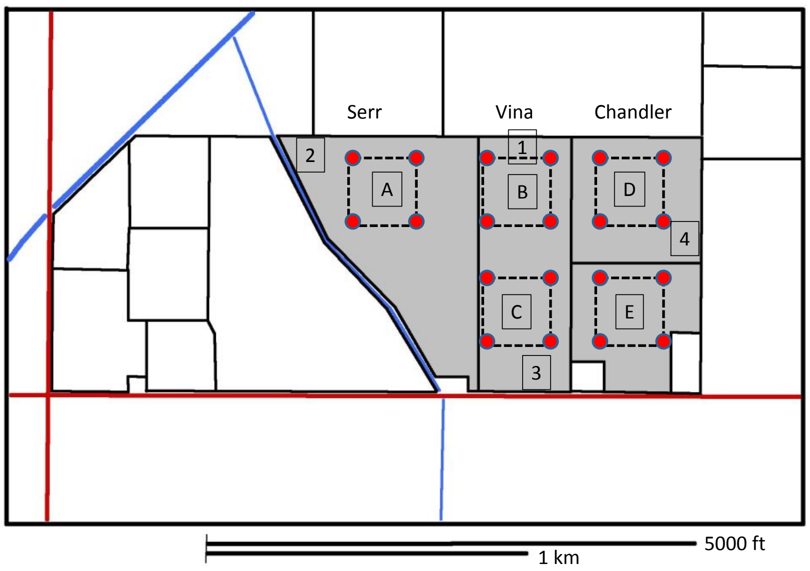


- Randomized blocks
- Inter-trap distance 180 m
- 14 nights during September 2013

Season-long trials, almonds & pistachios, 2013

- Inter-trap distance 200 m
- Trapping interval 3-4 days
- Lures tested 4-5 weeks
- Randomized block design
- 6 plots in each crop
- Little difference between wing traps baited with females or NOW Biolure
- Wing traps consistently out-performed delta traps when both baited with NOW Biolure

Effect of Trap density in walnuts



- Serr and Vina more susceptible than Chandler
- March-August: female-baited wing traps around periphery of block (1-4)
- September: replicates of trap-lure test (A-E)

Effect of Trap density in walnuts

Period	Trapping Unit	Observation periods	Males trapped
March-August	Trap 1	20 weeks	64 ± 4.9
	Trap 2	20 weeks	64 ± 6.3
	Trap 3	20 weeks	66 ± 7.1
	Trap 4	20 weeks	54 ± 5.9
	$F_{3,22}$ = 1.29	$F_{19,57}$ = 3.35***	
September	Plot A	3 days	116 ± 15a
	Plot B	3 days	115 ± 19a
	Plot C	3 days	87 ± 18ab
	Plot D	3 days	34 ± 5bc
	Plot E	3 days	21 ± 4c
	$F_{4,8}$ = 11.1***	$F_{2,8}$ = 1.3	

Differences between varieties apparent with dense traps, not with sparse traps

Summary, characterization of NOW Biolure

1) Wing traps and LDP traps capture proportional to glue area when both are baited with unmated females.
2) In one-day trials, wing traps baited with NOW Biolure captured ~50% fewer males compared to wing traps baited with unmated females. LDP and bucket traps performed similarly, with 10-20% of the capture in female-baited wing traps.
3) In wing traps, the number of males captured with NOW Biolure and with live females was more similar in multi-day tests.
4) When examining adjacent blocks, there is a trade-off between trap independence and local information.

Pest management tactics for NOW

NOW mating disruption outcomes: 2012 and 2013

2012	2013
Four mating disruption plots	Two mating disruption plots
Males abundant prior to mating disruption, and near-complete trap suppression	Few males in MD blocks prior to treatment. A few (1-4) males captured in the blocks during the season
In proportion to pre-treatment, significantly fewer eggs in MD blocks	Difference in proportion of eggs laid after treatment not significant
High damage in some MD blocks	High damage in some MD blocks

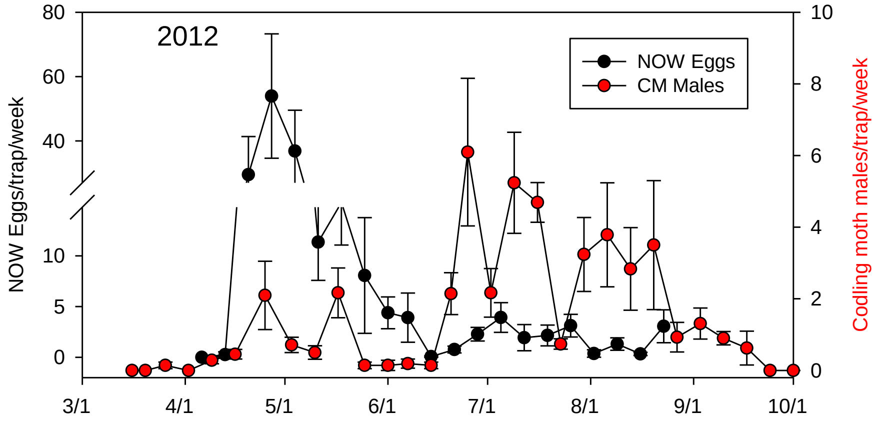
Mating disruption for NOW—practical considerations

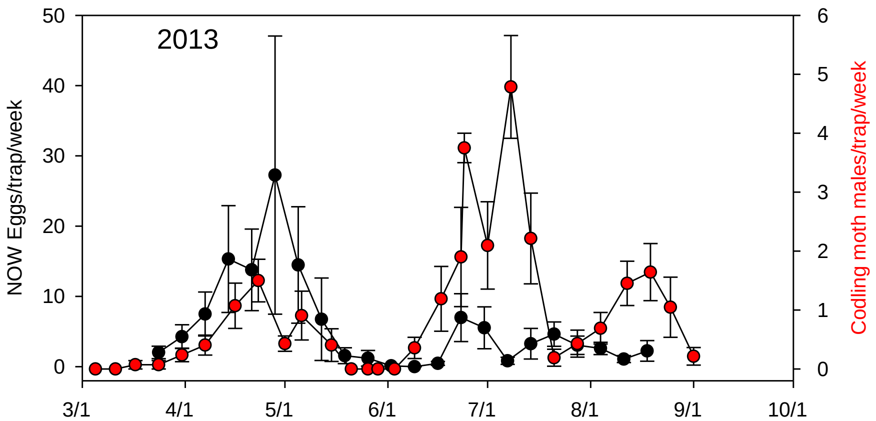
Block size

Canopy height

Existing control

Insecticide timing: NOW and CM



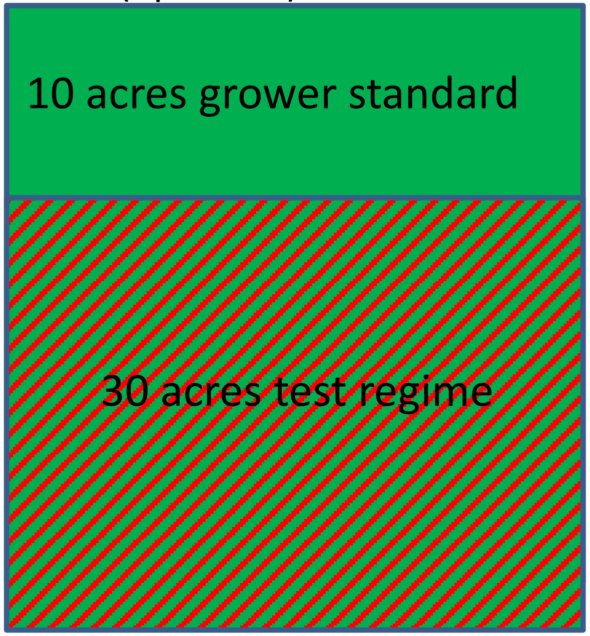


- NOW eggs: not representative for later flights
- CM 1B vs. start of NOW oviposition

CM Biofix	Plus 600 DDF	NOW First egg peak	Days difference
4/7/2012	5/19/2012	4/20/2012	29
3/31/2013	5/11/2013	3/31/2013	41

NOW Spring Treatment

40 acre block; presume north-south (up-down) rows



Treatment regimes

Grower’s standard:

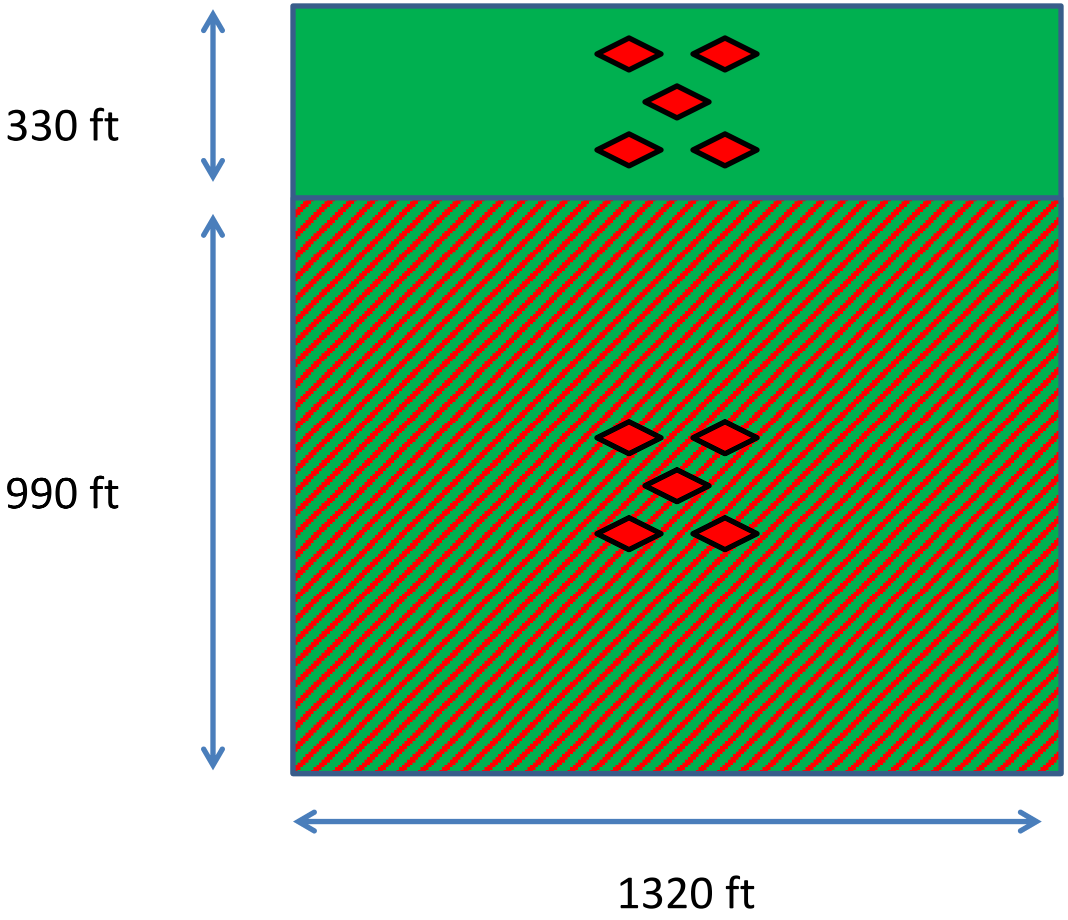
- CM treatment, flight 1B, Altacor or Belt (IRAC 28)
- CM treatment, flight 2A, Lorsban (IRAC 1B)
- Husksplit treatment, Brigade (IRAC 3)

NOW spring treatment

- Intrepid (IRAC 18A), full rate, at first peak egg activity
- Then follow grower’s standard

Response variables

- Egg traps (to assist NOW treatment timing)
- Males in pheromone traps
- Total and NOW damage in harvest samples:
  - Husksplit
  - First commercial harvest



Conclusions

1) NOW was a more important cause of damage than CM over two years in most of the study sites examined
2) Problems at trouble sites are more likely due to residents than immigrants
3) NOW Biolure is an important step forward—best used with wing traps.
4) For many blocks, important challenges must be overcome for mating disruption to be effective for NOW. NOW-specific management with insecticide can be improved.