Codling Moth, Navel Orangeworm, and Other Minor Worm and Borer Pests

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Navel Orangeworm (NOW)

Photo: Kathy Keatley Garvey

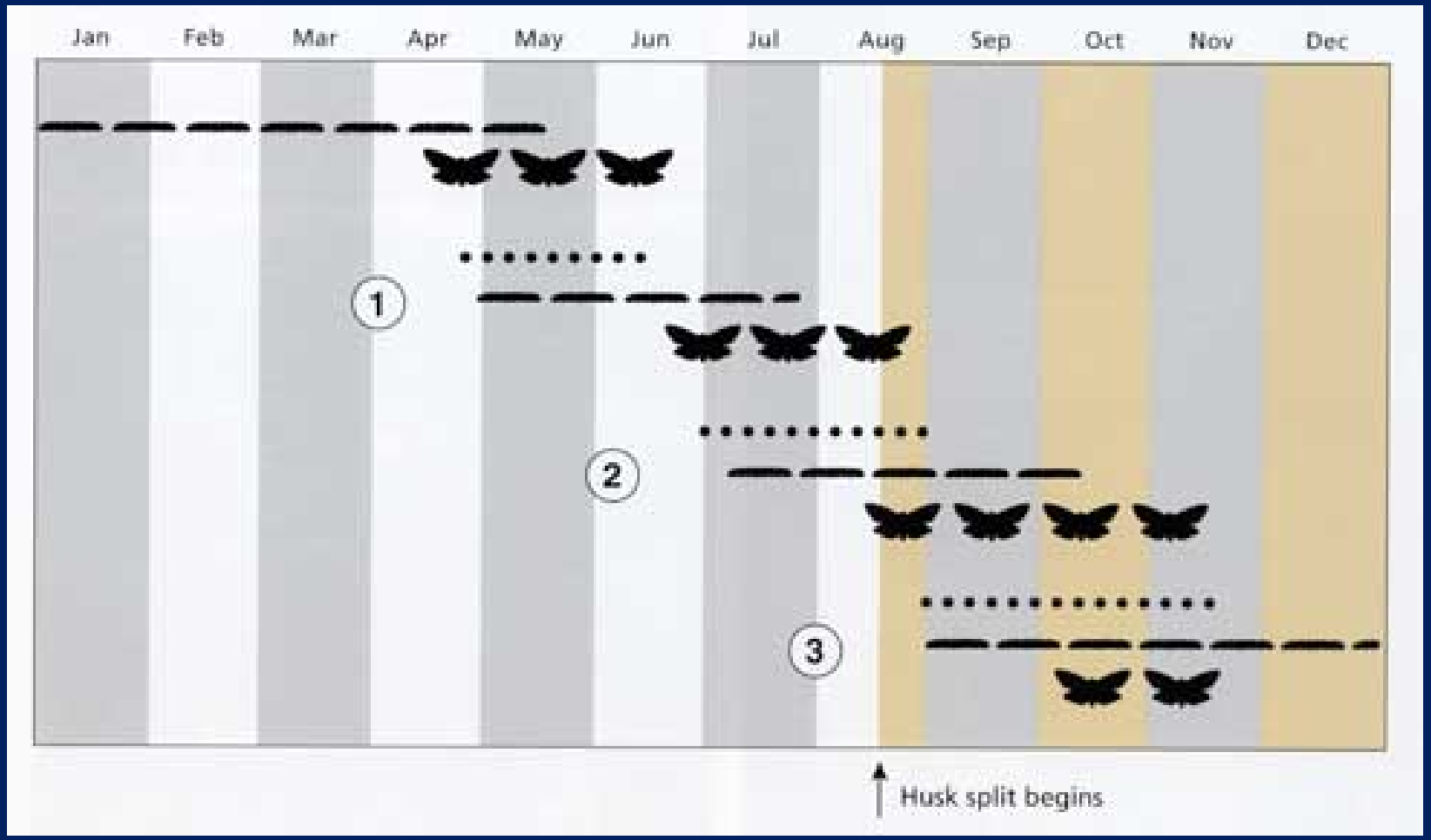
- Key pest of walnut and other nut crops
- Damage: direct (by feeding) and indirect (aflatoxin contamination)

Navel Orangeworm Biology

- Overwinters as larvae inside the mummy nuts on the tree & trash nuts on the ground
- Moths emerge in the Spring
- Females lay eggs singly on mummy nuts, codling moth-infested nuts, blighted nuts
- In late summer, some of the second generation larvae infest the new crop as the husks begin to split

Navel Orangeworm Biology

- 3rd or/and 4th flight attack on husk-split nuts (most susceptible)



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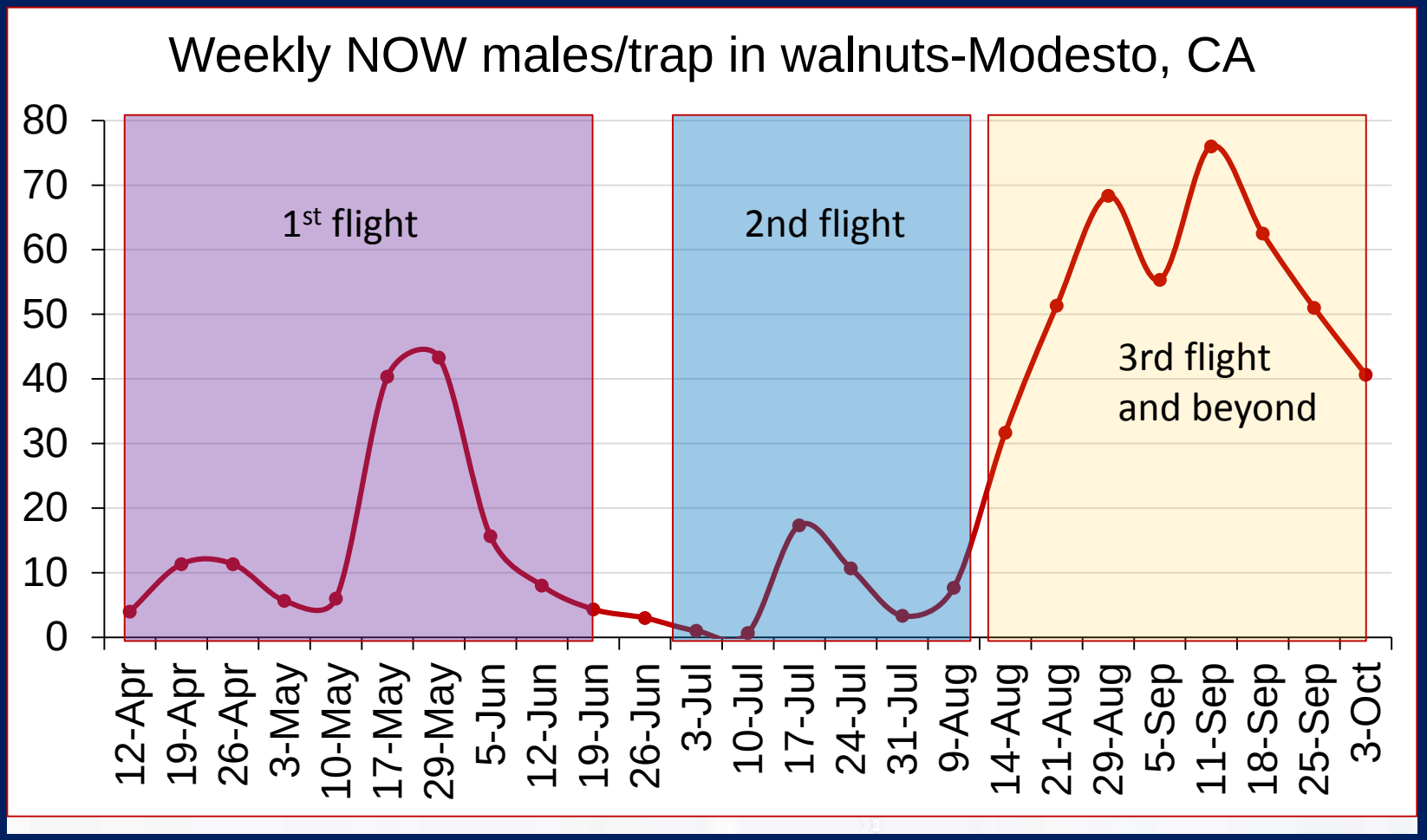


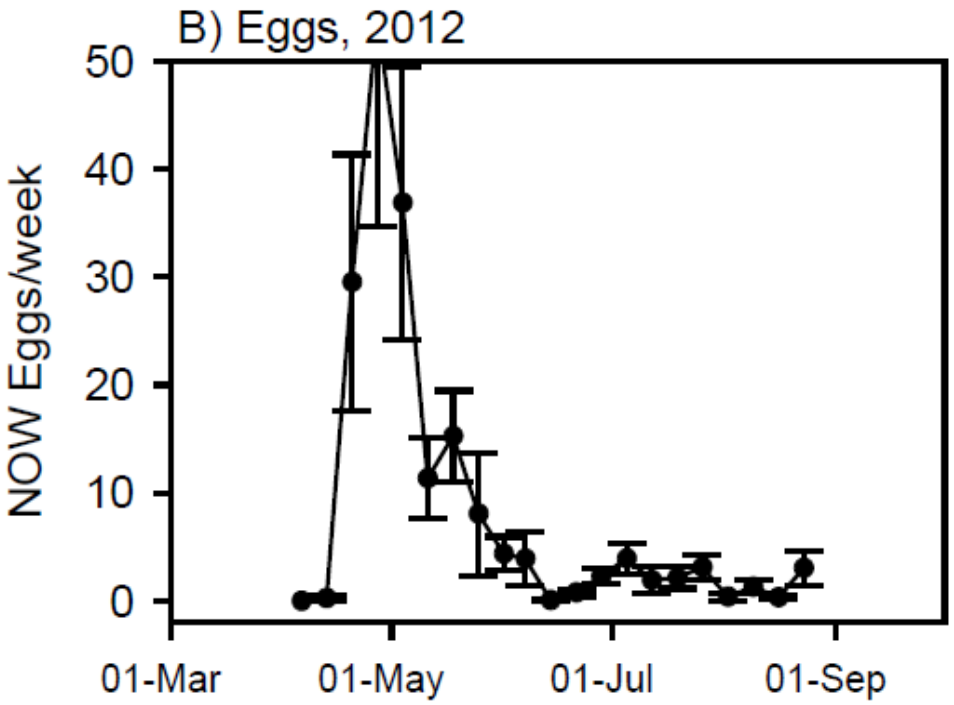
NOW Monitoring

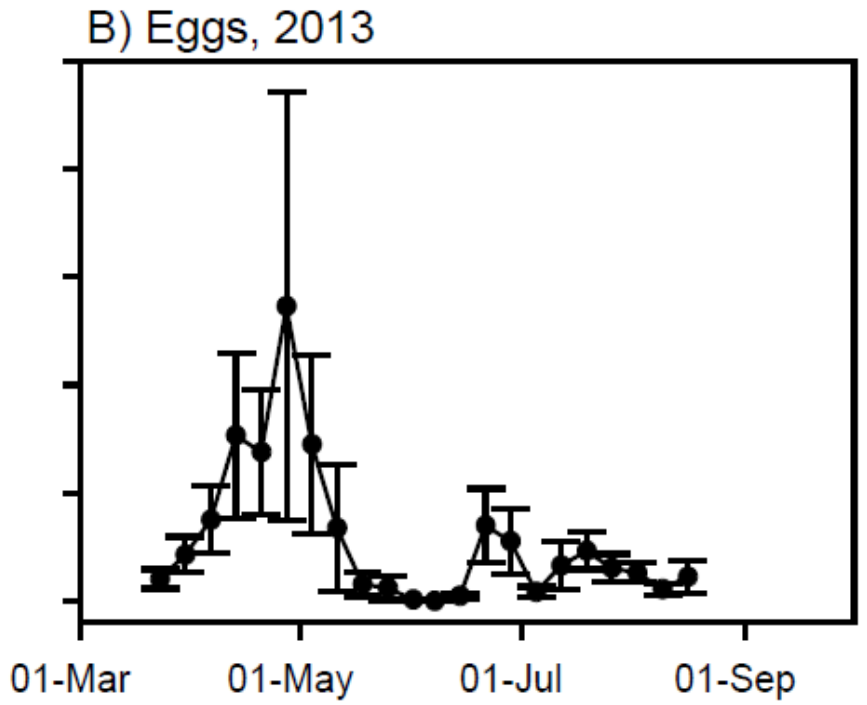
- Egg trap
- Ovibait female traps
- Pheromone trap
- Harvest sample

NOW Monitoring: Egg Traps

Bait

- Almond meal (commercial)
- Crude almond meal
- Ground mummy pistachio
- Others





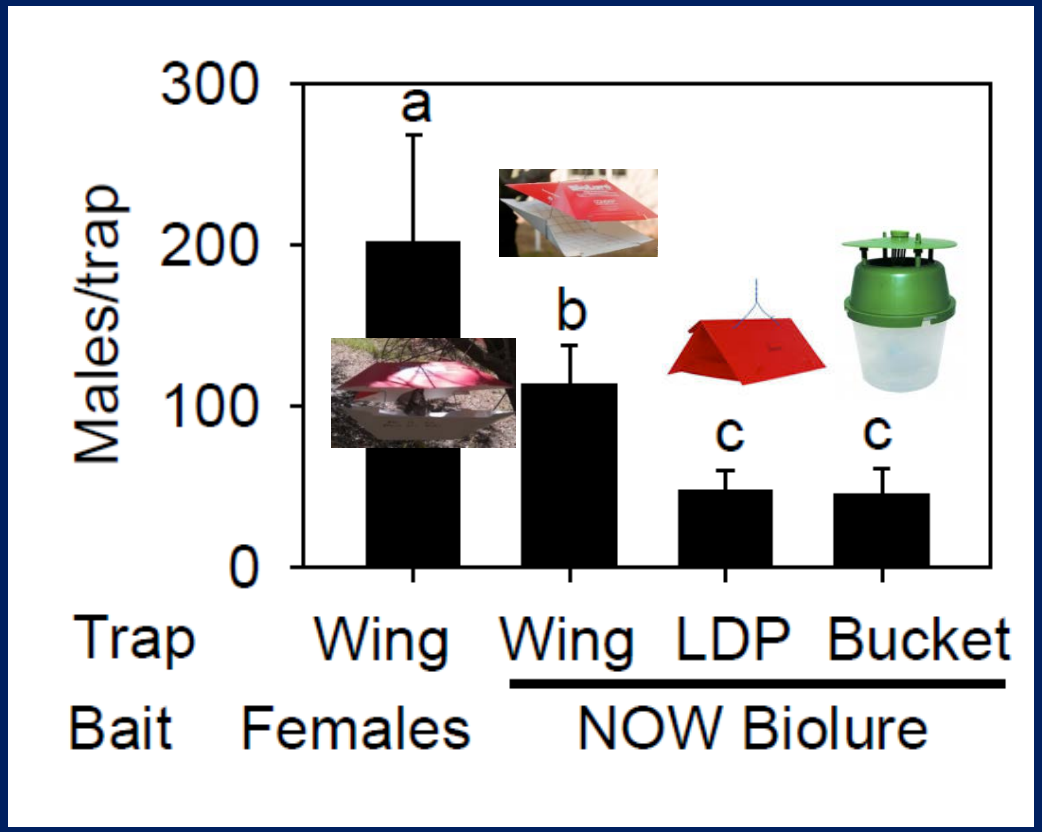
Burks et al. 2012, Walnut Res. Report

NOW Monitoring: Ovibait Female Trap

Wing trap baited with ground pistachio mummies

- Captures mated females (>90%)
- Complements egg traps
- Useful for conventional and mating disrupted orchards
- Adult female capture in the trap and NOW activity in early-split nuts are strongly associated with the NOW damage at harvest (in almonds) (Rosenheim et al. 2017)

NOW Monitoring: Pheromone Trap



- Wing trap captured significantly greater moths compared to delta and bucket traps
- Trap type depends of the purpose of monitoring
- However, delta trap is the most user-friendly
- Lures are commercially available

Burks et al. 2012, Walnut Res. Report

Harvest Sampling: Tracking NOW Pressure

- Take minimum of 1000 nuts
- Hand crack and assess the insect and other damage: CM, NOW, Ant, WHF, Sunburn

1. NOW: presence of crescent-shaped marking behind the head capsule

NOW

Vs.

CM

2. NOW: full of webbings and frass; multiple larvae

Vs.

NOW Management

1.Winter Sanitation (removing & destroying mummies)

- Foundation of NOW management
- Reduce overwintering populations by removing remaining nuts from trees and from the ground and destroy them

NOW Management

Destroying tree and trash nuts in winter is critical

Treatments	Reduction in adult emergence (%)
Nuts placed on bare berm (Control)	-
Nuts placed in weeds	24%
Nuts double-disked	68%
Nuts Shredded	97%

Sibbett and Van Steenwyk 1993, Cal Ag

NOW Management

2. Minimize other sources of nut damage

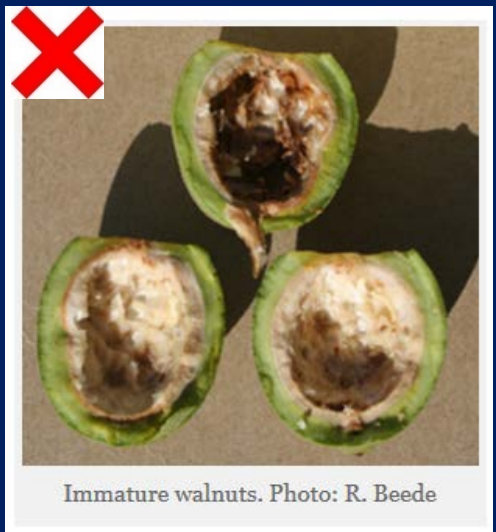
- Reduce nut damage by other causes (codling moth, sunburn, blight, mechanical injury) to minimize the point of entry for NOW
- All sound nuts are vulnerable to NOW attack at husk-split
- All varieties are susceptible to NOW damage including Chandler
- Knowing the crop and pest phenology is critical

NOW Management

3. Early harvest

- Longer the split nuts in the trees, higher the risk of damage
- Use of ethephon to advance (by 7-10 days) husk splitting
- Ethephon use time: most of the nuts are at the packing tissue brown (PTB)
    - One harvest, 100% nuts at PTB
    - Two harvests, 90-95% PTB

Packing tissue brown (PTB) stages

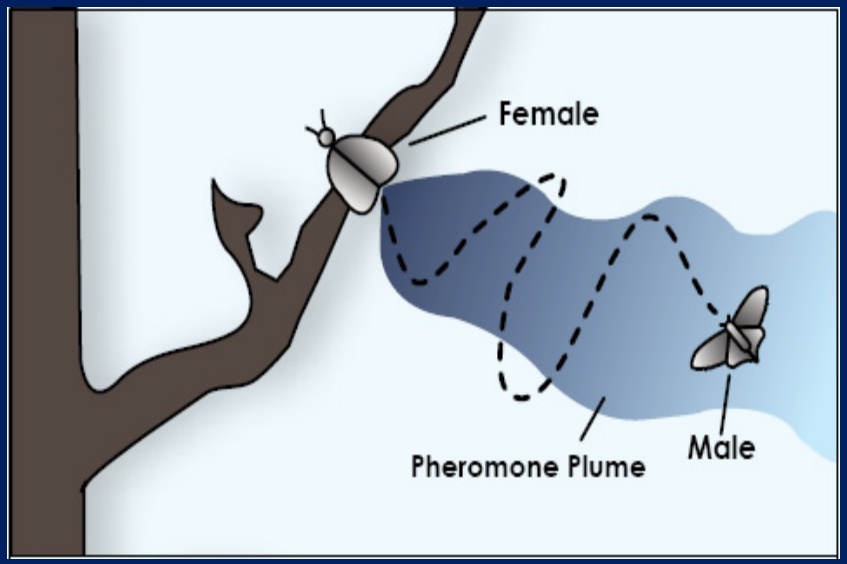


Immature walnuts. Photo: R. Beede

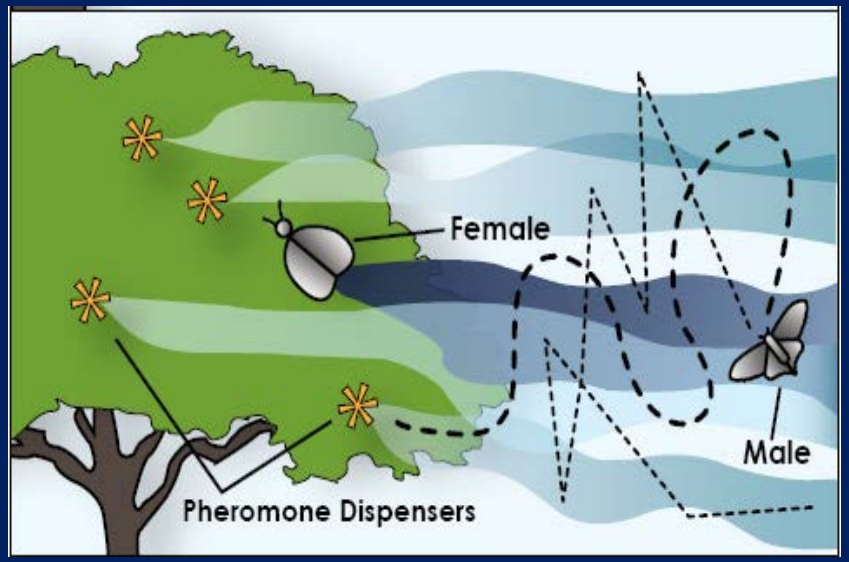
Mature and ready for treatment. Photo: R. Beede

NOW Management

4. Mating disruption



NO mating disruption



Mating disruption

http://utahpests.usu.edu/ipm/htm/fruits/fruit-insect-disease/codling-moth-md10

NOW Mating Disruption Products

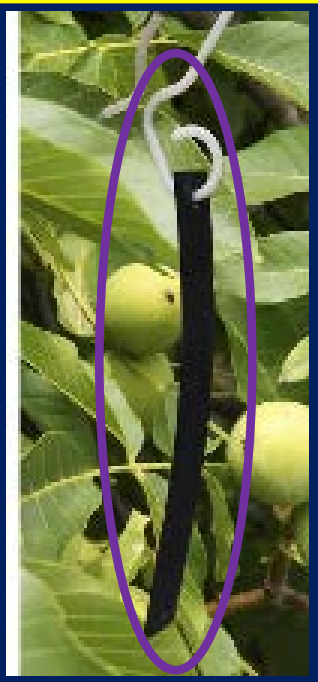
Puffer NOW (Suterra)
@2 units/A; 7.48 g a.i./A

Semios NOW Plus (Semios)
@1-2 units/A; variable a.i.

ISOMATE NOW Mist
(Pac. Biocotrol)
@1 unit/A; 7.1 g a.i./A

Cidetrak NOW Meso
(Trécé)
@20 dispensers/A

Organic use



Comparison of Four MD Products
(Data from Almonds)

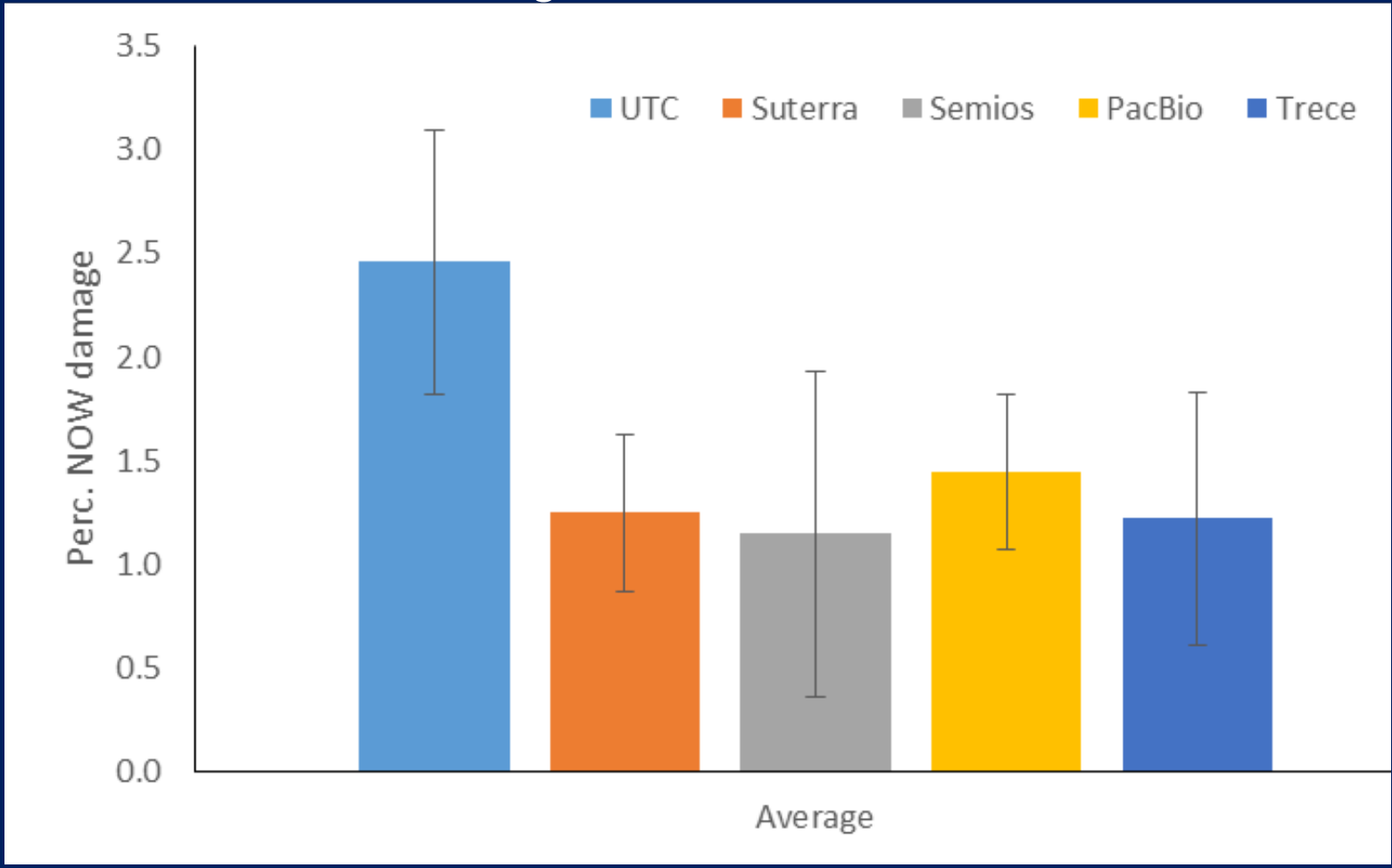
Damage Reductions

Wasco
62%

Maricopa
45%

Buttonwillow
20%

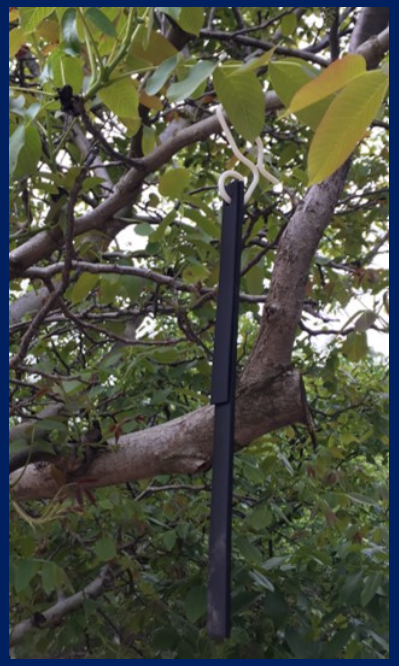
Average
46%



D. Haviland-Almond Board Project, 2017

Applying MD Dispensers in the Field

- Distribute the units @1-2 units/acre in a grid pattern, plus few more in upwind edge to compensate the potential wind influence
- Select the limb closer to the center of the tree at upper 1/3 of the tree height
- Place the units in a way to avoid direct pesticide sprays on them
- Avoid nozzle of the canister facing the foliage/limbs (3-ft clearance if possible)
- For passive dispenser by Trece, hang every few trees interval (based on spacing) using poles and provided hangers



Considerations When Using Mating Disruption

- Application timing (cover the entire season)
- Plan to use at least a few years
- Bigger block is better
- Uniform rectangular/square blocks best
- Low to moderate pest pressure
- Consider covering the edges well
- Apply in conjunction with the insecticides
- Immigrating moths

Example: Shape of the Orchard Block

Wasco

NOW damage Down 74%

Lost Hills

Down 79%

Maricopa

Down 5%

Turlock

Down 50%

Escalon

Down 77%

Ballico

Up 100%

Square sites MD cost/benefit
~$120 for MD = ↑$222 in crop value

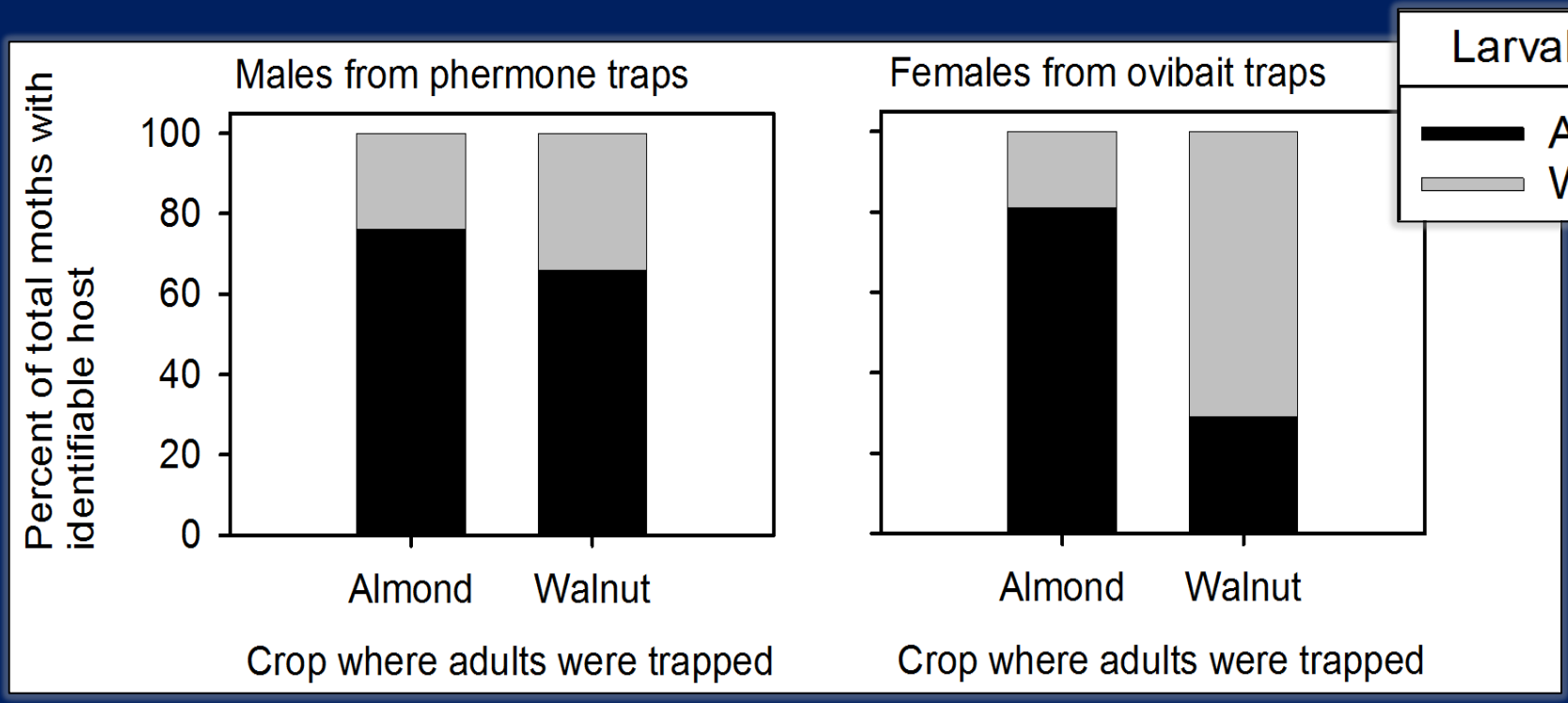
Triangle sites
~$120 for MD = ↓$17

Haviland and Rijal- DPR PMA Project, 2017

Moth Migration Potential

- **Association of crop in which moth captured and crop in which larva developed significantly different between males and females**

- **Females more likely to be captured as adults in the crop in which they developed as larvae**



Chi-square = 2.75, P = 0.097

Chi-square = 24.07, P < 0.0001

NOW Management

5. Insecticides

- Protecting husk-split nuts is critical; combine insecticide with ethephon treatment (if applicable)
- Rotate the chemistries if applying multiple times in a year;
- Insecticides applied for walnut husk fly and codling moths may help to control NOW.
- Spray coverage is critical as insecticides do not provide a complete control of NOW

NOW Management-Insecticide Options

For third generation adults and larvae:

A.I.	Trade name	MOA	Rate/A	Comments
bifenthrin	Brigade	3A	8-32 oz.	21-28 days residual at high rate
lamda-cyhalothrin	Worrier II (with Zeon)	3A	2.56 fl. oz.	Larvicide
methoxyfenozide	Intrepid 2F	18	8-16 fl. oz.	IGR with upto 18 days residual; target is young larvae
methoxyfenozide + Spinotoram	Intrepid Edge	18	10-18 fl.oz.	Good residual, but has impact to mite predators
chlorantraniliprole	Altacor	28	3-4.5 fl. oz.	Larvicide. The best timing is to apply before egg hatch
spinetoram	Delegate WG	5	6-7 fl. oz.	
phosmet	Imidan 70 W	1B	5 lb.	
esfenvalerate	Asana XL	3A	9.6–19.2 fl oz	

Disclaimer: Always check the insecticide label before its use

http://ipm.ucanr.edu/PMG/r881301111.html

Codling Moth

CM adults: coppery markings on their wing tips

Codling Moth Biology

- Overwinters as a larva on tree barks
- Overwintering generation adults (first flight) emerge in March-May
- Females can lay 30 (overwinter) to 60 (seasonal) eggs singly on fruit.
- 1st gen. young larvae bore into nutlets through blossom end. Earlier flights often have two peaks, (1A, 1B or 2A, 2B)
- Most nuts damaged by 1A flight larvae drop, but not 1B and consecutive flights
- 3-4 generations per year

3-4 generations/year

Trap-based Monitoring

Under no-mating disruption:

- **1 mg (1X) lure**, put traps (southeast side of the tree, 6-7 feet high), higher placement-more capture
- 1X lures has pheromone (codlemone), only attracts males

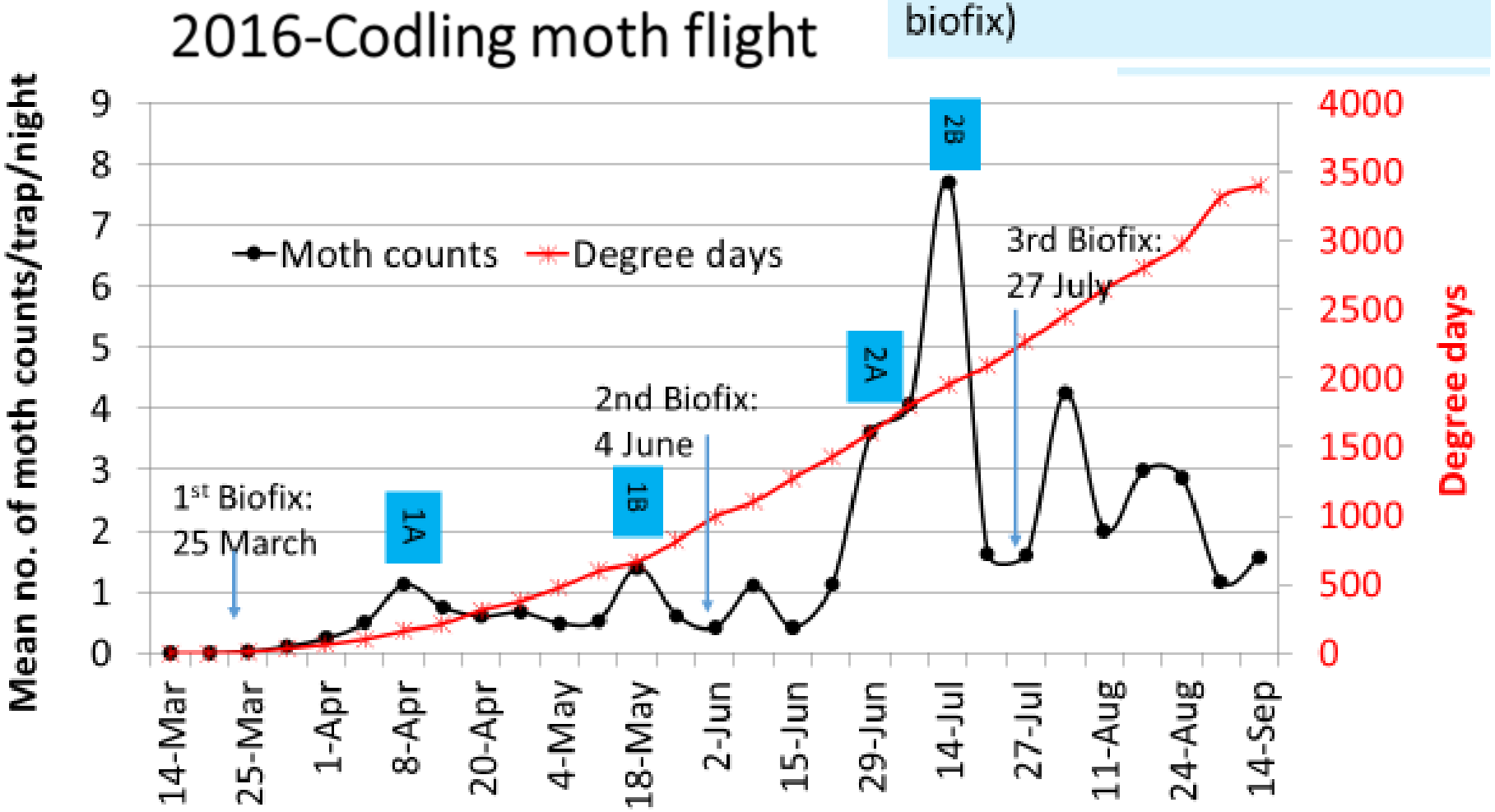
Under mating disruption or influenced by MD

- Use both: 1x, and CM-DA combo lures
- CM-DA combo has both codlemone and kairomone (pear volatile), and attracts both male and female

Use traps to determine the biofix and track the flights, and degree-days for making spray timing decisions

Example: Seasonal trap counts and treatment decision using degree days

1B spray timing (600-700 DD)= May 16
2A spray (300 DD from 2nd biofix) = June 17-18
3rd gen. spray (250 DD from 3rd biofix)



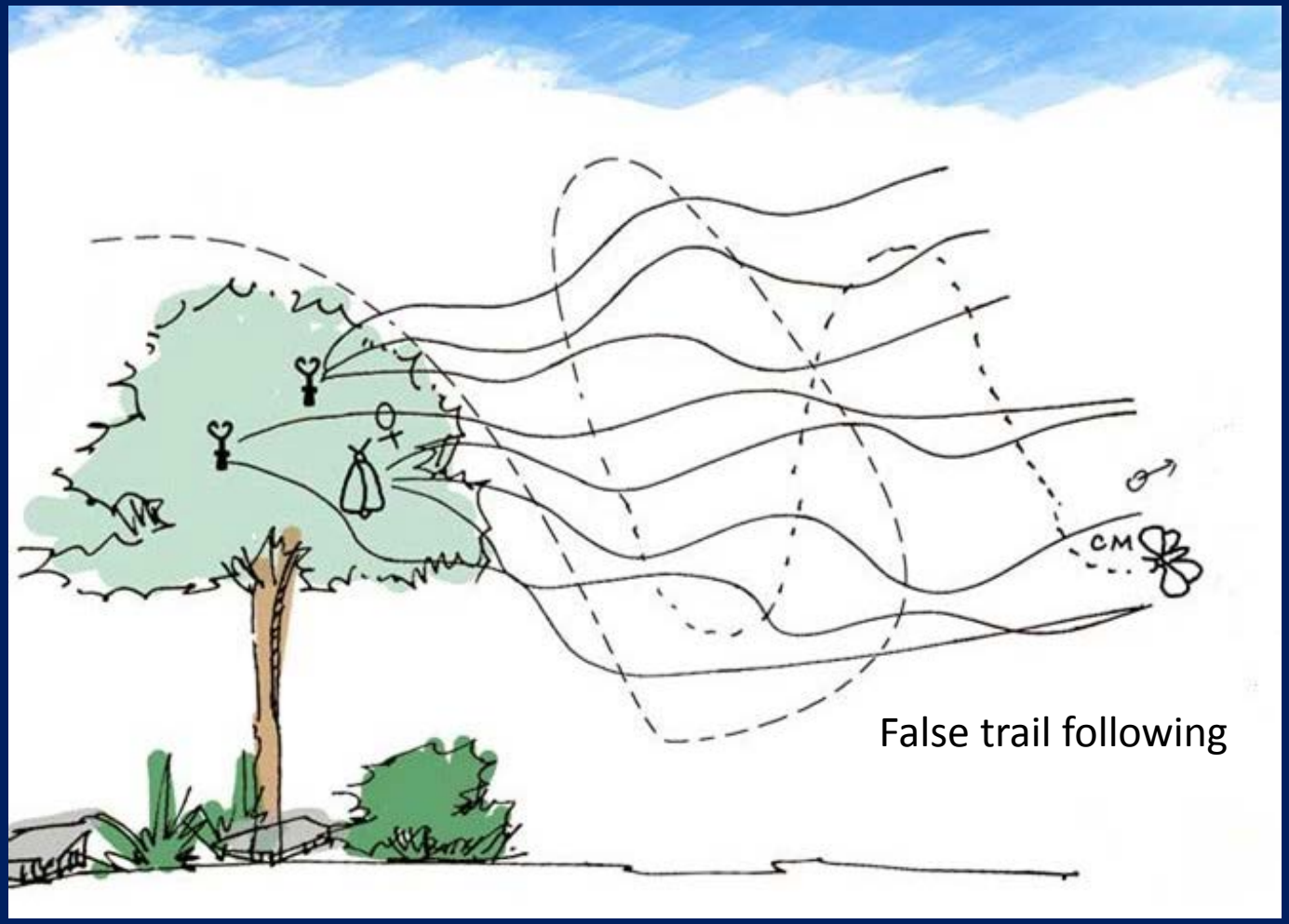
Nut Sampling and Damage Assessment

- Seasonal: During each codling moth generation, examine 1,000 mid-canopy nuts from each block (20 nuts per tree on 50 trees per block) for signs of codling moth larval entry.

- % infested nuts helps to determine the overall damage at harvest (e.g., >1% damaged nuts after the first generation or 2% after the second may results in >5% damage at harvest)

- At harvest: Take 1000 nut samples for insect pest and other kinds of damage (e.g. sunburn)- plan for next year

Codling Moth Control-Mating Disruption



Picture source: http://smartgreenbio.com.au/pest-biology/mating-disruption

Codling Moth Control-Mating Disruption

1. Sprayable liquid formulations

-Tiny microcapsules release pheromones

-Easy to apply

-Short residual activities (2-4 wks)

2. Plastic (hand-applied) dispensers

-20 to 200 units/acre

-Season long passive release

-Small and moderate-sized orchards

3. Aerosol dispensers

-1.5 to 2 units/acre

-Released pheromone at programmed intervals

Codling Moth Control-Insecticide Options

Moderate to High Codling Moth Pressure

- spinetoram (Delegate WG)
- chlorantraniliprole (Altacor)
- cyantraniliprole (Exirel)
- lamda-cyhalothrin (Worrier II with Zeon)
- bifenthrin (Brigade WSB)
- cyfluthrin (Baythroid XL)

Moderate Codling Moth Pressure

- Acetamiprid (Assail 70 WP)
- emamectin benzoate (Proclaim)
- phosmet (Imidan 70 W)
- Chlorpyrifos (Lorsban Advanced)
- Methoxyfenozide (Intrepid 2F)
- esfenvalerate (Asana XL)

Organic

- Cydia pomonella Granulosis virus (Cyd-X)
- spinosad (Entrust)

Source: http://ipm.ucanr.edu/PMG/r881301111.html

Disclaimer: Always check the insecticide label before use

Fall Webworm

- Overwinters as a pupa. Moth emerges in late spring. 1 generation per year
- Pale brown or gray caterpillars attack leaves in late summer. They form silken tent and feed on leaves within
- Cut out and destroyed infested twig. Localized spray may be needed under high pressure.
- NOW and CM sprays should be enough. Bt for young caterpillars. Spray must penetrate silken tents

Fruittree Leafroller

- Overwinters as egg stage on limbs
- Larvae are green with black heads and are about 1 inch long
- Larvae may enter young walnuts and devour the kernel. The damaged nut becomes dry and collapses with large slot-like holes
- No controls recommended. 1st gen. codling moth treatment can also be effective for fruittree leafroller caterpillars

Redhumped Caterpillar

- Minor pest of walnut
- Striking color of larvae, yellow with longitudinal reddish and white stripes
- Larvae sclerotized the leaves by leaving only the veins.
- Natural enemies keep the population under control (most cases)
- Parasitic wasps and general predators include spiders, lacewings, bigeyed bugs, and damsel bugs.

Pacific Flatheaded Borer

- The adult is a small, flat beetle
- The front part of the larval body is broad and flat (i.e. flatheaded borer)
- Overwinters as pre-pupal stage inside the wood. 1 or 2-yr life cycle.
- Eggs laid on the bark, usually in sites exposed to the sun or weakened limbs
- Larvae feed on cambium, also move deeper into xylem
- Prune out the infested branch; white latex paint for young tree trunks

Thank you for your attention!