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Using Mating Disruption for Managing Light Brown Apple Moth on Berry Crops

Frank Zalom
Dept. of Entomology
University of California
Davis, CA 95616

UCDAVIS
UNIVERSITY OF CALIFORNIA

Light Brown Apple Moth

Epiphyas postvittana

First detected in California February, 2007 in Berkeley; announced in March, 2007.

It has since been detected in Alameda, Contra Costa, Los Angeles, Marin, Monterey, Napa, San Benito, San Francisco, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, Sonoma and Yolo counties - and now in Oregon.

Light Brown Apple Moth

Native to Australia, specifically the southeastern quarter of Australia

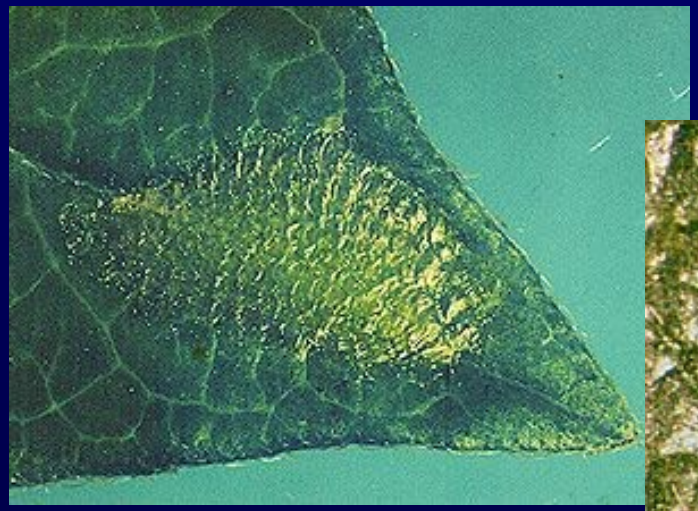
It was introduced into Tasmania, New Zealand, United Kingdom, Ireland, New Calendonia, and Hawaii

LBAM has a broad host range with some indication of preference for plants in the aster (Asteraceae), legume (Fabaceae), knotweed (Polygonaceae), rose (Rosaceae) and protea (Proteaceae) families

Light Brown Apple Moth

Eggs are white to light green when newly laid, broadly oval and flat, and are laid slightly overlapping each other.

An egg mass may contain up to 170 eggs, but typically has 20 to 50.



Photos from: http://www-staff.it.uts.edu.au/

Light Brown Apple Moth

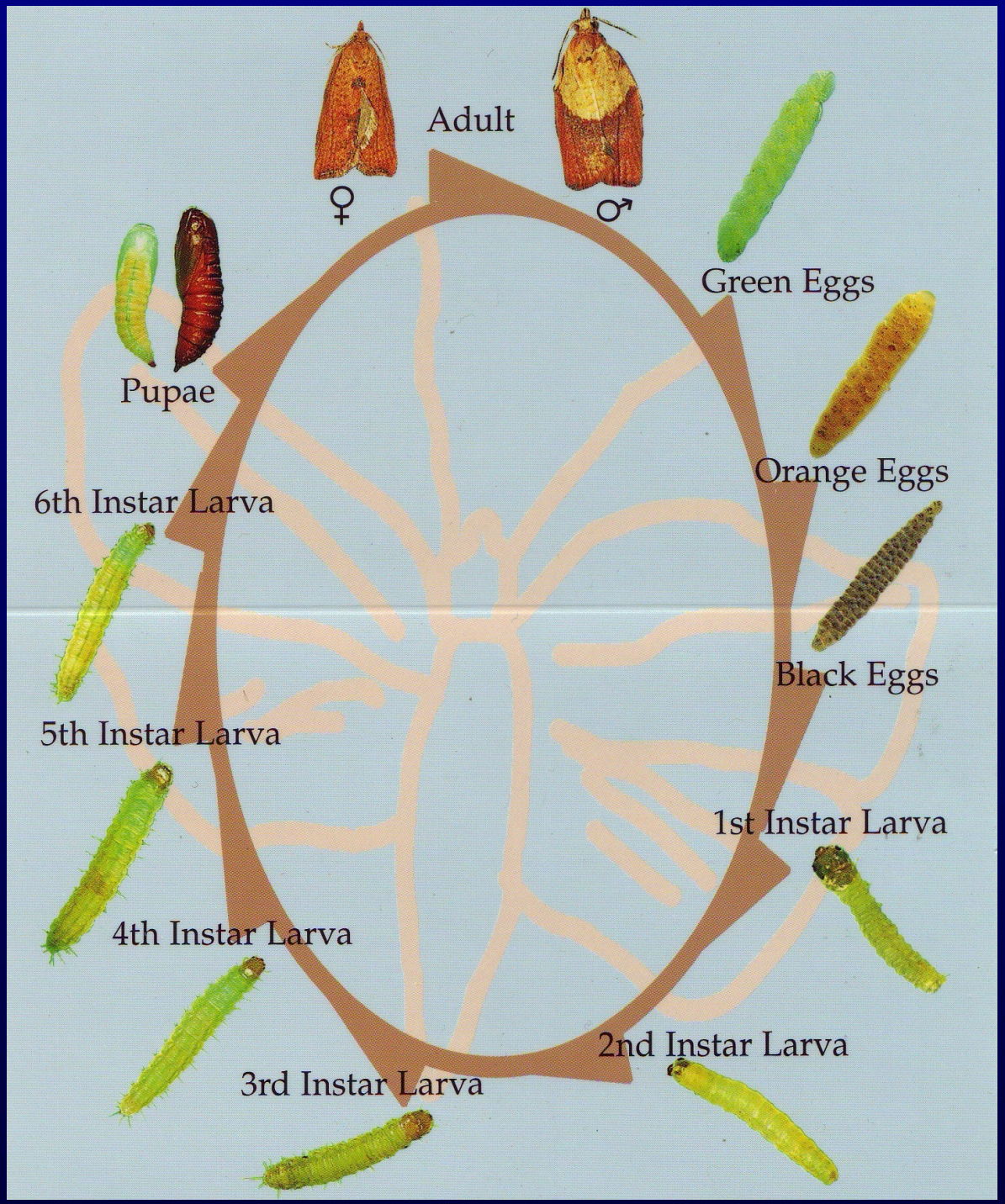
Mature larva are 0.4 to 0.7 inch (10–18 mm) long.

The head is yellow-brown and the prothoracic shield (segment behind the head) is light greenish-brown with no dark markings. The body is medium green. The hairs on the body are whitish.

Larvae of the light brown apple moth often have three distinct darker bands running the length of the body

LBAM

Life Cycle -



Light Brown Apple Moth

Development is continuous with no diapause, but its development is slowed under cold winter temperatures.

In Australia, there are typically 2-3 generations per year.

Light Brown Apple Moth

Observations from Australia -

It is a more serious pest in cooler areas with mild summers, moderate rainfall (~ 29 inches), and moderate-high humidity (~70%).

Hot, dry conditions may significantly reduce populations.

This seems to be true in California as well...

Light Brown Apple Moth

Adult biology

Moths are quiescent during the day and are found on the foliage of its hosts.

Females produce a pheromone to attract the males.

LBAM pheromone - ~95:5 mixture of (E)-11-Tetradecenyl acetate: (E,E)-9, 11-Tetradecadienyl acetate

Light Brown Apple Moth

Adult biology

Moths are unlikely to disperse far from areas with abundant, high-quality hosts.

Males disperse farther than females:

In a mark-recapture study, 80% of recaptured males and 99% of recaptured females were within

100 m of the release point.

Light Brown Apple Moth

Larval Biology - similar to other leafrollers

The 1st instar larva spins a silken tunnel, usually on the underside of a leaf, and feeds from the shelter.

2nd and later instars create feeding shelters by rolling leaves or webbing multiple leaves together.

Fruit are not a preferred feeding site, so feeding on fruit likely happens by chance.

Light Brown Apple Moth

At this point, LBAM is widely distributed in landscape plantings and natural landscapes in Santa Cruz County.

Beach Street,
Santa Cruz, 2007

Presence of other common leafrollers in the area confound growers in the quarantine area

Orange tortrix: *Argyrotaenia franciscana*

3 generations per year- most common

Other common leafrollers in the area

Apple Pandemis, *Pandemis pyrusana*
2-3 generations per year

Garden Tortrix, *Ptycholoma peritana*
2-4 generations per year
Found in orange tortrix traps

Other common leafrollers in the area

Fruittree Leafroller, *Archips argyrospila*
1 generation per year

Green larva with dark brown head and a tan plate behind the head

Other common leafrollers in the area

Obliquebanded Leafroller, *Choristoneura rosaceana*

2-3 generations per year

Greenish yellow larvae with dark heads

Light Brown Apple Moth

My involvement began in April, 2007, through meetings with berry industry leadership and Ag Commissioners to determine how to ship fruit if LBAM was found.

The first finds in Santa Cruz County occurred two weeks later, and quarantine areas were established.

Light Brown Apple Moth

CALIFORNIA STRAWBERRY COMMISSION

PRODUCTION GUIDELINES

IDENTIFYING LEAFROLLERS, INCLUDING LIGHT BROWN APPLE MOTH

FRANK G. ZALOM

Issue 5 May 2007

The light brown apple moth (LBAM), *Epiphyas postvittana*, is a native of Australia and New Zealand, and is now established in Great Britain. It has a broad plant host range, including landscape trees, ornamental shrubs, fruit and certain vegetable crop hosts. The light brown apple moth has been reported as a pest on apple, pear, peach, apricot, citrus, persimmon, avocado, oak, willow, walnut, poplar, cottonwood, alder, pine, eucalyptus, grape, kiwifruit, strawberry, caneberries, rose, camellia, jasmine, chrysanthemum, clover, plantain, and cole crops. The light brown apple moth has become a pest of concern because it has been found recently in California and the climate is favorable in a majority of the state for this pest.

The light brown apple moth is not capable of flying long distances. Research shows that the moth can typically fly up to 100 meters to find suitable host material. The light brown apple moth is most likely to move with infested nursery plants or greenwaste, and on equipment and containers. An effective sex pheromone for attracting male light brown apple moths is available commercially. This pheromone is used in delta traps to detect the presence of the moth. Pheromone traps to detect and monitor the male moths are deployed at one per 5 acres, with at least one in every field no matter how small.

The adult is about 0.4 inch (10mm) long, with a 0.75 inch (18mm) wingspan. This moth is yellowish brown, with forewings darker brown towards the outer edges (Figure 1). It stays sheltered in the foliage during the day, and flies after sunset and before daybreak. The eggs are pale white to light green and are laid slightly overlapping each other as an egg mass or a raft on the upper surface of the foliage. Egg masses are occasionally deposited on fruit. Newly hatched larvae are pale yellow-green. Mature larvae are light green with a light brown head. The larvae are active, and grow to 0.6-0.75 inch (15-18mm) in length at maturity (Figure 2). They wriggle violently when disturbed. After emerging, the larva builds a silken shelter by rolling a leaf lengthways and webbing its edges together. Leaves may also be webbed together or joined to fruit. The larvae feed within these shelters, and they may feed on fruit when it touches a leaf. A larva is most likely to be found near the calyx or in the endocarp. The light brown apple moth does not have a diapause, and will most likely overwinter as a larva in leaf litter and other plant material.

Figure 1. Light Brown Apple Moth adult

Figure 2. Light Brown Apple Moth larva

A degree-day model used for predicting LBAM development indicates that there will most likely be two generations a year in the central coast area, and 3 to 4 generations a year in the central valley and southern California.

A number of other leafrollers in the Lepidoptera family Tortricidae are common in California. These endemic leafrollers vary in importance with crop and region of the state. Leafrollers do not generally cause significant damage to strawberries, but they can be a problem when they feed on fruit and when there are high larval populations. The damage caused by larvae feeding is typically superficial and not deep within fruit.

Identifying Leafrollers, including Light Brown Apple Moth — May 2007 — Zalom

First printed May, 2007
Over 5000 distributed

Crop value, Santa Cruz and Monterey Co.

Strawberries - $780 million
Caneberries - $130 million

from NASS, 2009

No LBAM larval finds were confirmed in berry shipments at coolers in 2007 or 2008...

Larval finds of *other* leafroller species were found in berry shipments at coolers, and these had to be sent for positive identification...

Aerial spraying of LBAM pheromone for eradication began in September, 2007.

Light Brown Apple Moth

First quarantines of caneberry fruiting fields for larval finds in fruit, June, 2009, in 3 fields

LBAM

Orange Tortrix

Mating Disruption of Light Brown Apple Moth in California Caneberries

Objectives:

- Determine efficacy of mating disruption as a management tool for LBAM in commercial caneberries
- Compare efficacy and economic costs of three mating disruption products

Project conducted by Dr. Hillary Thomas

Funded through a cooperative agreement with USDA – APHIS PPQ, Dr. Miriam Cooperband

Local collaboration with Mark Bolda, UCCE

Mating Disruption of Light Brown Apple Moth - background

- Has been used commercially in Australia and New Zealand apple orchards
- Pheromone dispensers are typically applied *in addition to* a grower's usual chlorpyrifos treatments in apple orchards
- The use of ground-applied pheromones resulted in fewer insecticide applications needed in mating disruption plots relative to blocks without the pheromone dispensers (Suckling et al,1990)
- Mating disruption has also been used successfully for management in Australian citrus groves (Mo et al, 2006)

Procedures & Experimental Design

Pre-experiment trapping with pheromone lures to determine LBAM population distribution in the study area

One-time application of pheromone dispenser treatments on 10 acre mixed-variety blackberry plots

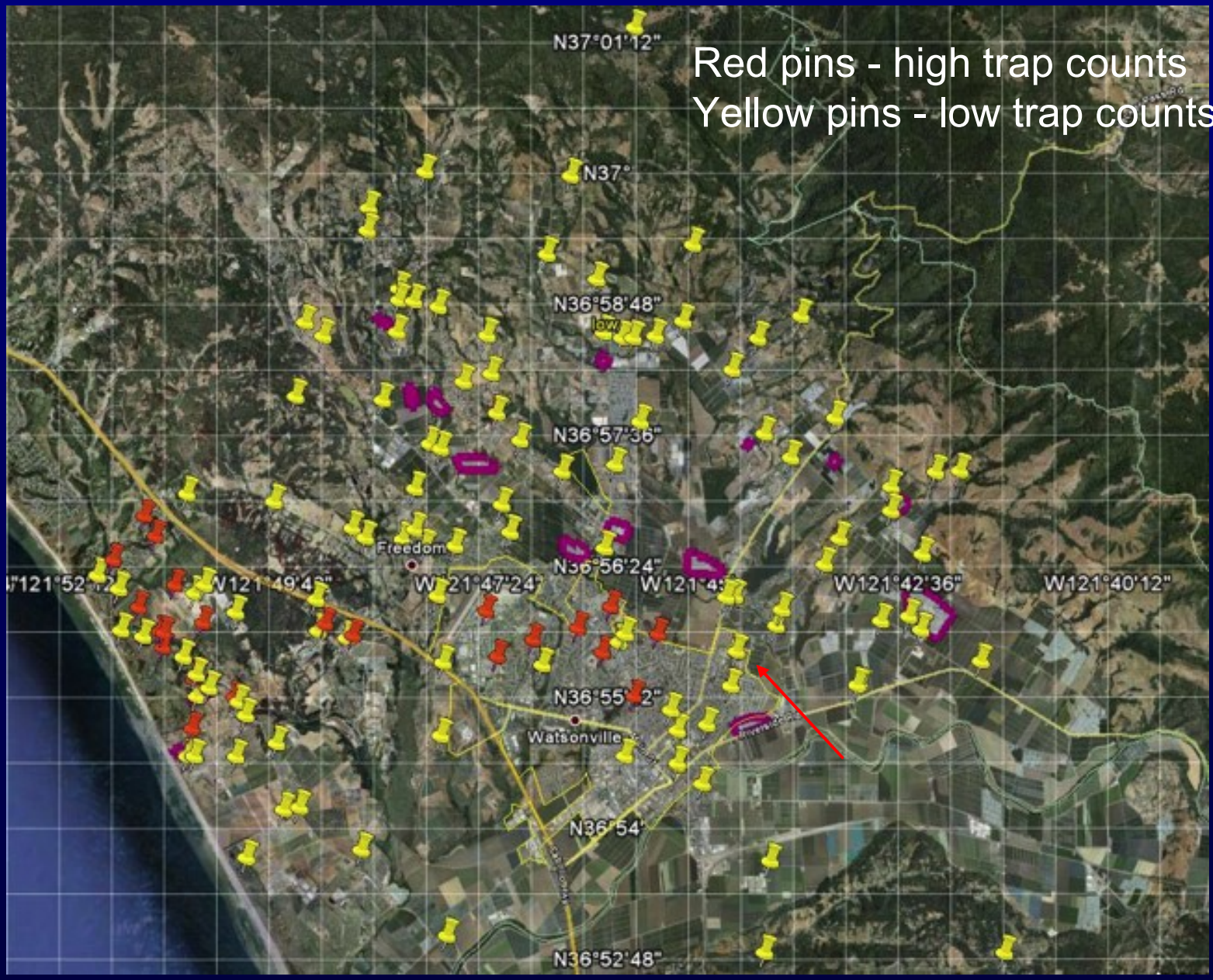
- 3 types of pheromone dispensing products were included in the study
- 3 replicates of each product (total application on 30 acres for each product)
- Target rate for application - 25 g active ingredient/acre

Weekly monitoring of LBAM in treatment plots and untreated (control) plots using sticky traps and pheromone lures

Procedures & Experimental Design

Mating disruption products were deployed after hoops were removed and canes were pruned and tied.

Trapping data, August, 2009



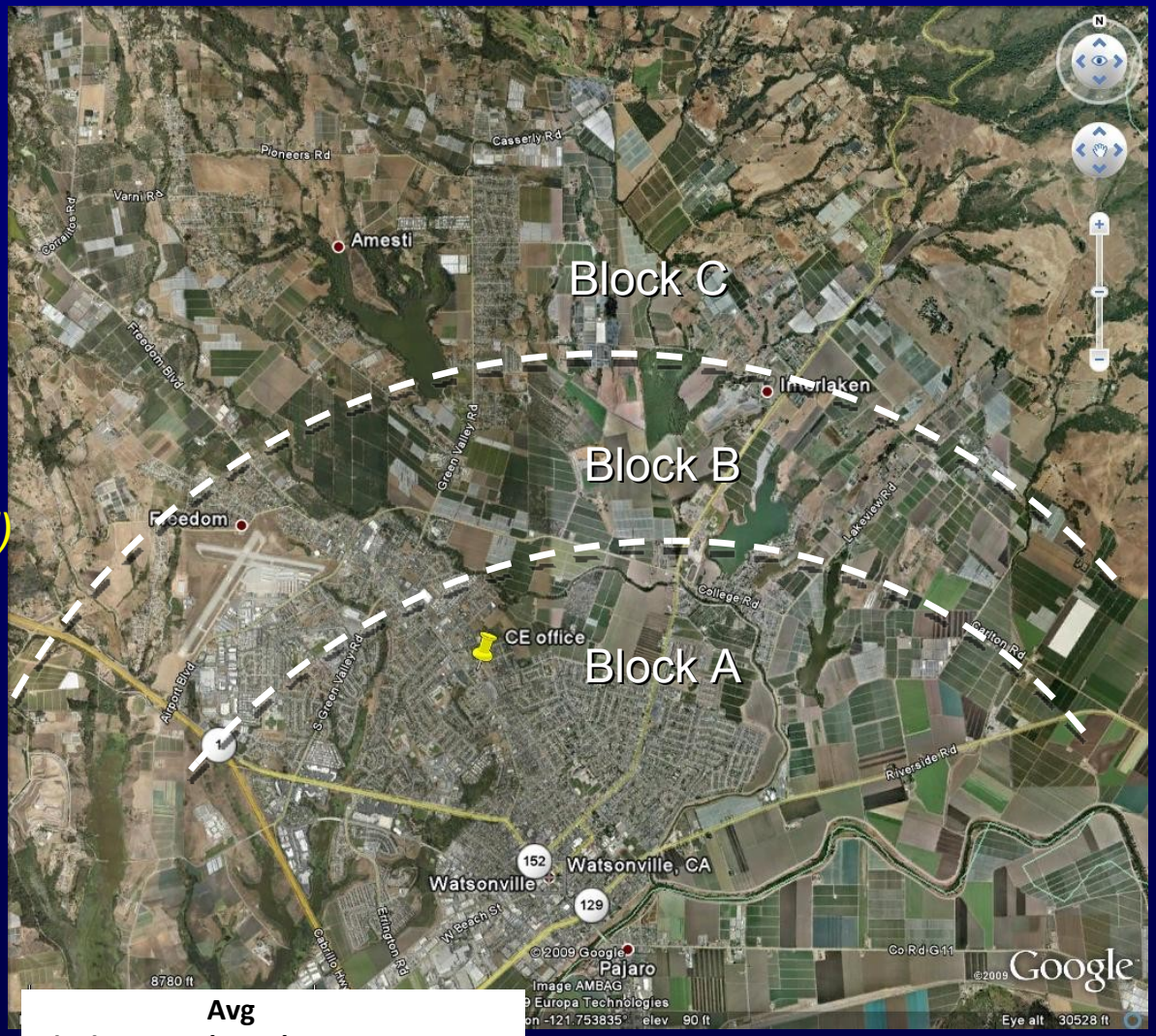
Map of Treatment Blocks

- Replicates were blocked by LBAM population density:

  Block A: High Density (near town)

  Block B & C: Medium to Low density

- *All treatment plots at least 250' feet apart (most > 250')*
- Control plots placed upwind of treatment plots
- Based plot selection and blocking on pre-experiment trapping data with pheromone-baited red wing traps placed at a number of caneberry farms in the area



Block	Avg LBAM/Trap/Day		
A	3.894230769	±	1.371932
B	0.802884615	±	0.250416
C	0.373213713	±	0.22139

Trap Comparison - Pre-study

3 sites (blocks), 4 traps per site

Average male LBAM captured over four weeks using four different pheromone trap and lure combinations

Treatments:

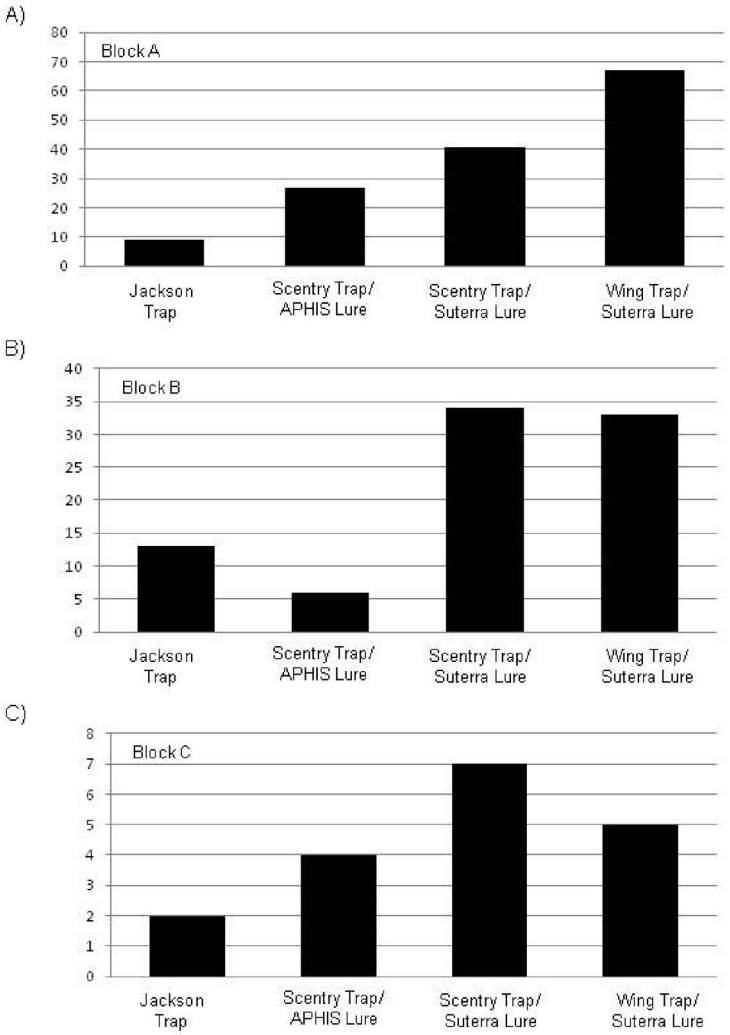
Jackson trap with 3 mg Suterra lure

Red Scentry Delta trap with 3 mg Suterra lure

Red Scentry Delta trap with 3 mg APHIS-supplied lure

Red Suterra wing trap baited with 3 mg Suterra lure

Significant effect of block (= site for this experiment) in the model ($F_{[2,42]}$=4.3, P=0.02)



Pheromone Dispenser Products
(treatments included in the experiment)

Product Name:

Isomate LBAM-Plus

Company:

Pacific Biocontrol & Shin-Etsu

Product Name:

SPLAT LBAM

Company:

ISCA Technologies

Product Name:

Disrupt Microflake LBAM

Company:

Hercon Environmental

Isomate Application
(Pacific Biocontrol)

Manual application with a crew of 10 people

Twisted dispensers onto top wire

Spacing calculated for application rate

Manual application crew

Application of twist ties

After application

Target: 25 g a.i. /ac (200 twist ties/acre)

Applied: average 24.08 ± 0.31 g a.i. per ac (=average of 193 ± 25 twist ties per acre)

Note: actual was 35.69 ± 0.47 because the product label was incorrect

SPLAT Application
(ISCA Technologies)

ISCA Technologies applied using their Splat o' Gator (2 person operation)

(Can also be applied using a grease gun, metered dosing gun, or aerially).

After calibrating amount of pheromone per "splat", drove at a set speed to apply target rate (# of splats/row) with one or two equipment arms

Target: 25 g a.i. /ac
Average of 28.18± 5.9 g a.I./ac with one site overapplied *by 159% possibly due to viscosity change*

SPLAT-o-gator

Mixing SPLAT

Application with one equipment line

SPLAT after application

Disrupt Application
(Hercon Environmental)

Applied using a modified paintball gun and gator (2 person operation); CO_2 cannister and regulator as hip attachment

(Can also be applied using a grease gun, metered dosing gun, or aerially).

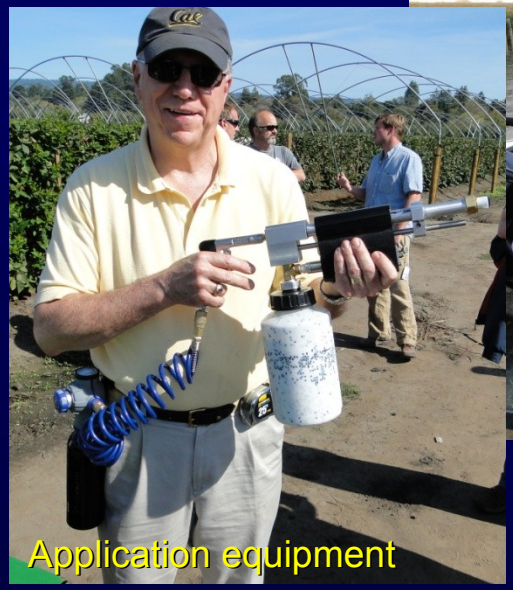
Avg applied ≈ 22.22 g a.i. /acre (*Target = 25 g a.i./ac*)
Two underapplications possibly due to temperature influences
Reapplied at one site to achieve the desired a.i.

Micro-tac glue

Disrupt Microflakes

Glue + Microflakes

Application


Application equipment

Disrupt after application

Monitoring after treatment

9 traps per plot

Traps checked weekly, then every other week after start of the rainy season

Large plastic delta style traps (LPD) with 3 mg pheromone lures from Suterra, LLC

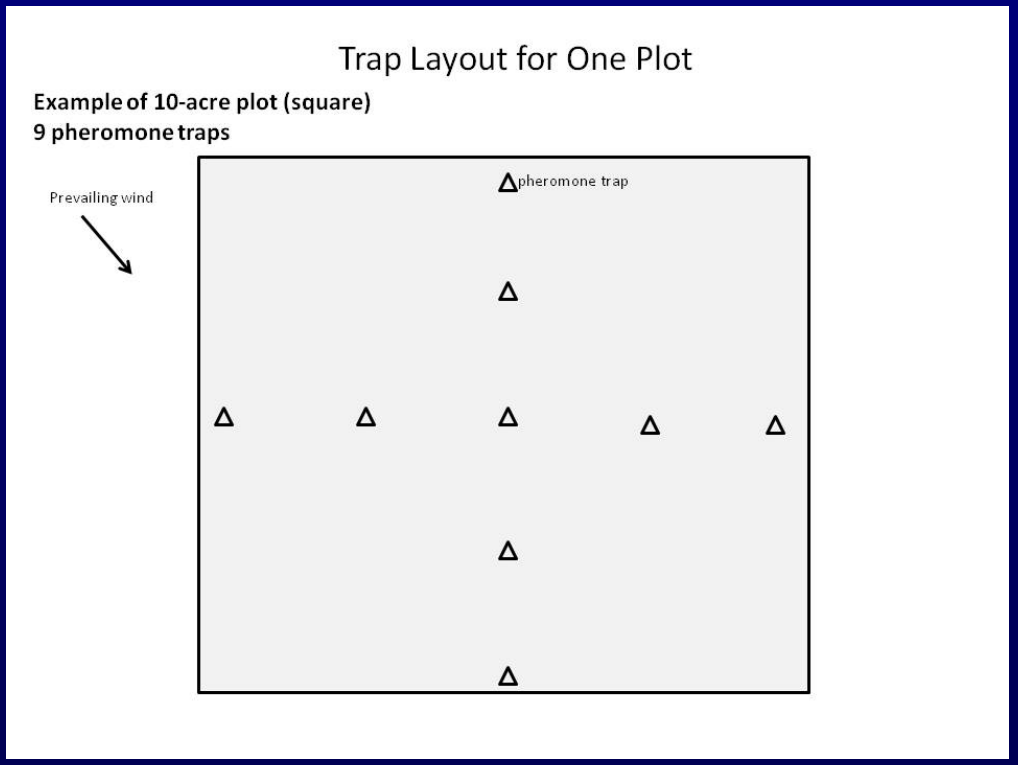
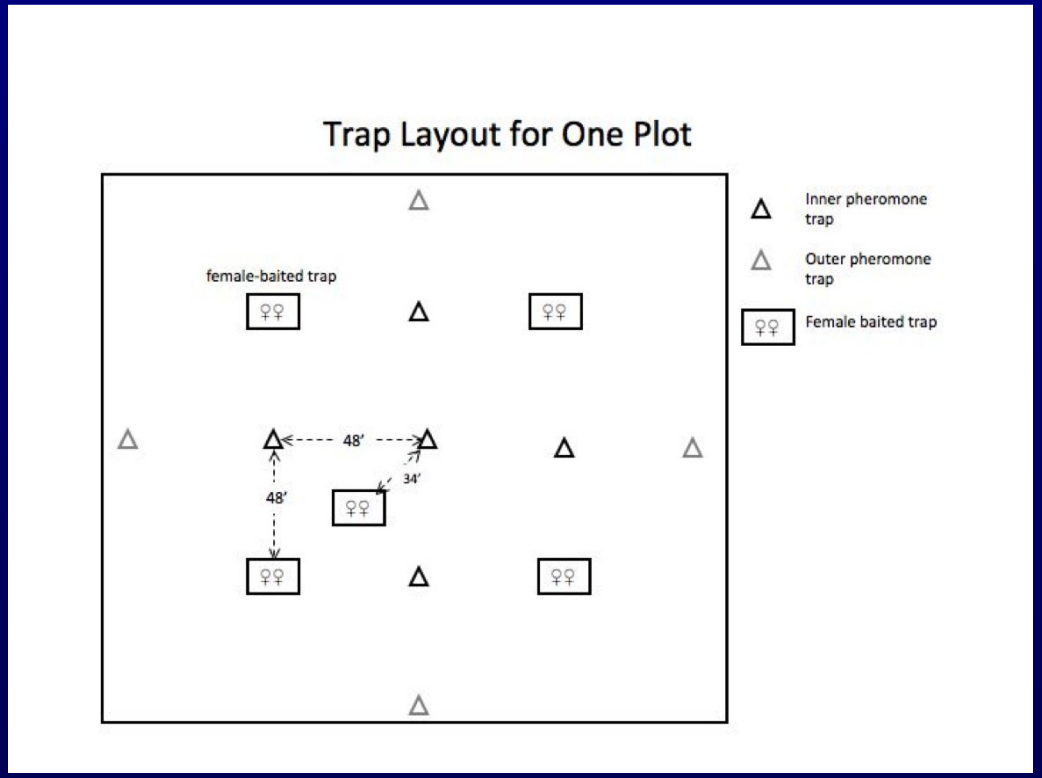


Figure and photograph by Miriam Cooperband, USDA-APHIS

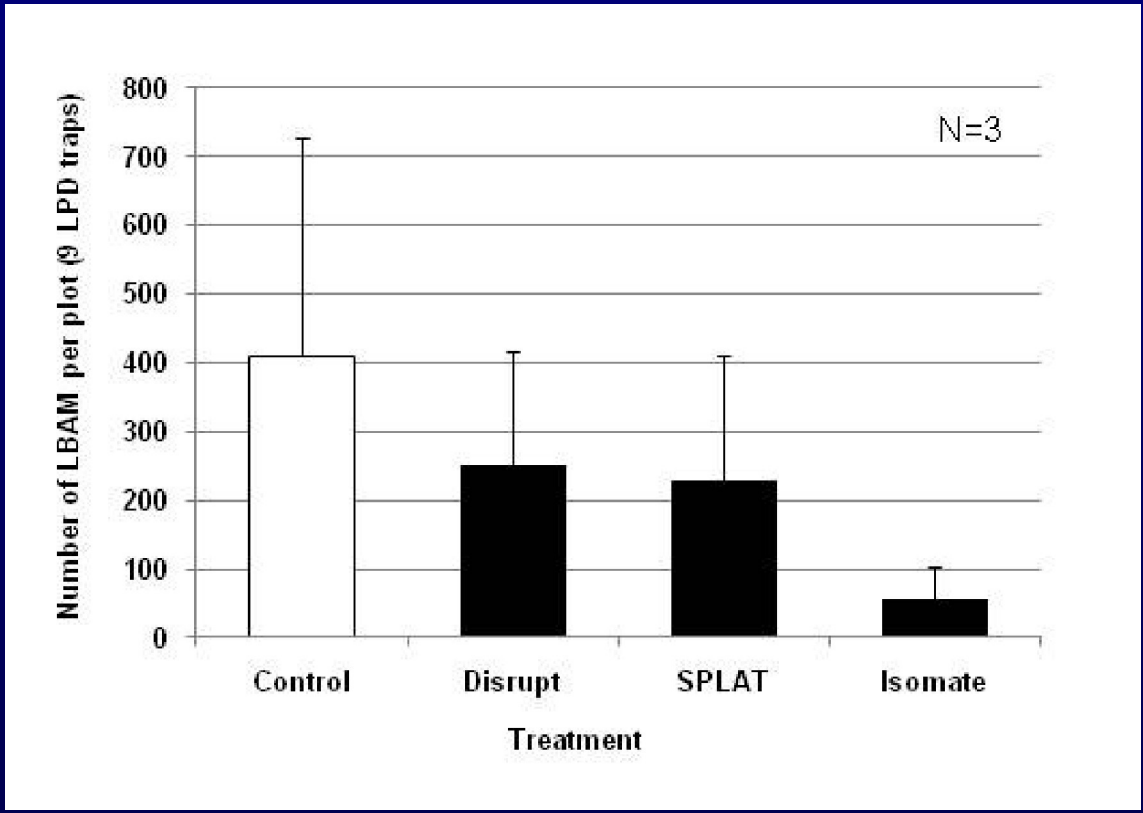
Monitoring after treatment

5 sterile virgin female cages (2 females per cage) per plot (from Moss Landing), each cage placed in a large plastic delta style trap.

Deployed on November 18 for 5 days, killed and returned to Moss Landing 5 days later.



Mean number of LBAM captured in 9 pheromone traps for each treatment (N=3) for 100 days after products were applied

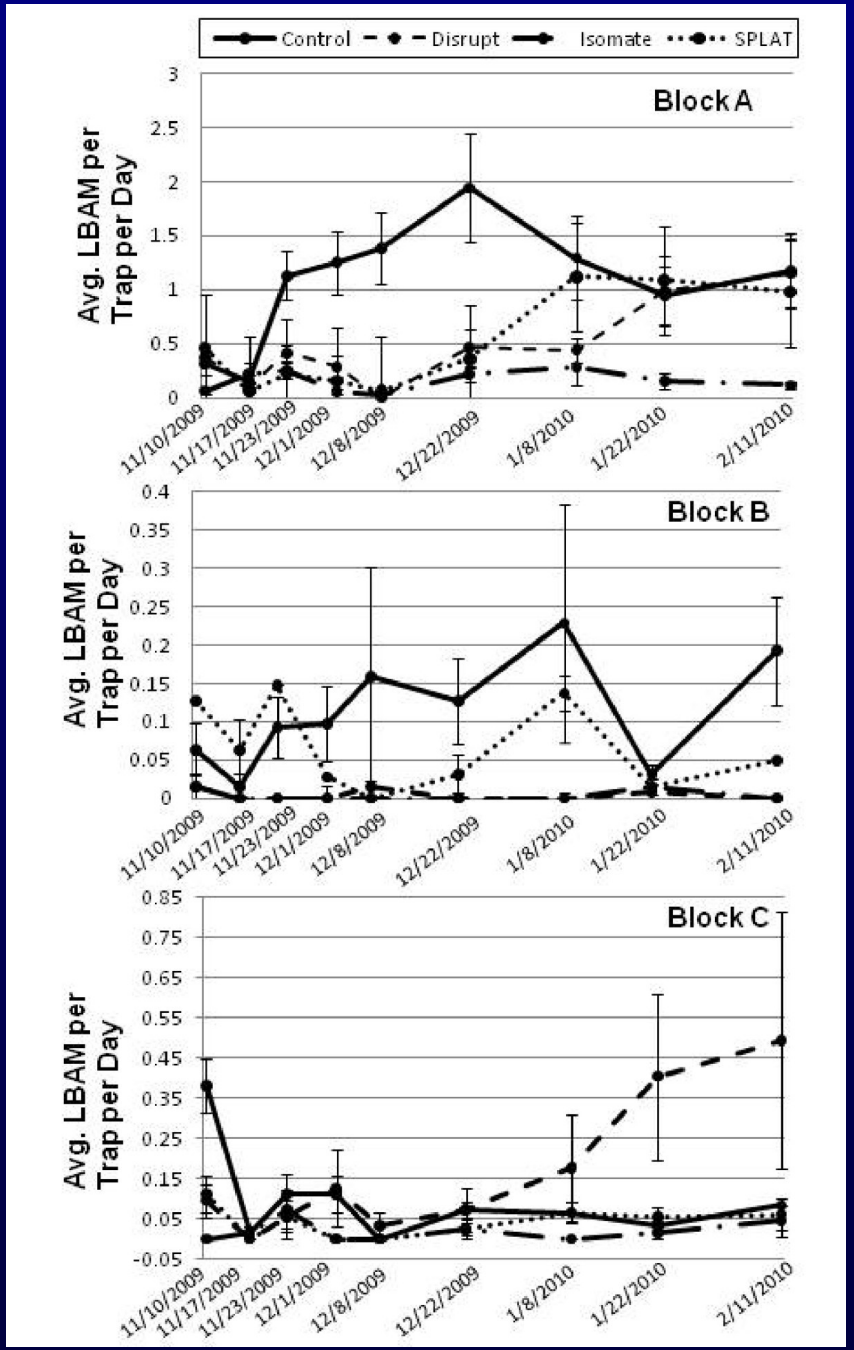


Pheromone a.i./acre

Disrupt 22.22
SPLAT 28.18±5.90
Isomate 35.10±0.47

Number of male LBAM per trap per day captured in all pheromone traps in each block for all sampling dates

A Poisson model found that for 100 days of pooled data there was a significant treatment effect ($F_{[4,6]}$=14.51, P=0.0031)



t-values for means comparison of LBAM male moth captures at 66, 80 and 100 days following application[1]

66 days	Control	Disrupt	SPLAT	Isomate
Control	-	4.35*	3.64*	5.21***
Disrupt		-	-0.92	1.82
SPLAT			-	-2.62
Isomate				-
80 days				
Control	-	2.80	2.48	4.32*
Disrupt		-	-0.36	2.37
SPLAT			-	-2.65
Isomate				-
100 days				
Control	-	1.71	1.98	3.93*
Disrupt		-	0.29	2.86
SPLAT			-	-2.66
Isomate				-

[1] pairwise means differ significantly at *P<0.05 or **P<0.01 by Tukey-Kramer test.

Mean ± SE male light brown apple moths captured per trap (N=5) per day in pheromone baited traps and traps baited with two sterile virgin female moths, November, 2009.

Block	Treatment	Mean ± SE LBAM/pheromone trap/day	Mean ± SE LBAM females/ trap/day
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0.04 ± 0.04

Starting in March, 2010, the Agricultural Commissioners in Santa Cruz and Monterey counties were supplied with 10 million Isomate dispensers for free distribution. Caneberry growers were among those with the highest priority for the dispensers based on our research… There was almost universal adoption.

No caneberry fields were quarantined in 2010.

Light Brown Apple Moth

First quarantines of strawberry fruiting fields for larval finds in fruit, June, 2010; 3 organic fields

LBAM Mating Disruption in Strawberries

Four reps of 8-acre treatment plots in organic strawberries, paired control and treated plots

Pre-experiment trapping to establish background levels of infestation

Rate of 300 Isomate dispensers/ac (~56 g a.i./acre) deployed June 21, 2010 and terminated October 5, 2010

Pre-application trap captures

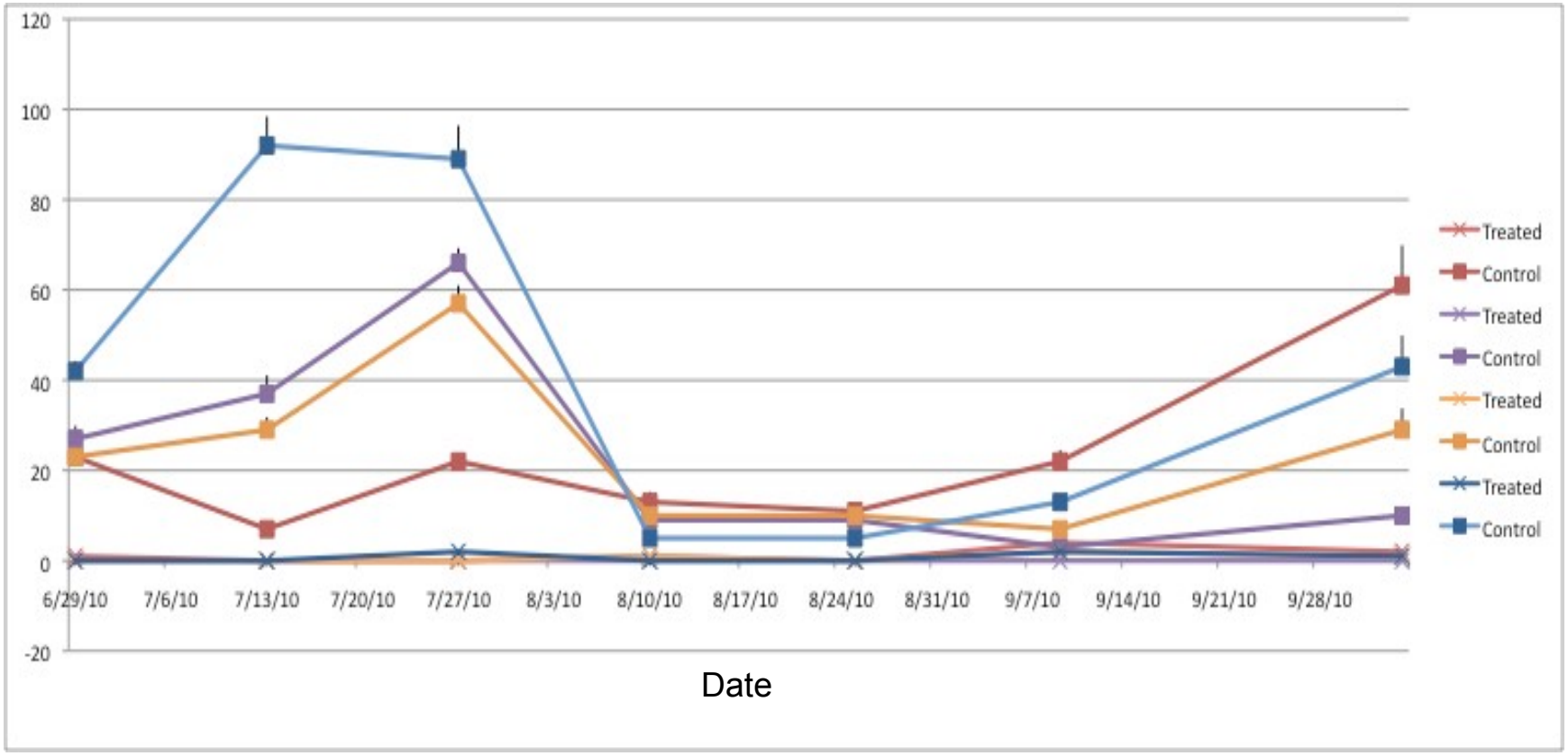
Site	Two week avg/trap
Sites 1, 2 (two pairs of treated and control plots on one ranch)	7.60
Site 3	8.50
Site 4	4.67

Aggregated Trap Data (count) by Site, Treatment

June 28 - October 5, 2010

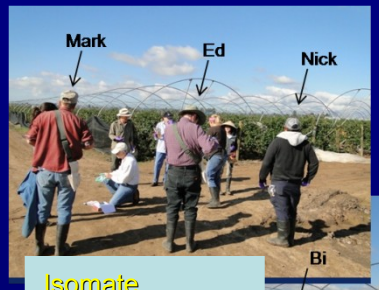
	Total LBAM captured per site	
Site	Pheromone	Control
1		
2		
3		
4		

LBAM moths captured in 12 traps at all sites on each sampling date from June 28 to October 5, 2010



Conclusions

- Trying to do research in commercial fields that are in a quarantine area is a challenge, necessitating considerable compromise in design
- Ground-applied LBAM mating disruption significantly reduced moth captures in pheromone-baited traps in both caneberries and strawberries
- Moth captures were not reduced to zero for all but one (strawberry) site at product label rates; the technique is useful for management but probably not as a stand-alone tactic in a quarantine situation
- Application of ground applied products, especially their calibration, remains a challenge and additional studies need to be conducted before they can be applied reliably at target rates. Isomate dispensers may be an exception.



Isomate Application Crew

Pat Weddle

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