Light Brown Apple Moth Management

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Cooperative Extension

December 12, 2013
Watsonville, CA.

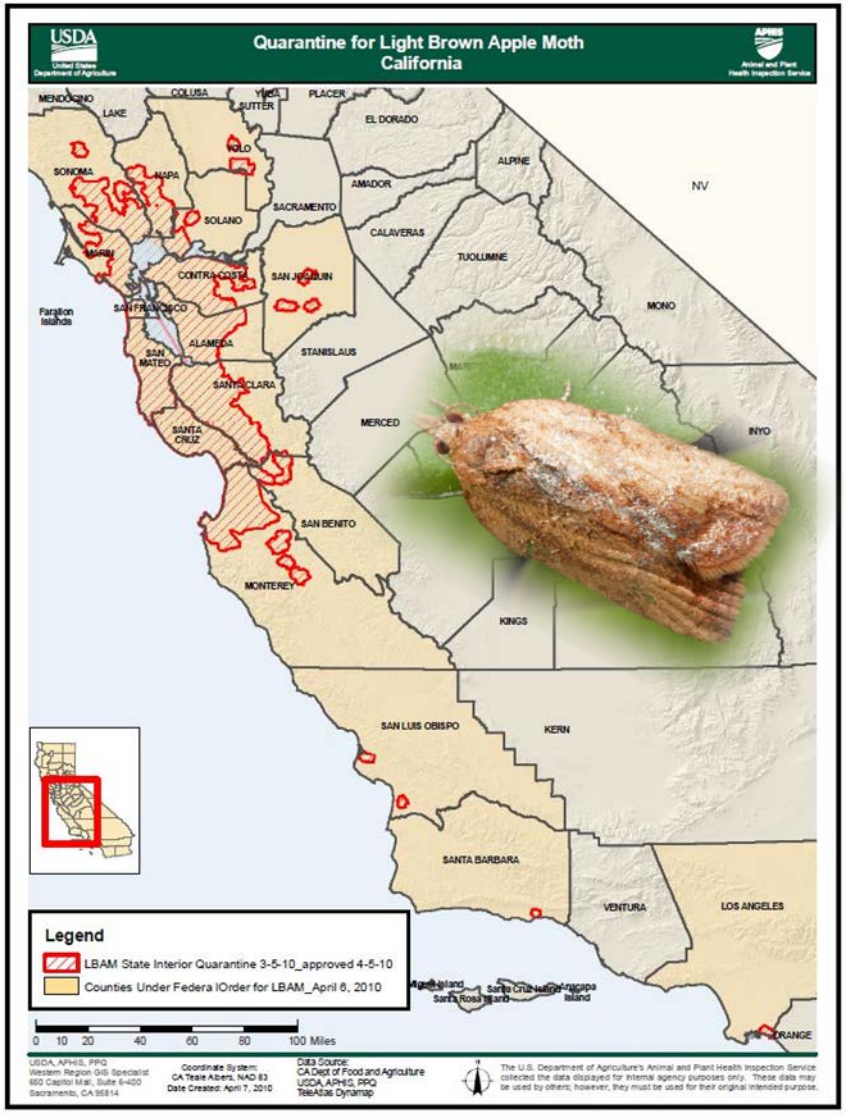
Funding: CDFA / USDA Specialty Crop Block Grant

Presentation Outline

- Importance and regulations
- Basic biology
- Perimeter hosts and moth migration
- Biological control
- Pheromone mating disruption
- Insecticides

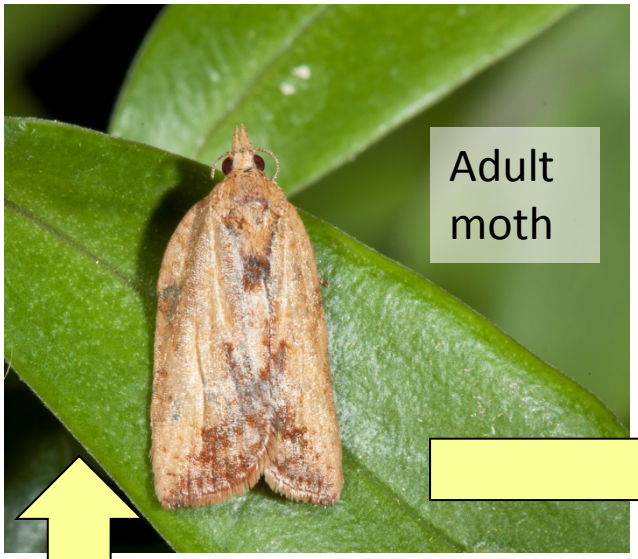
Light Brown Apple Moth (LBAM)

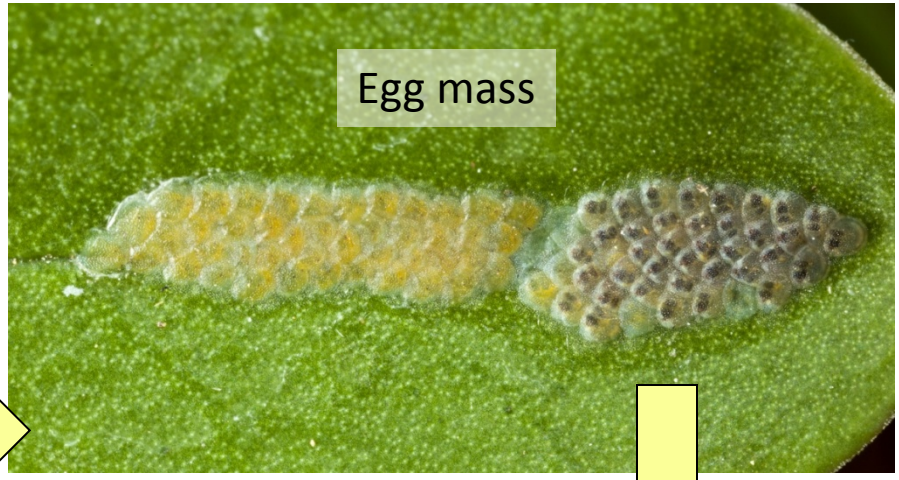
- A new invasive pest from Australia detected in Alameda Co. in March 2007
- Favored by cooler coastal climates (Found 16 counties)
- Broad host range (Established in natural areas and landscapes)
- Production loss due to regulatory closures
- Great increase in pesticide use in nurseries

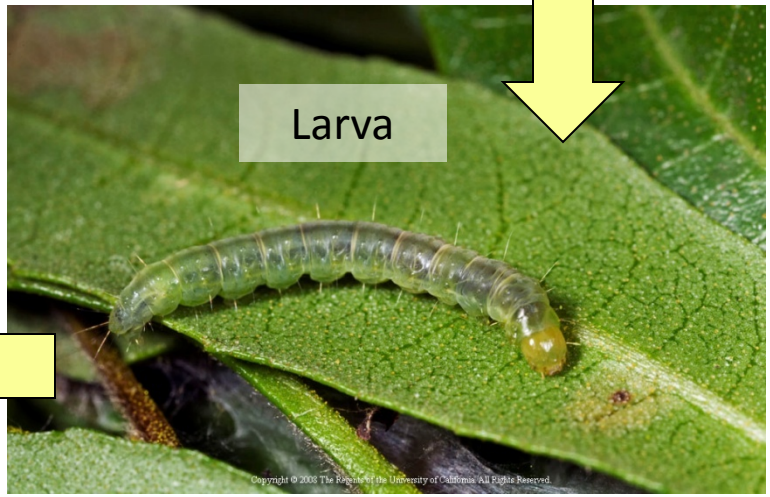


Feb, 2011

LBAM life stages and cycle

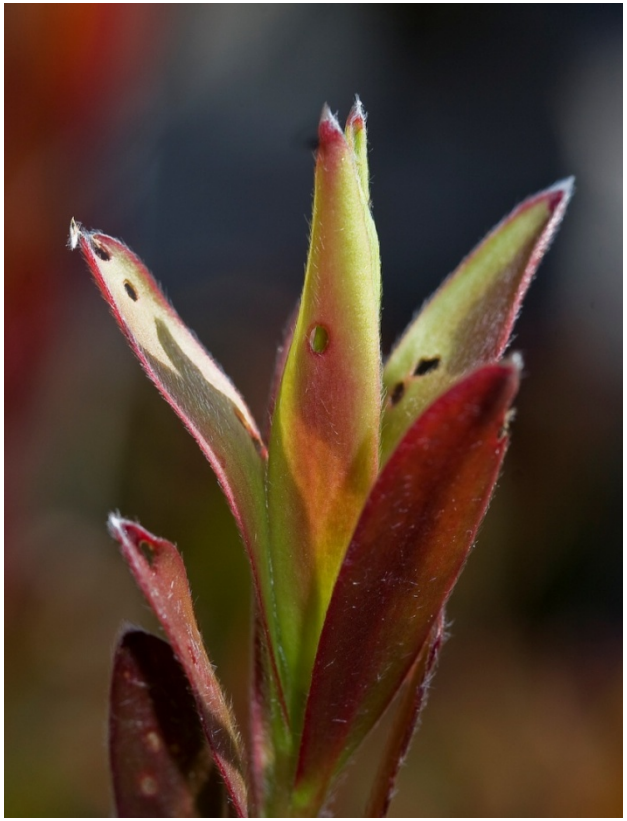




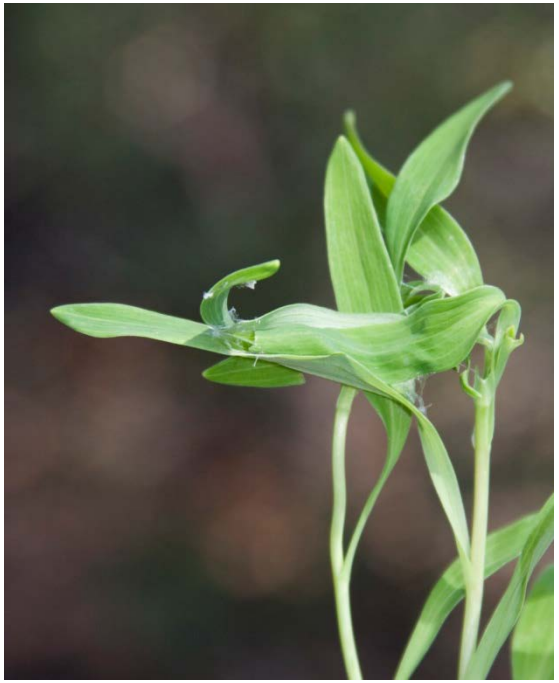


No diapause, development continues 45 ^{o}F to 88 ^{o}F. Nearly 4 life cycles in Watsonville

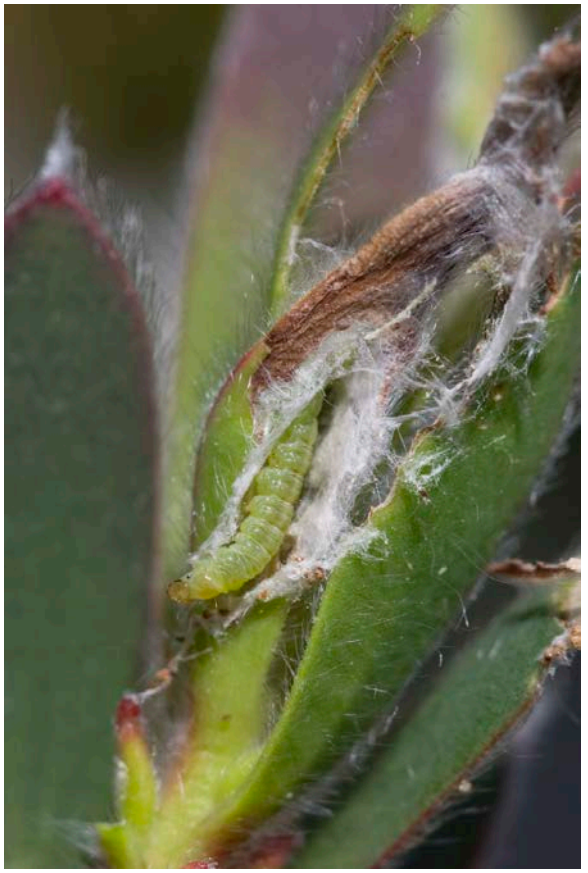
Typical Damage



Leaves chewed



Leaves distorted



Leaves bound together with silk-like webs

HOST PLANTS

545 plant species, 363 genera, and 121 families*
Herbaceous plants preferred over woody plants
Common: many weeds, ornamentals, and berry crops

Adiantum sp., *Aguilegia* sp., *Amaranthus* sp., *Arbutus* sp., apple (*Malus domestica*, *Malus* spp.), apricot (*Prunus armeniaca*), *Artemesia* sp., *Astartea* sp., *Aster* sp., avocado (*Persea americana*), *Baccharis* sp., black alder/European alder (*Alnus glutinosa*), blackberry and raspberry (*Rubus* spp.), black poplar (*Populus nigra*), blueberry (*Vaccinium sp.*), *Boronia* sp., *Brassica* sp., *Breynia* sp., broad bean (*Vicia faba*), broadleaf dock (*Rumex obtusifolius*), *Bursaria* sp., butterfly bush (*Buddleia* sp.), *Calendula* sp., *Callistemon* sp., camellia (*Camellia japonica*), *Campsis* sp., capeweed (*Arctotheca calendula*), *Cassia* sp., *Ceanothus* sp., Chinese gooseberry (*Actinidia chinensis*), *Choisya* sp., chrysanthemum (*Chrysanthemum* sp.), citrus (*Citrus* spp.), *Clematis* sp., *Correa* sp., cotoneaster (*Cotoneaster* sp.), *Clerodendron* sp., clover (*Trifolium repens*, *Trifolium* sp.), *Cupressus* sp., curled dock (*Rumex crispus*), currant (*Ribes* sp.), *Cydonia* sp., *Dahlia* sp., *Datura* sp., *Daucus* sp., *Dodonaea* sp., *Eriobotrya* sp., *Eriostemon* sp., *Escallonia* sp., eucalyptus (*Eucalyptus* sp.), euonymus (*Euonymus* sp.), fat-hen (*Chenopodium album*), *Forsythia* sp., *Fortunella* sp., fox's brush (*Centranthus* spp.), *Gelsemium* sp., *Genista* sp., *Gerbera* sp., gorse (*Ulex europaeus*), grape (*Vitis vinifera*, *Vitis* sp.), *Grevillea* sp., *Hardenbergia* sp., hawthorn (*Crataegus* sp.), hebe (*Hebe* spp.), *Helichrysum* sp., hop (*Humulus lupulus*), horn of plenty (*Feijoa sellowiana*), ivy (*Hedera helix*, *Hedera* spp.), jasmine (*Jasminum* spp.), *Juglans* sp., kiwifruit (*Actinidia deliciosa*), *Lathyrus* sp., *Lavendula* sp., *Leucodendron* sp., *Leptospermum* sp., *Linus* sp., litchi (*Litchi chinensis*), *Lonicera* sp., alfalfa (*Medicago sativa*), *Lupinus* sp., *Lycopersicum* sp., *Macadamia* sp., malabar ebony (*Diospyros* sp.), *Mangifera* sp., *Melaleuca* sp., *Mentha* sp., *Mesembryanthemum* sp., *Michelia* sp., *Monotoca* sp., montbretia (*Crocosmia* sp.), *Myoporum* sp., oak (*Quercus* sp.), *Oxalis* sp., *Parthenocissus* sp., peach (*Prunus persica*), pear (*Pyrus* sp.), *Pelargonium* sp., *Persoonia* sp., *Petroselinum* sp., persimmon (*Diospyros kaki*), *Philadelphus* sp., *Photinia* sp., *Pittosporum* sp., pine (*Pinus* muricata, *P.* radiata, Pinus sp.), plantain / ribwort (*Plantago lanceolata*), *Platysace* sp., *Polygala* sp., *Polygonum* sp., poplar and cottonwood (*Populus nigra*, *Populus* sp.), potato (*Solanum tuberosum*), privet (*Ligustrum vulgare*, *Ligustrum* sp.), *Pteris* sp., *Pulcaria* sp., *Pyllanthus* sp, *Pyracantha* sp., *Ranunculus* sp., *Raphanus* sp., *Reseda* sp., raspberry and boysenberry (*Rubus idaeus*, *Rubus* sp.), rose (*Rosa* sp.), *Salvia* sp., *Senecio* sp., Scotch broom (*Cytisus scoparius*), *Sida* sp., *Sisymbrium* sp., *Smilax* sp., *Sollya* sp., St. John's wort (*Hypericum perforatum*), strawberry (*Fragaria* sp.), *Tithonia* sp., *Trema* sp., *Triglochin* sp., *Urtica* sp., *Viburnum* sp., *Vinca* sp., wattle (*Acacia* sp.), willow (*Salix* sp.).

*E.G. Brokerhoff, et.al. (2011)

Eradication in Nurseries is Difficult

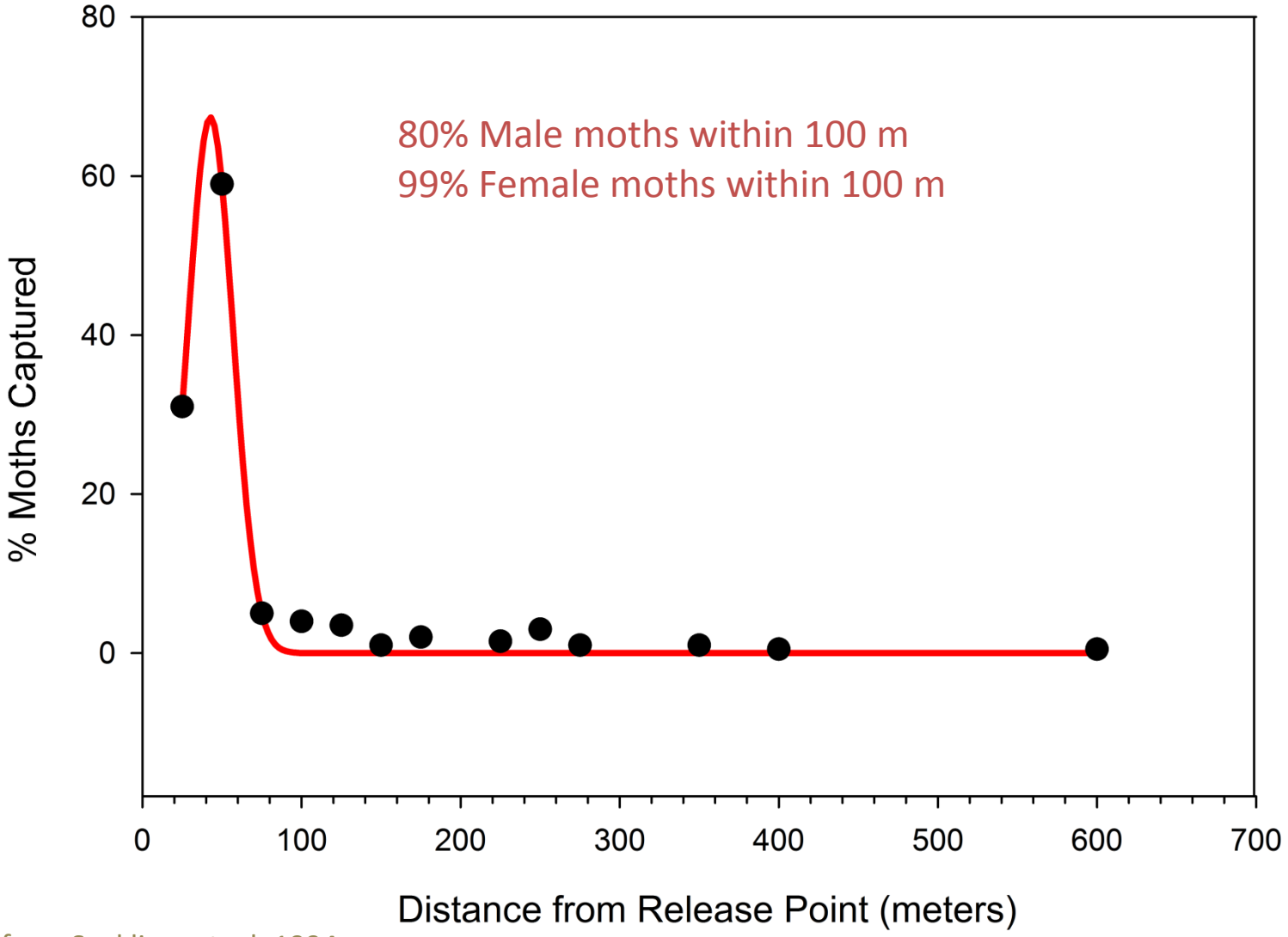
LBAM can be introduced from surroundings

USDA official detections Mar 2010 to Sept 2010

LBAM Larvae Detection in Raspberries (1 A)

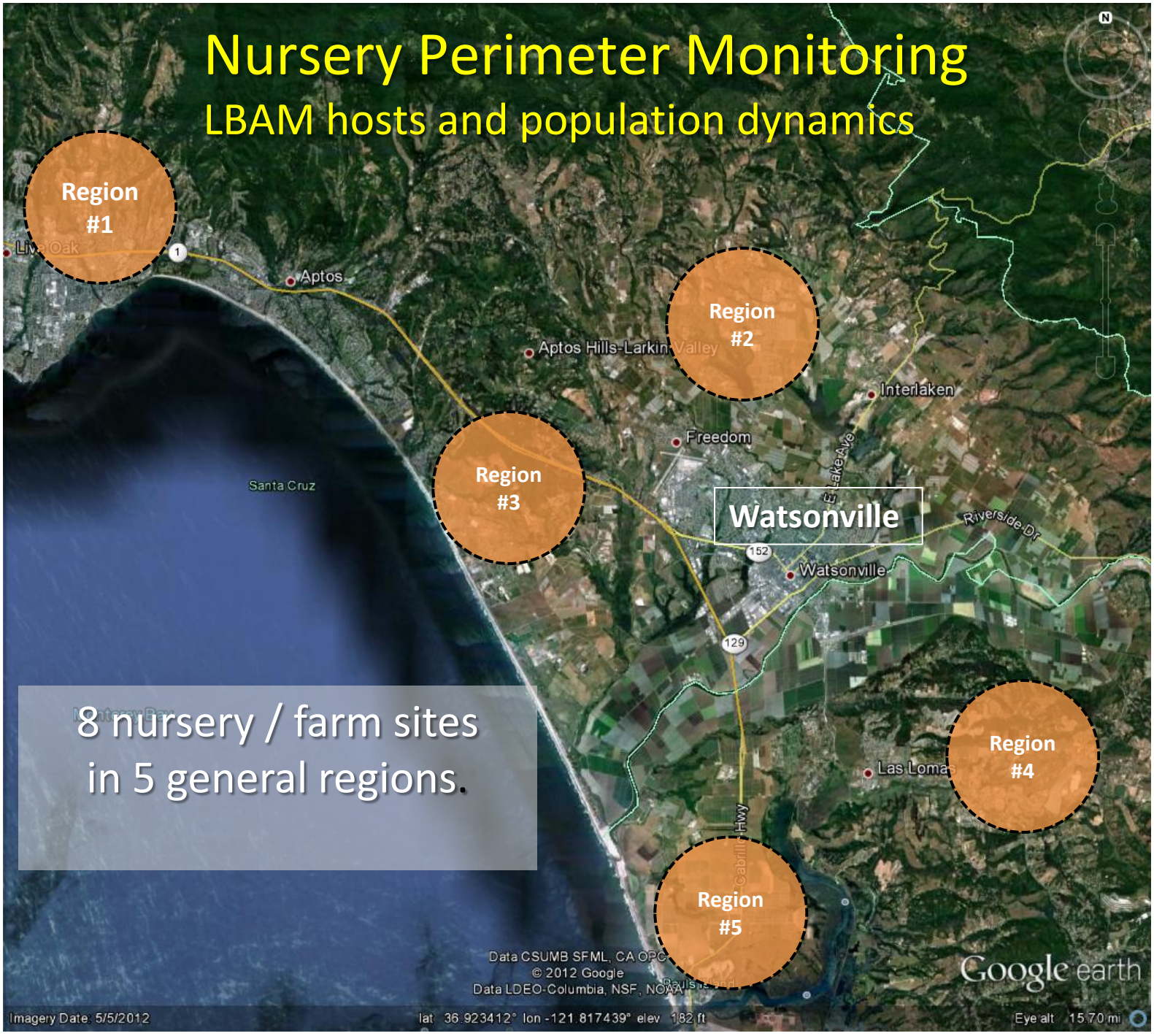
RED number of leaf rolls
BLUE number of larvae

LBAM Moth Migration



Adapted from Suckling, et. al. 1994

What are the important LBAM hosts and when do they migrate ?


Nursery Perimeter Monitoring
LBAM hosts and population dynamics
Region #1
Region #2
Region #3
Region #4
Region #5
Watsonville
8 nursery / farm sites in 5 general regions.
Aptos
Aptos Hills-Larkin Valley
Interlaken
Freedom
Santa Cruz
Watsonville
Las Loma
Riverside Dr
Data CSUMB SFML, CA OPC
© 2012 Google
Data LDEO-Columbia, NSF, NOAA
Google earth
Imagery Date: 5/5/2012
lat 36.923412° lon -121.817439° elev 182 ft
Eye alt 15.70 mi

Monitor Moth Population Dynamics

- Delta traps with LBAM pheromone
- Bucket traps with terpinyl acetate / brown sugar bait
- Monitored every 2 weeks since Oct 2011

Monitor and Identify LBAM Larvae on Hosts

French broom

Genista monspessulana

Example of Monitoring Plan

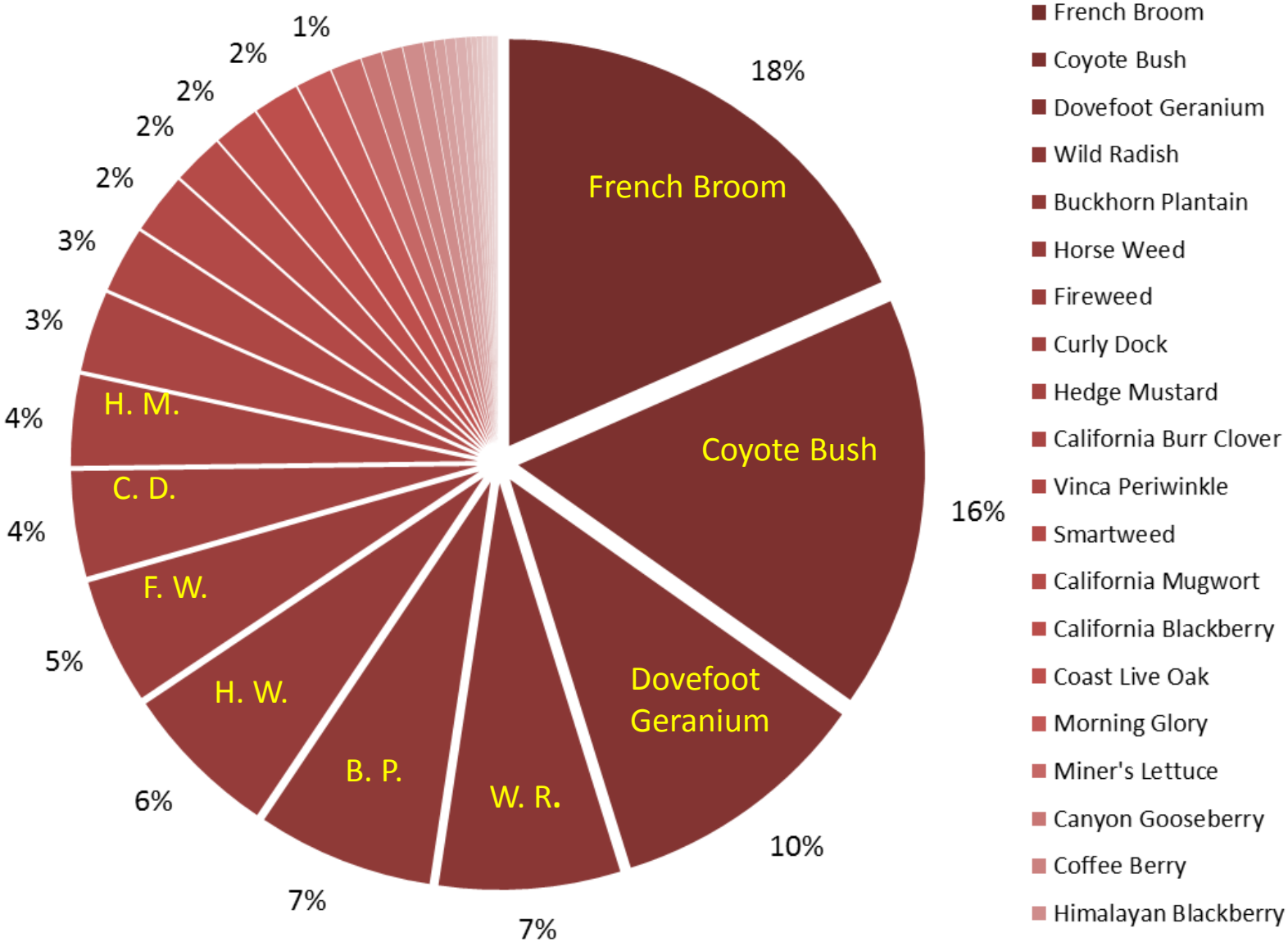
Purple line is nursery perimeter (1.25 miles)

Green areas are scouted for symptoms of LBAM infestation

Terpinyl / Brown Sugar Bait Bucket Trap

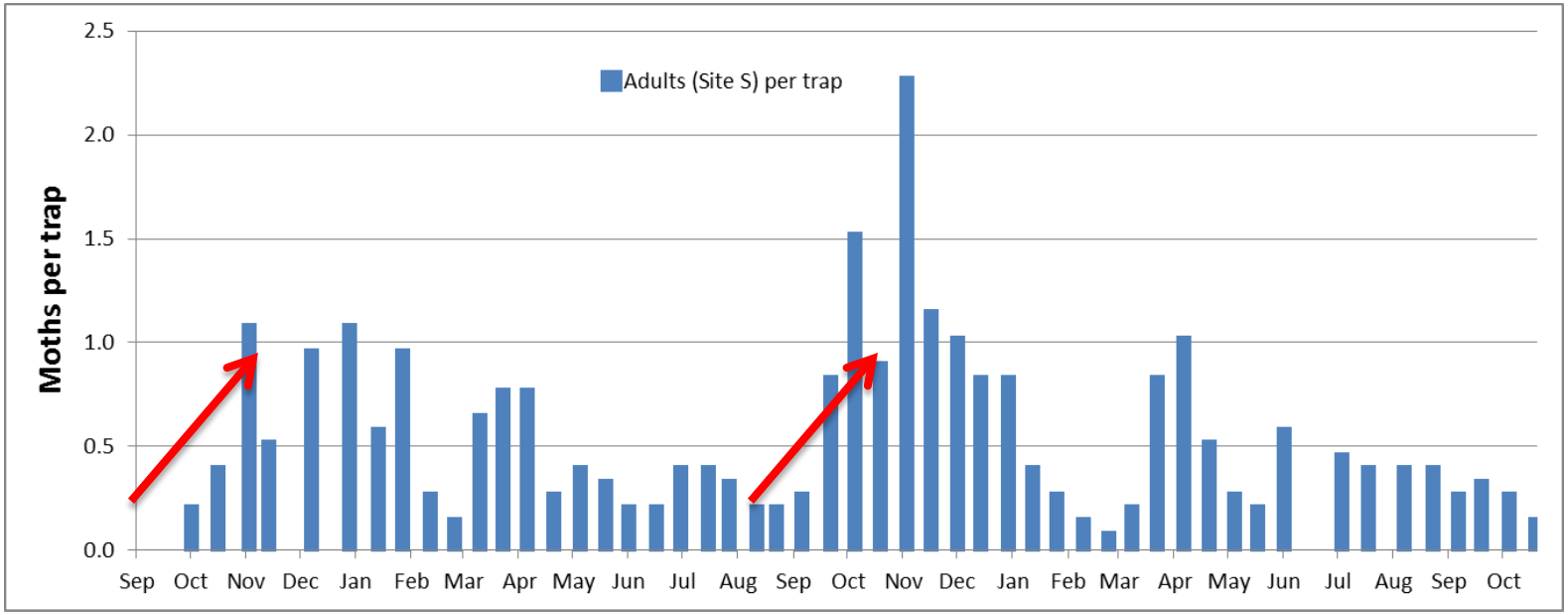
Pheromone Jackson Trap

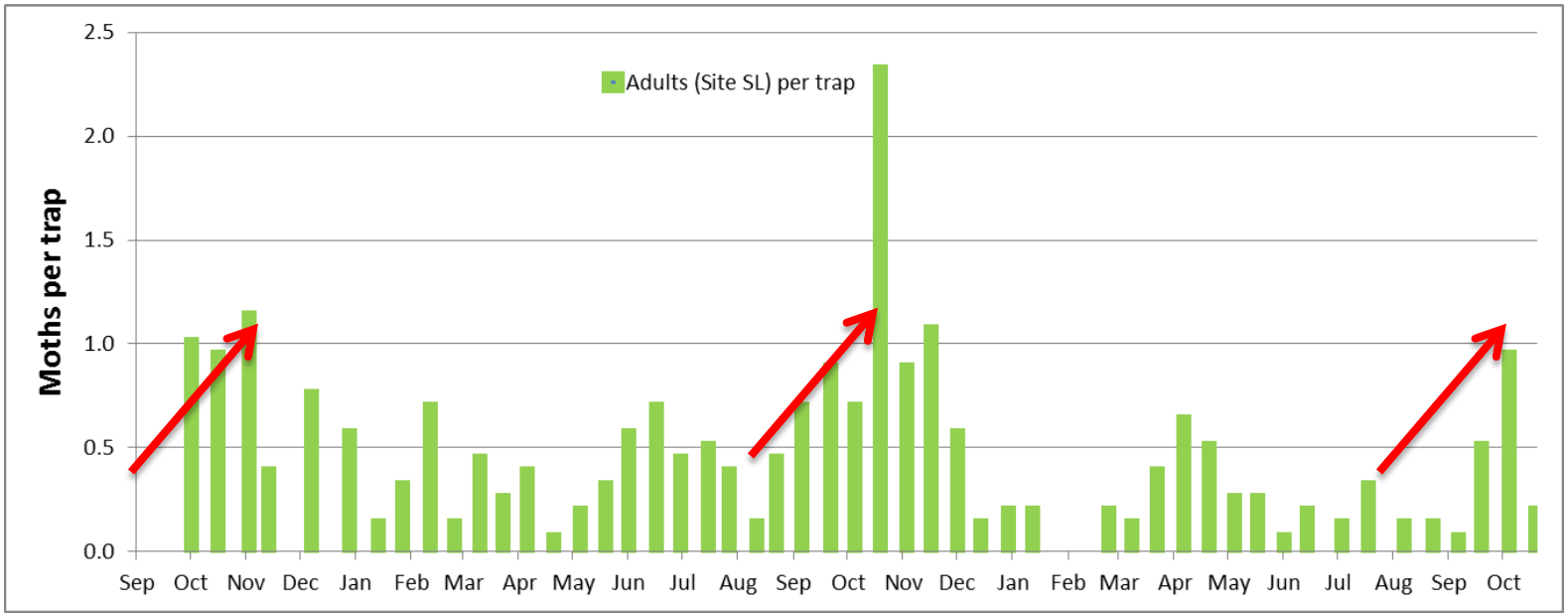
% Larvae Detected on Perimeter Hosts



N = 500 larvae, Oct 2011 to Sep 2013

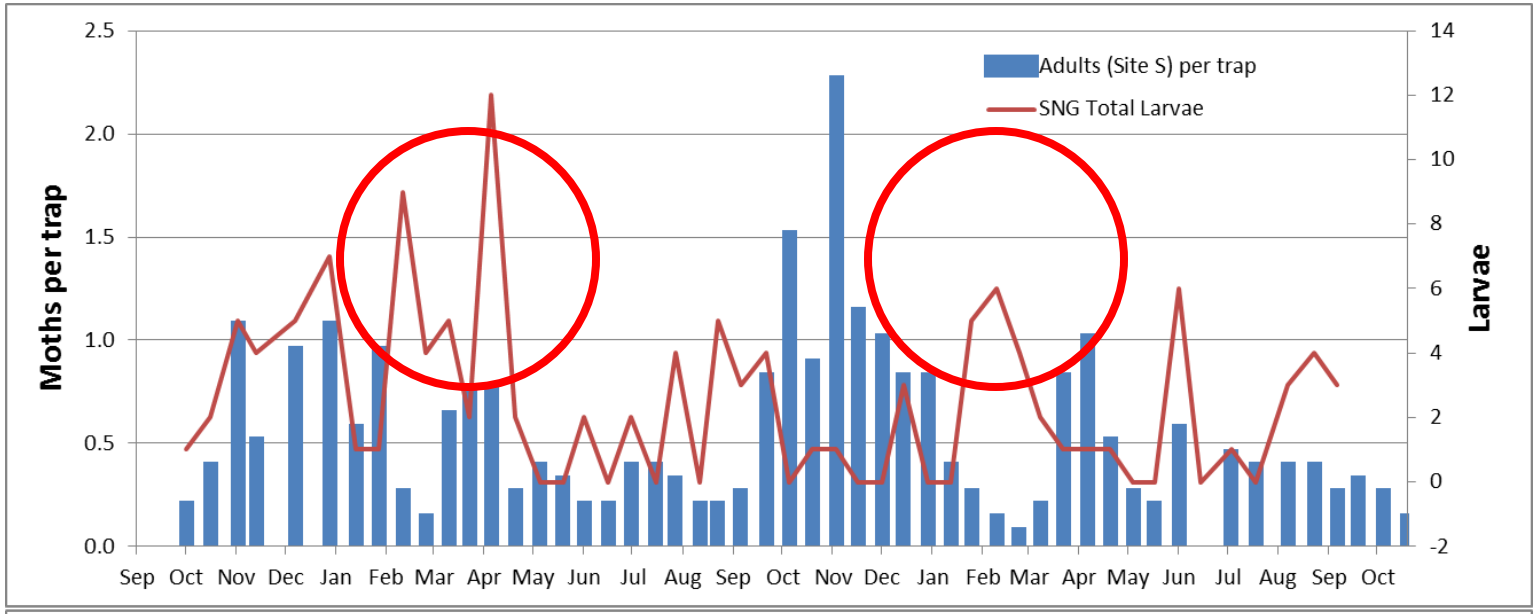
Moth Numbers (2 of 8 Sites)

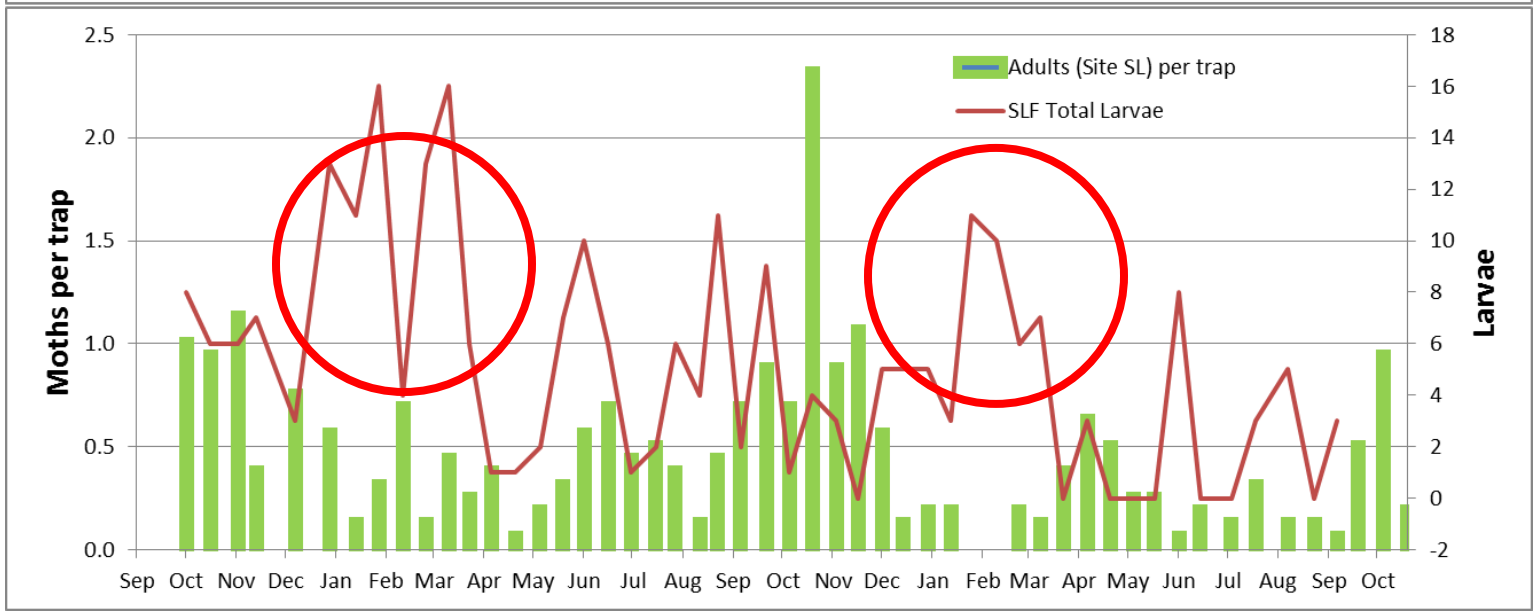




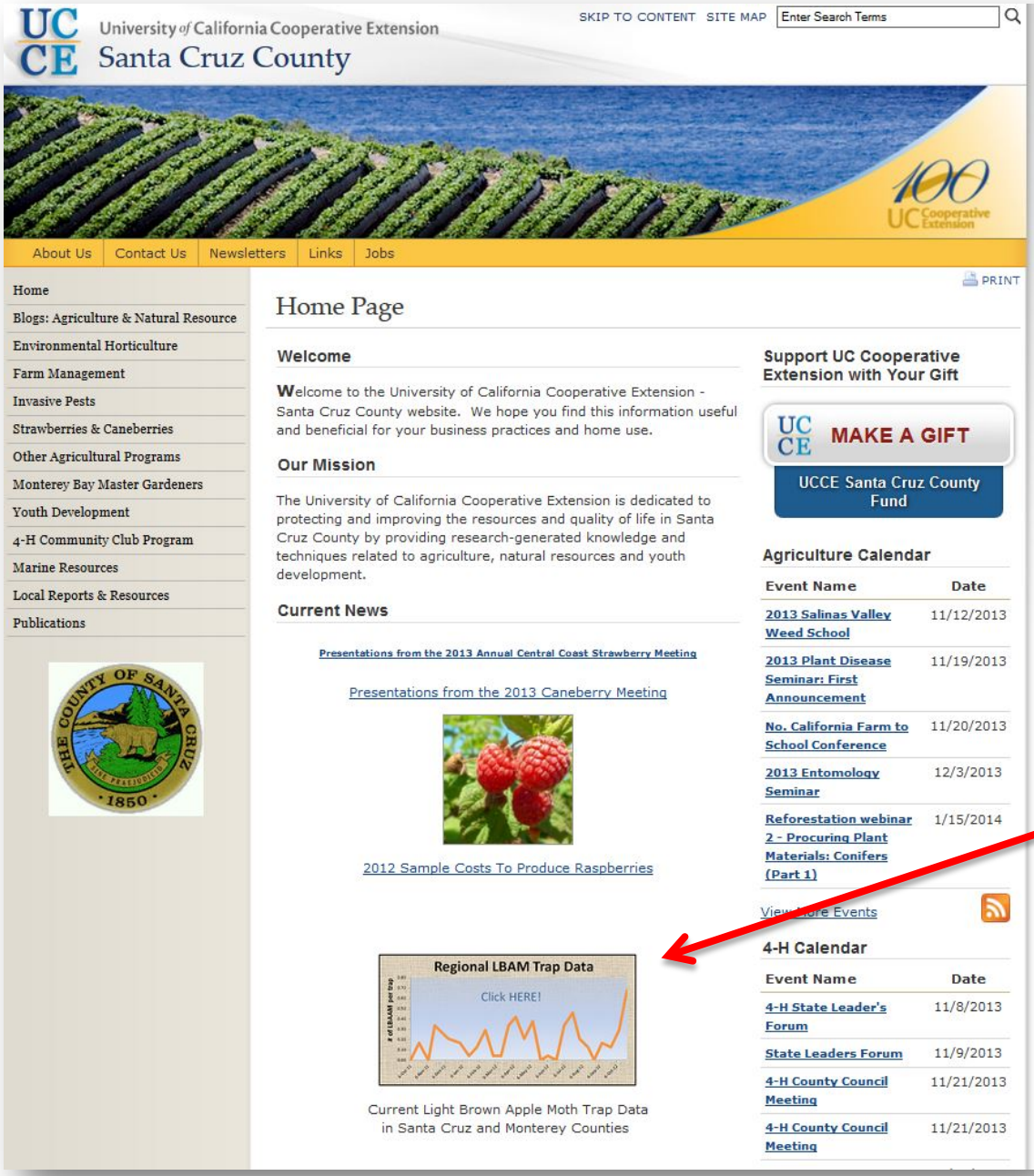
2011 2012 2013

Moth and Larvae Numbers (2 of 8 Sites)





2011 2012 2013



UCCE Santa Cruz home page

http:// cesantacruz.ucanr.edu

LBAM Indigenous Parasitoids

- Notable indigenous parasitoids include:

Trichogramma platneri

and *T. fasciatum*

– egg parasitoids

Meteorus trachynotus

– larval parasitoid

Enytus eureka

– larval parasitoid

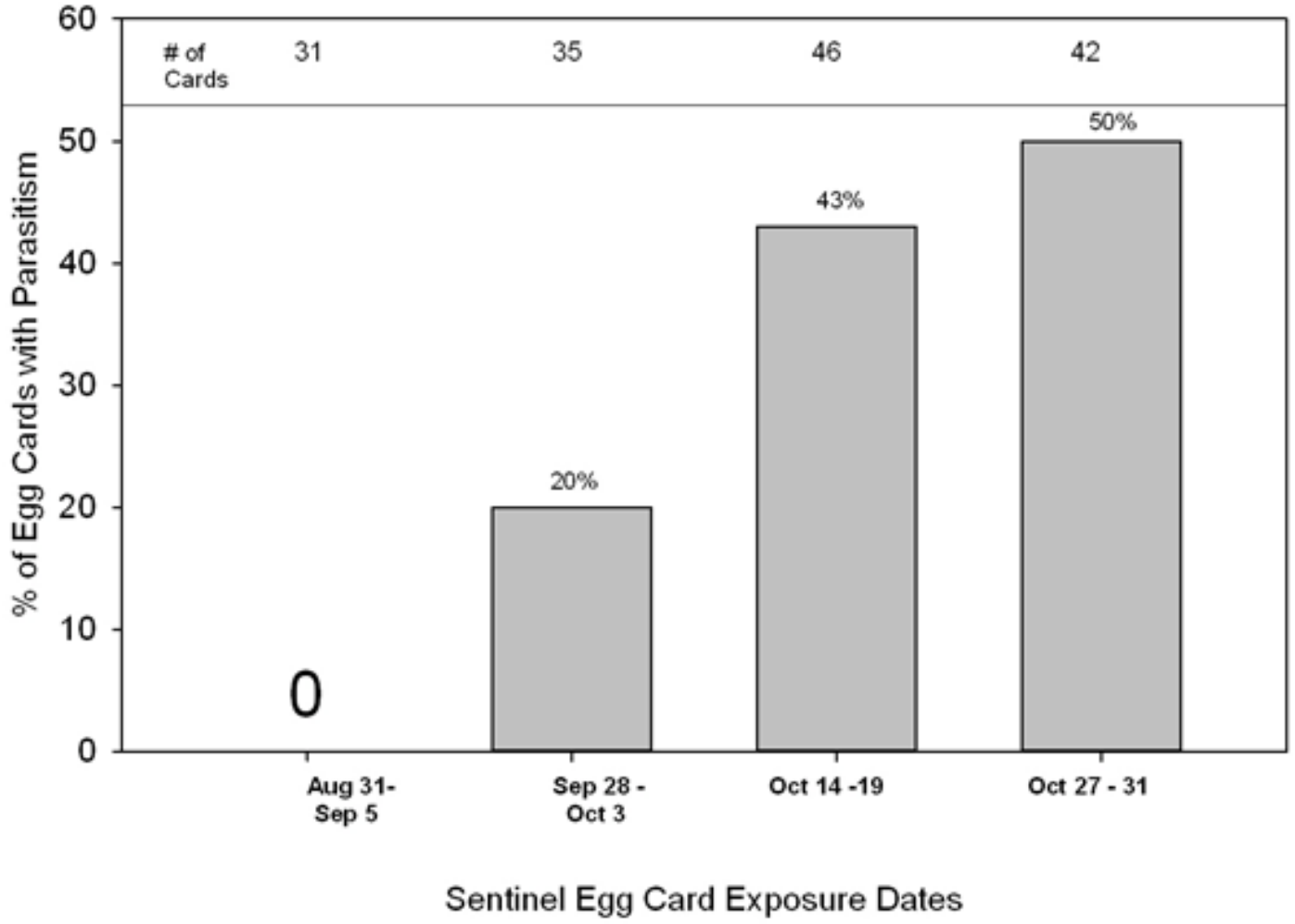
Slide credit: Nick Mills, UC Berkeley

Biological Control

Augment biological control with releases of commercially available *Trichogramma platneri* at nursery perimeters or within nursery.

Bill Roltsch, CDFA

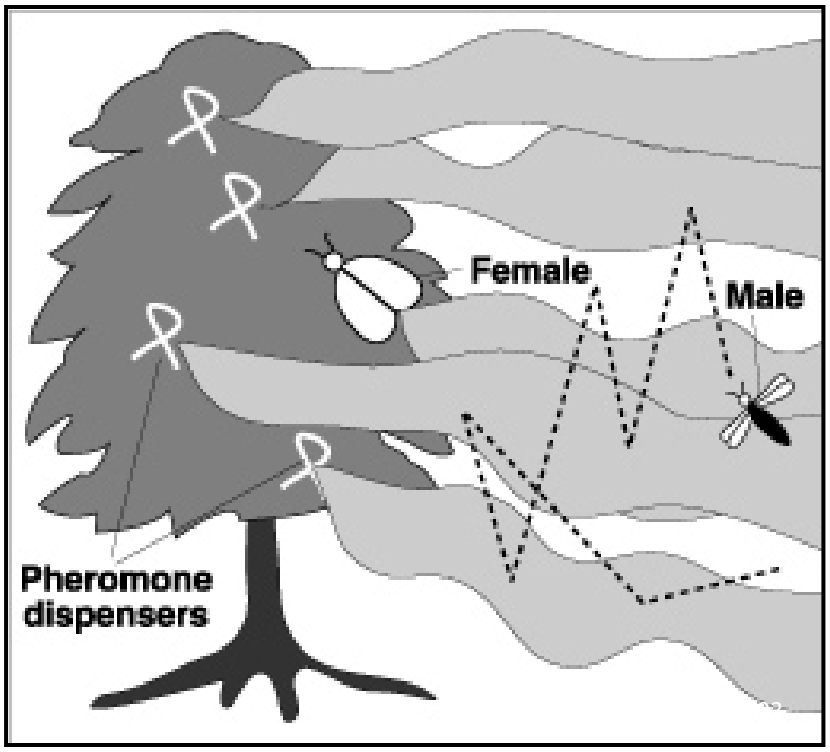
Egg Parasitism by *T. platneri*



T. platneri 100k/ A . Every 2 weeks. Evaluation based on parasitism of OBLR eggs

Pheromone Mating Disruption

Management Theory

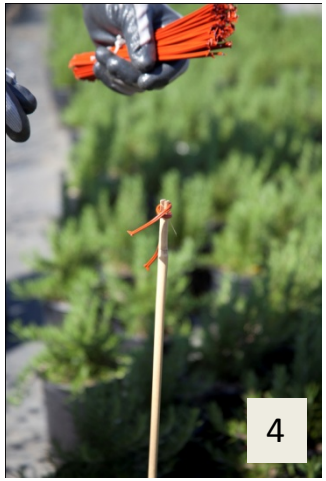


Synthetic Pheromone

- Applied in mass to the field in dispensers
- Male moth can not orient to female and does not successfully mate
- Conventional recommendation is to use large (> 10 A) and uniform, contiguous areas

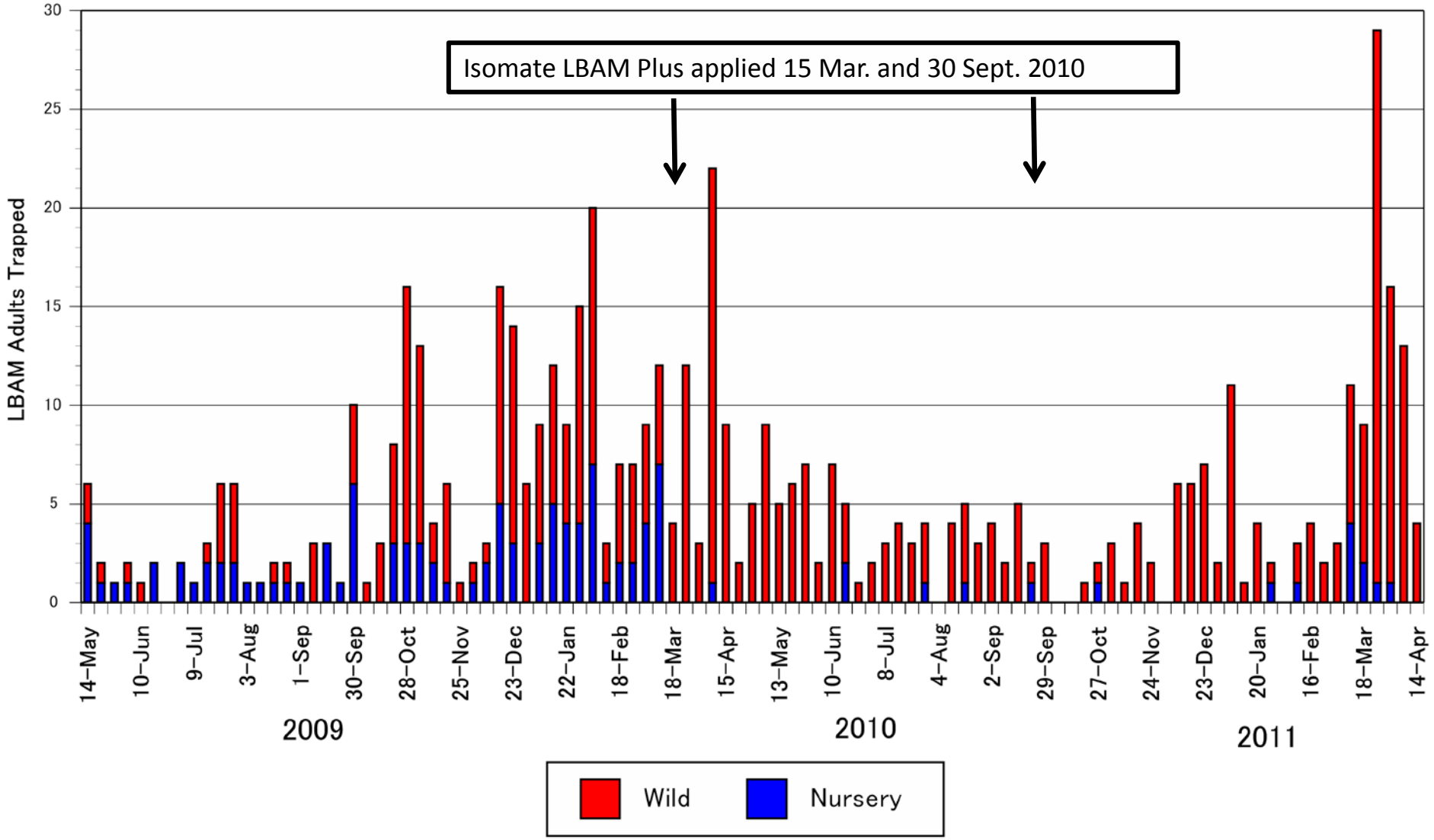
Isomate ® LBAM Plus

Application in Nurseries

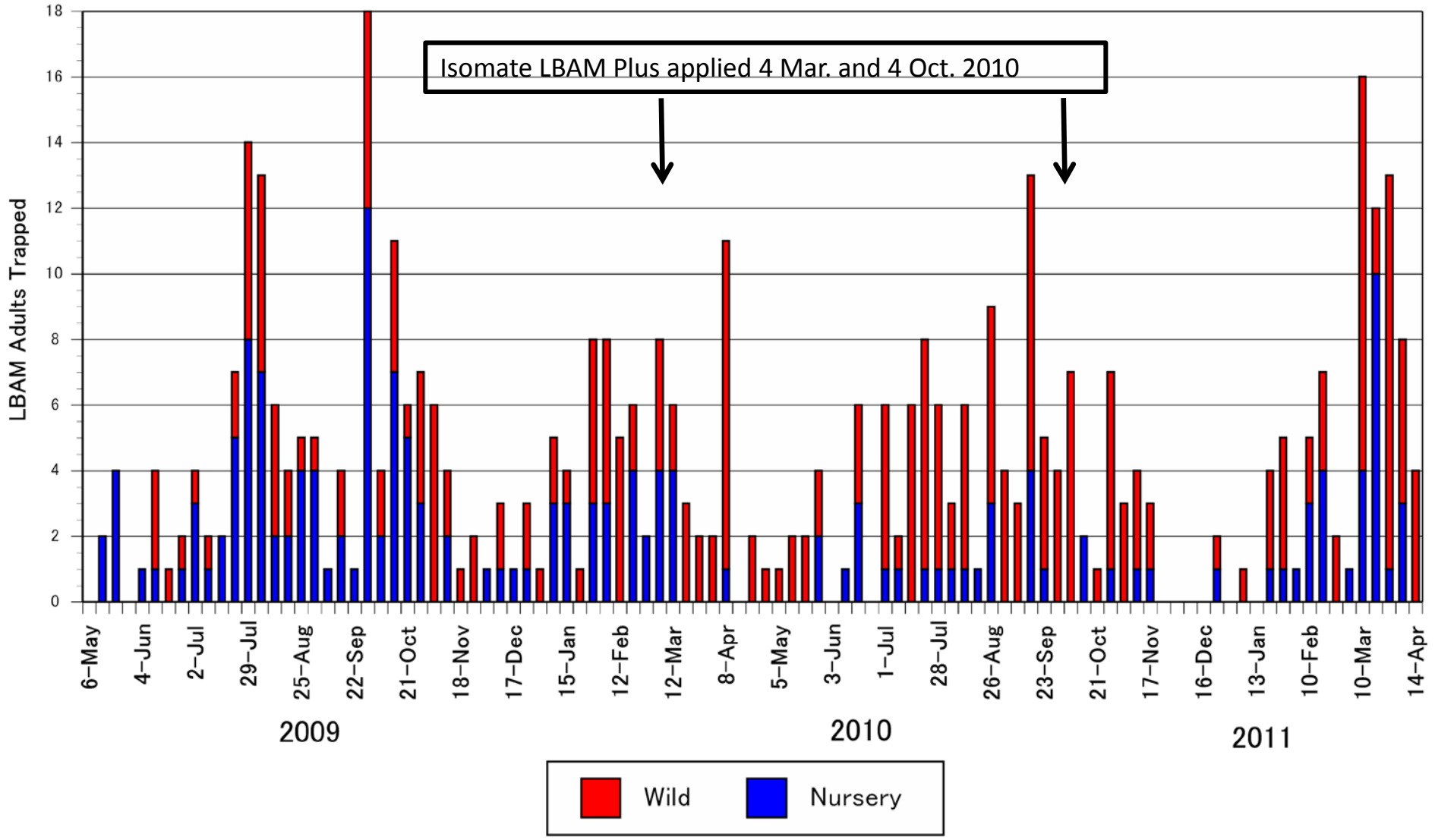


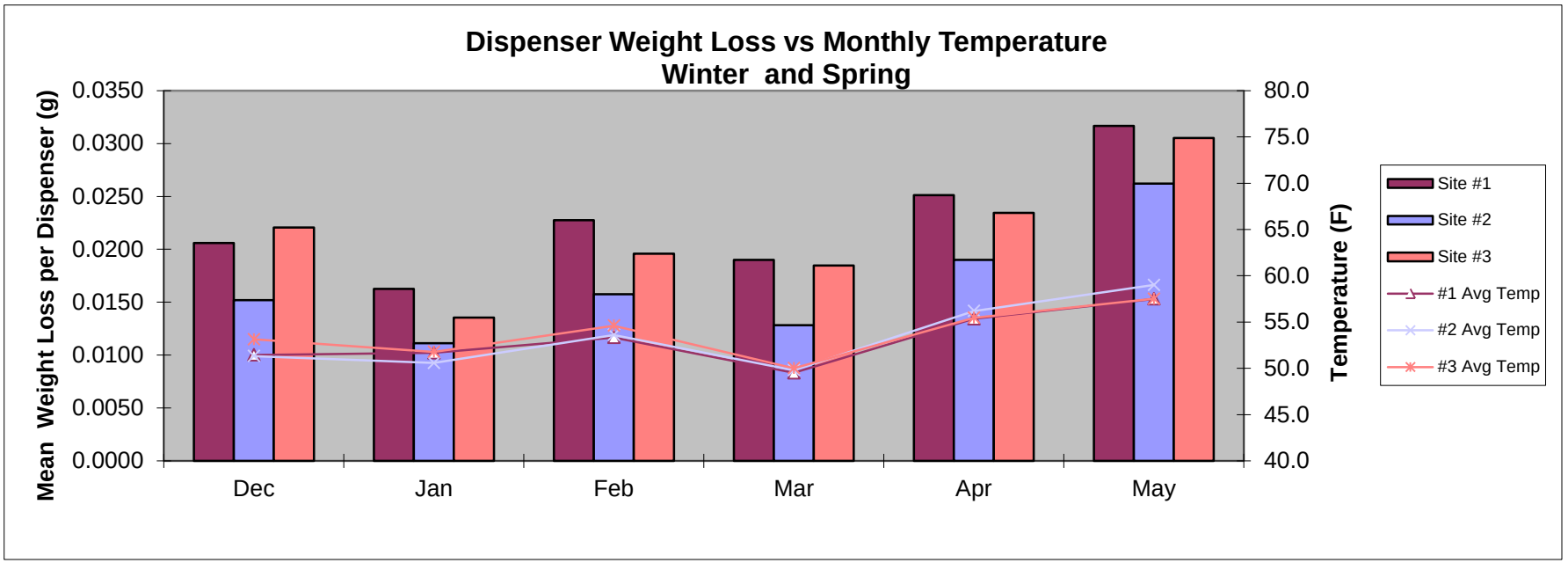
300 twist ties per Acre = 13 X 13 foot square

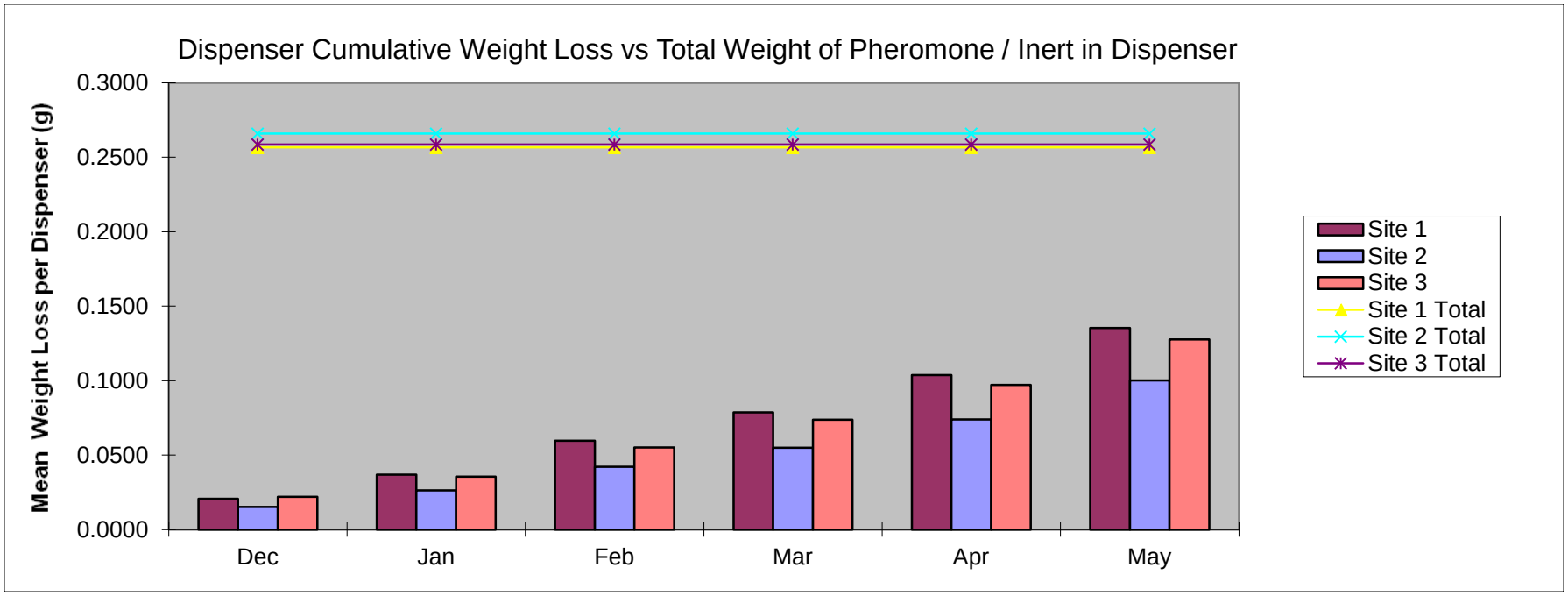
Nursery 1 (8.0 acres, Santa Cruz County)
LBAM moths trapped

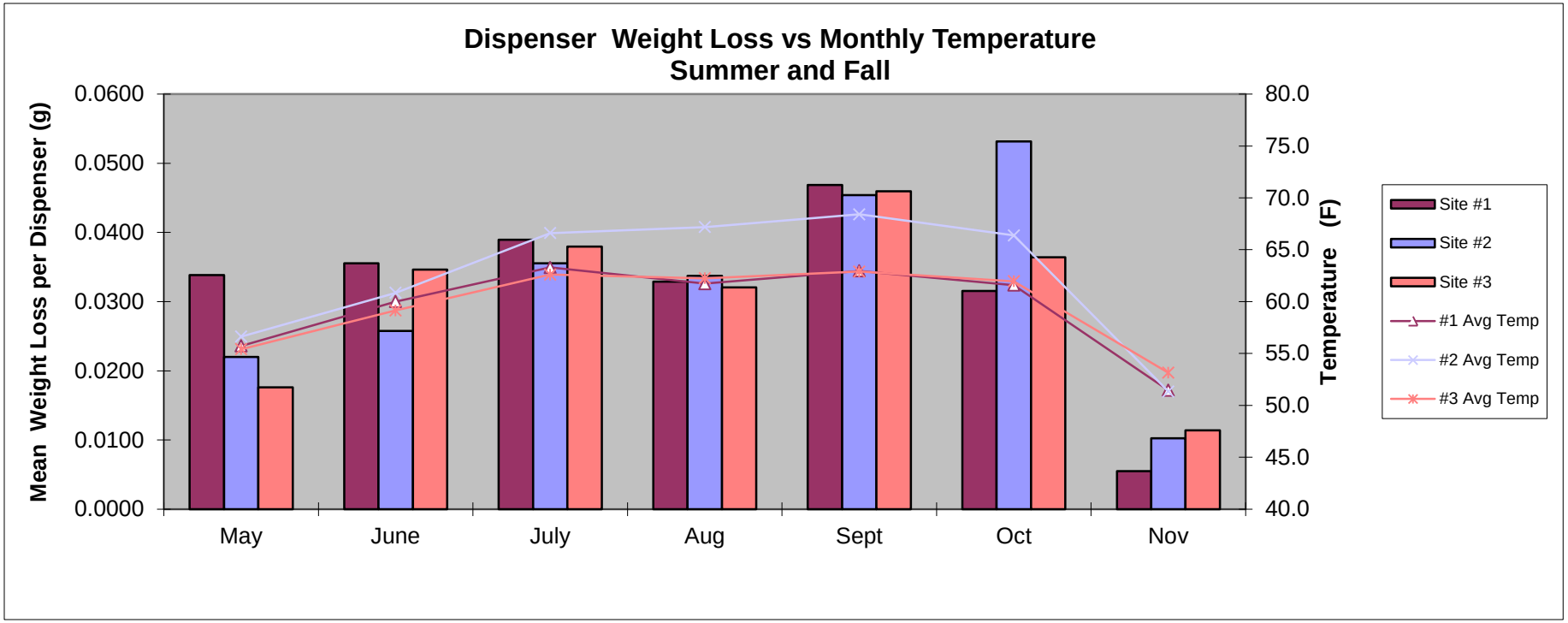


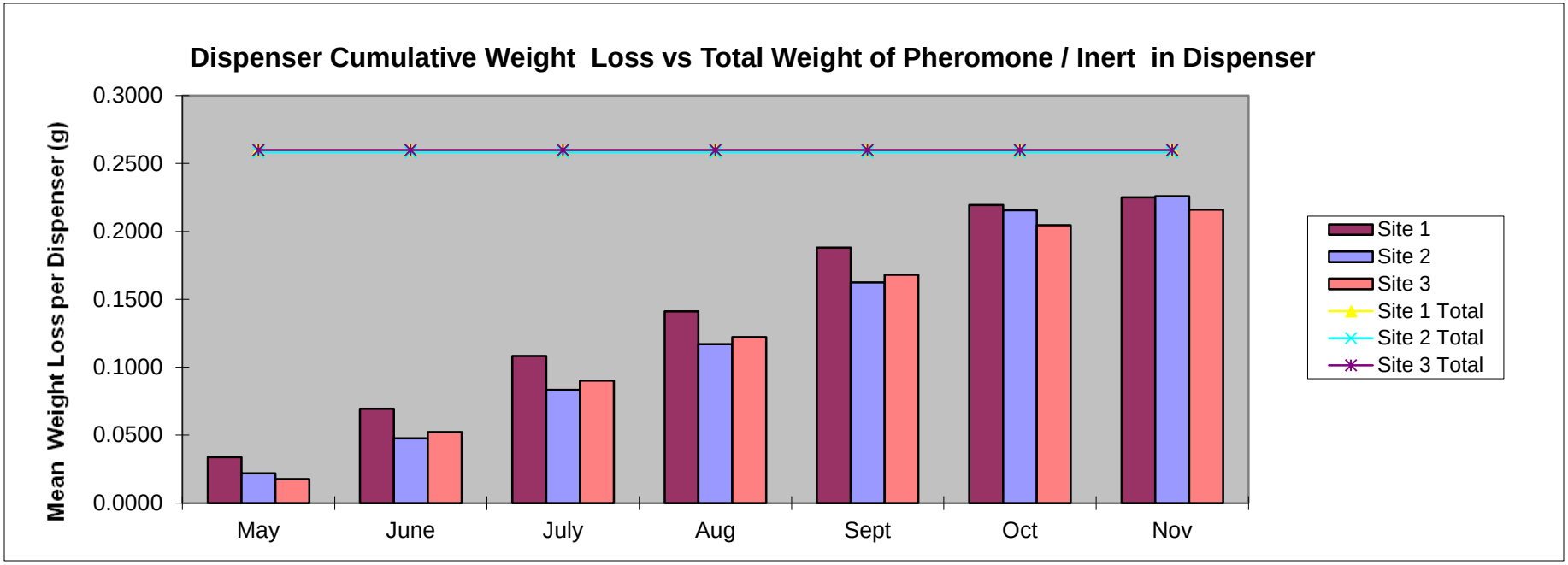
Nursery 2 (2.2 acres, Santa Cruz County)
LBAM moths trapped




Dispenser Weight Loss vs Monthly Temperature
Winter and Spring
Mean Weight Loss per Dispenser (g)
0.0350
0.0300
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
Temperature (F)
Dec
Jan
Feb
Mar
Apr
May
Site #1
Site #2
Site #3
#1 Avg Temp
#2 Avg Temp
#3 Avg Temp


Dispenser Cumulative Weight Loss vs Total Weight of Pheromone / Inert in Dispenser
Mean Weight Loss per Dispenser (g)
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
Dec
Jan
Feb
Mar
Apr
May
Site 1
Site 2
Site 3
Site 1 Total
Site 2 Total
Site 3 Total


Dispenser Weight Loss vs Monthly Temperature
Summer and Fall
Mean Weight Loss per Dispenser (g)
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
80.0
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
Temperature (F)
May
June
July
Aug
Sept
Oct
Nov
Site #1
Site #2
Site #3
#1 Avg Temp
#2 Avg Temp
#3 Avg Temp


Dispenser Cumulative Weight Loss vs Total Weight of Pheromone / Inert in Dispenser
Mean Weight Loss per Dispenser (g)
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
May
June
July
Aug
Sept
Oct
Nov
Site 1
Site 2
Site 3
Site 1 Total
Site 2 Total
Site 3 Total

Field evaluation of LBAM insecticides

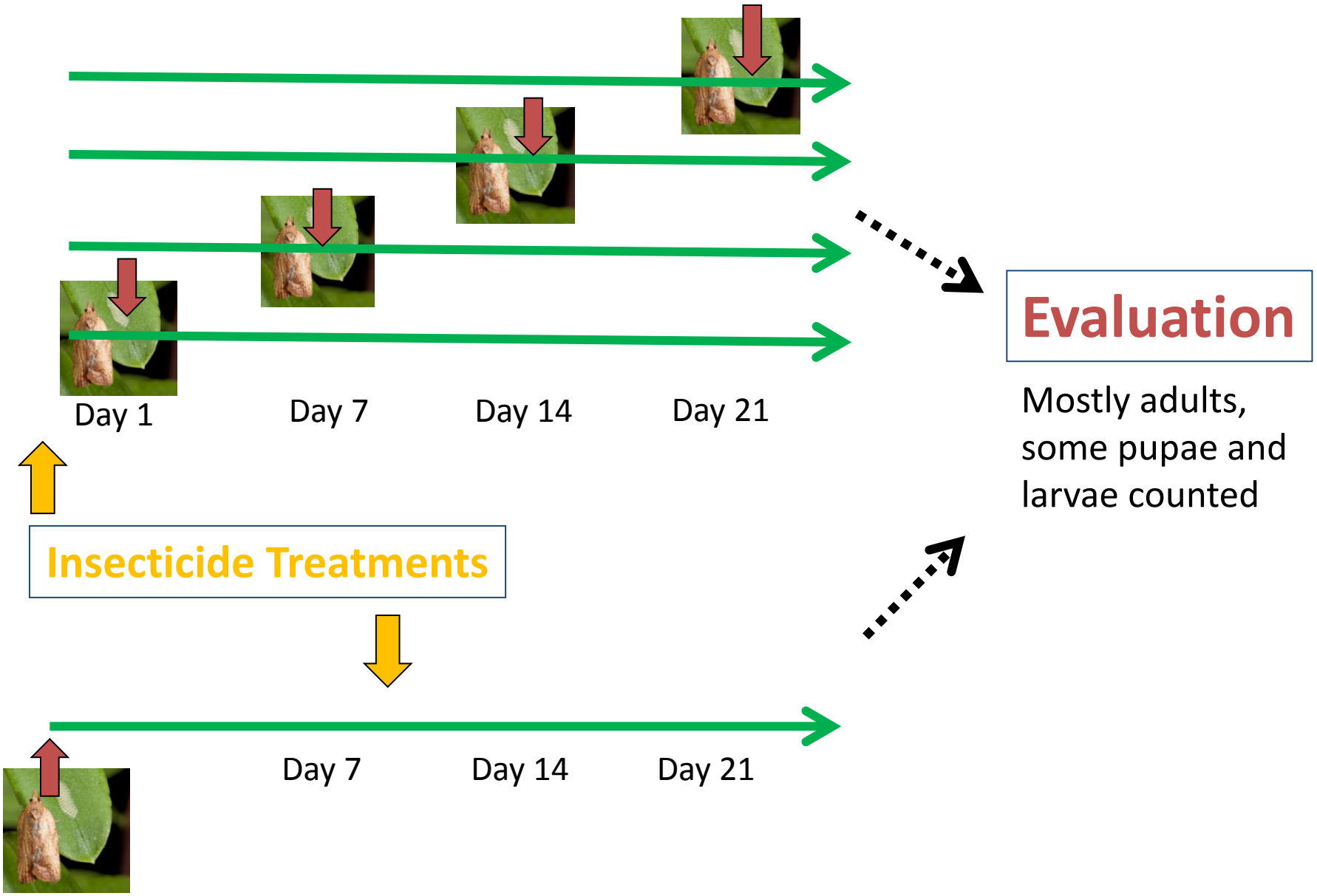
Fall 2010 and Spring 2012

- Evaluate efficacy of many of the CDFA approved insecticides in field conditions.

- Evaluate residual insecticidal action.

Residual Control Before and After Egg Laying

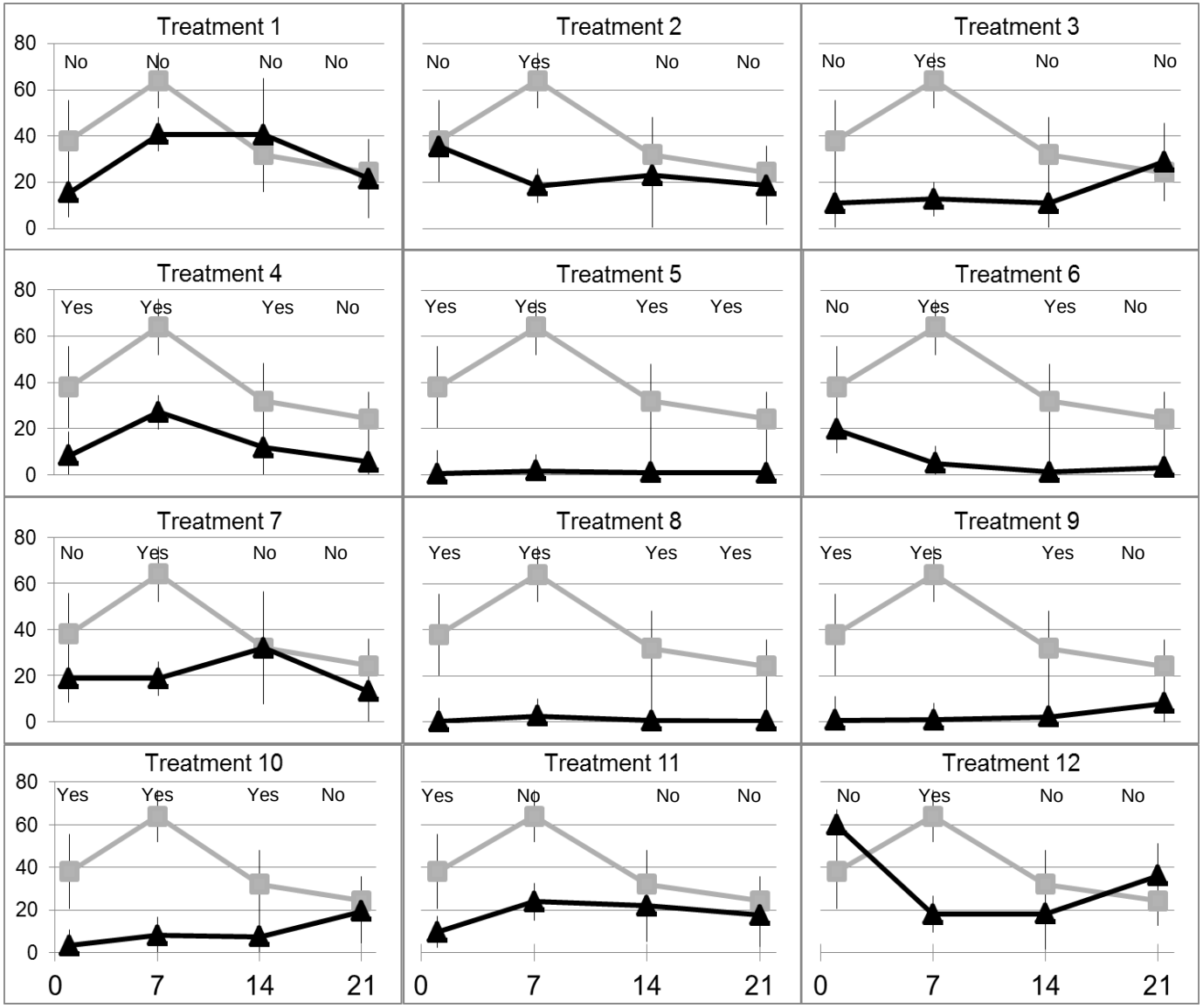
Two Experiments with Adult Emergence as Endpoint



Treat	Active Ingredient	Product	Mode of Action / Class
1	Bacillus thuringiensis ssp. kur.	Dipel Pro	11a Microbial disruptors
2	+ oil	Dipel Pro + oil	
3	spinosad	Conserve	5 Spinosyns
4	+ oil	Conserve + oil	
5	methoxyfenozide	Intrepid	18 Ecdysone receptor IGR
6	+ oil	Intrepid + oil	
7	horticultural oil (petroleum oil)	Pure Spray Green Oil	Misc Oils
8	lambda-cyhalothrin	Scimitar	3a Pyrethroids
9	emamectin benzoate	Enfold / Proclaim	6 Avermectin/Milbemycins
10	chlorantraniliprole	Acelepryn	28 Diamides
11	indoxacarb	Provaunt	22a
12	difluobenzuron	Dimilin	15 Chitin biosynthesis IGR
13	Untreated Check		

Treatments at maximum labeled rate, Oil at 1% v/v, Surfactant added to all

Surviving LBAM Life Forms
2010



Days after treatment (Infestations)

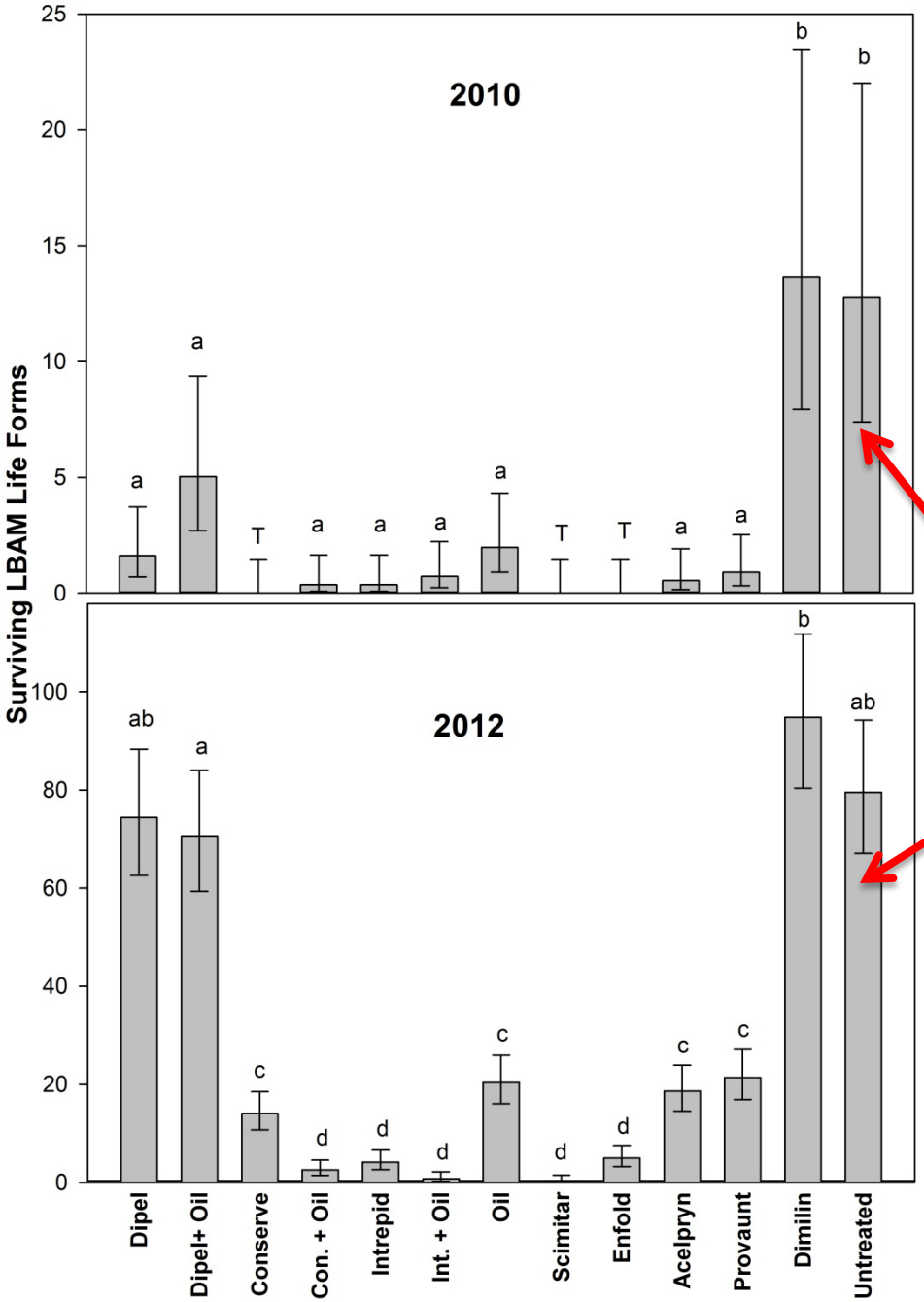
Days after treatment (Infestations)

Days after treatment (Infestations)

□ = Control ▲ = Treatments

Residual activity (2010 and 2012)

- Dipel , Provaunt : 1 week
- Conserve : 1 to 2 weeks
- Acelpryn, Enfold : 2 to 3 weeks
- Intrepid, Scimitar : 3 to 4 weeks
- Horticultural oil: + or -
  Was not consistent on residual effect.
- Dimilin: inconsistent and low activity
- Scimitar repelled or killed moths and prevented egg laying.



Effect of Insecticides on LBAM Survival 2010 and 2012

Insecticides applied after egg laying

Untreated

Systemic insecticide activity needed for larvae?

Treatments

Treat	Active Ingredient	Product	Mode of Action / Group
1	methoxyfenozide	Intrepid	18 Insect growth regulator
2	emamectin benzoate	Enfold / Proclaim	6 Chloride channel activator
3	acephate	Orthene TO	1B Organophosphates
4	cyantraniliprole	Mainspring / Cyazypyr	28 Diamides
5	dinotefuran	Safari	14 Neonicotinoids
6	spirotetramat	Kontos	23 Tetronic acid derivatives
7	untreated check		

Treatments at maximum labeled rate. Surfactant added to all.

3 egg masses per plant
8 July

Treatments on Different Larval Stages

First and Second Instars
Sprayed 18 July

Evaluation
23 Sept.

Fifth and Sixth Instars
Sprayed 16 Aug.

Third and Fourth Instars
Sprayed 6 Aug.

Treatment		Percent Control	Statistically Similar Groups
First and Second Instars			
	Orthene	100.0	a
	Enfold	100.0	a
	Intrepid	100.0	a
	Mainspring	98.2	ab
	Kontos	82.8	bc
	Safari	49.0	cd
	Untreated Check	0.0	d
Third and Fourth Instars			
	Orthene	100.0	a
	Enfold	100.0	a
	Mainspring	100.0	a
	Intrepid	99.7	a
	Safari	5.5	b
	Kontos	2.8	b
	Untreated Check	0.0	b
Fifth and Sixth Instars			
	Orthene	100.0	a
	Enfold	99.0	ab
	Intrepid	99.0	ab

Conclusions

- Importance and regulations
- Basic biology
- Perimeter hosts and moth migration
- Biological control
- Pheromone mating disruption
- Insecticides