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# Monitoring and **I**ntegrated **P**est **M**anagement practices for insect pests – novel technologies


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# Important insect pests of fruit tree system

## Fruit (internal feeders):

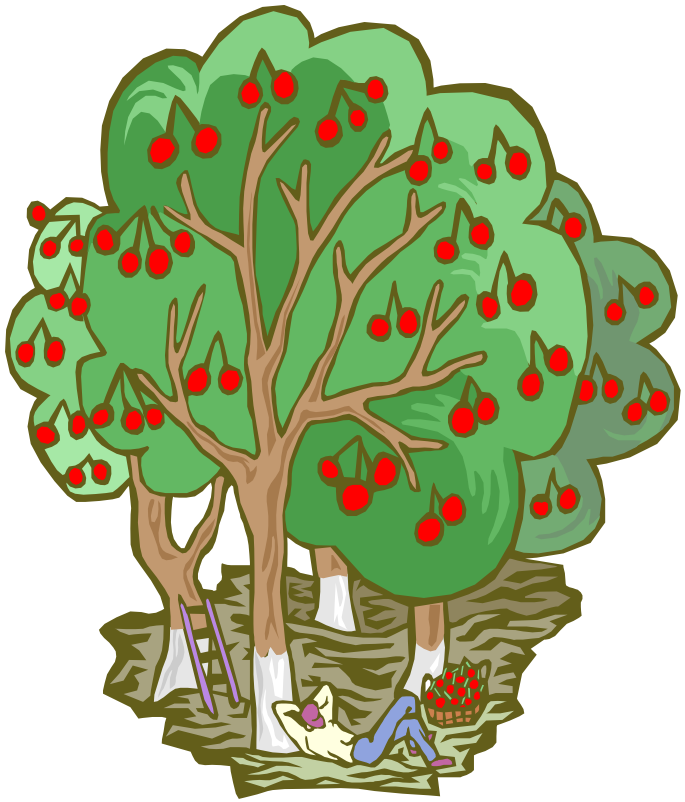
*Apple maggot*
*Oriental fruit worm*
*Codling moth*
*Lesser appleworm*
*European apple sawfly*
*Plum curculio*
*Dock sawfly*
*European corn borer*

## Fruit (external feeders)

*Tufted apple bud moth*
*Obliquebanded leafroller*
*Mullein plant bug*
*Rosy apple aphid*
*San Jose scale*
*Tarnished plant bug*
*and many more .....*

## Trunk and branches:

Rodents
Scales
Borers
Wooly apple aphid
Shoothole borer
Periodical cicada



## Foliage:

Aphids
Leafhoppers
Mites
Leafminers
Leafrollers
Cutworms

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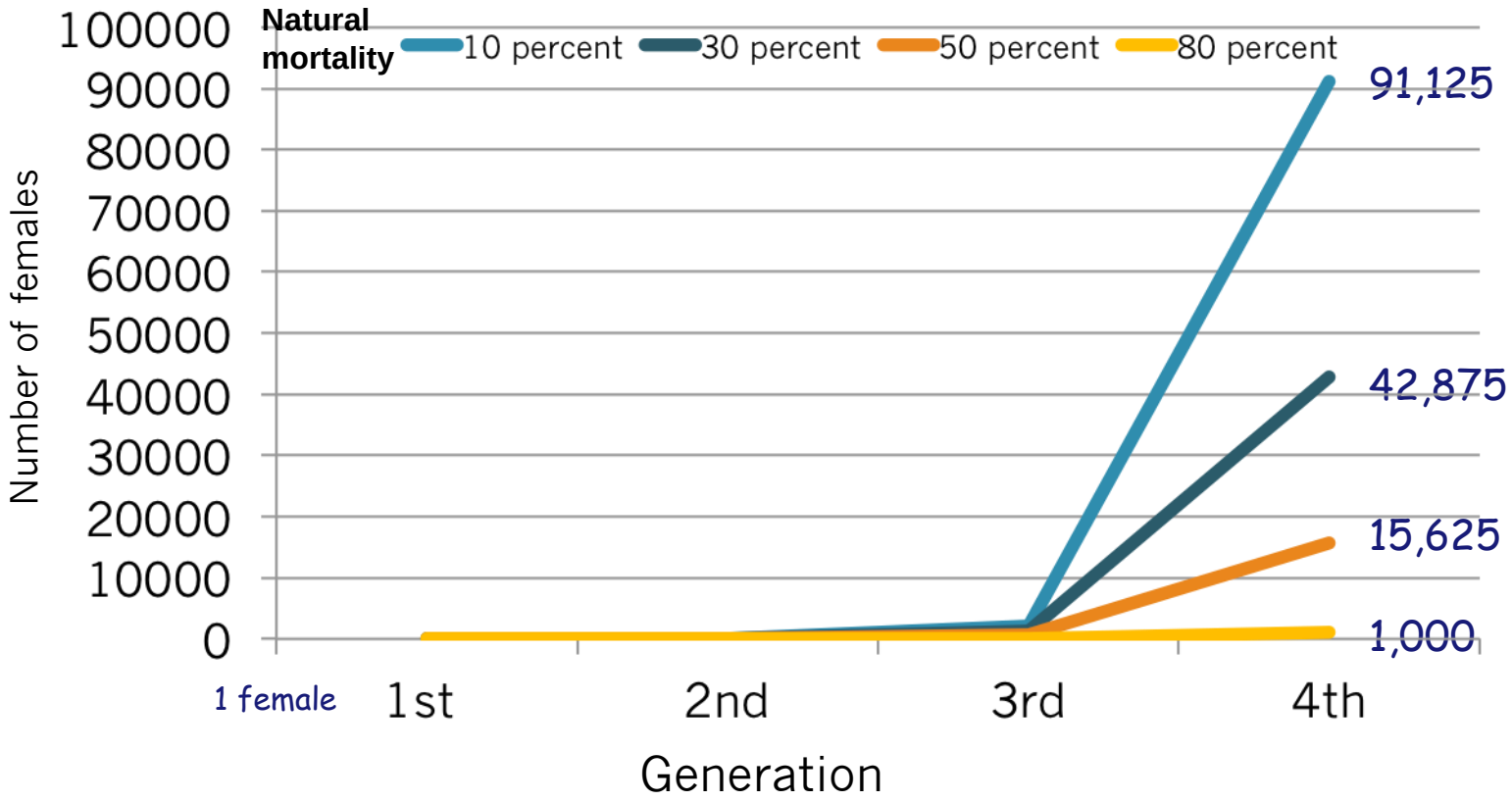
# Hypothetical potential for population growth under various natural control levels

*Exponential population growth assuming **100 eggs** per female: why it is difficult to control insect pests?*



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# Sustainable Agriculture and Integrated Pest Management - IPM

Word "sustain" – from Latin "*sustinere*" (*sus* – from below; *tenere* – to hold) –
to keep in existence or maintain, implies long term support or permanence.

Based on the 1990 US Farm Bill the term **sustainable agriculture** means:
"Integrated system of plant and animal production practices having a site-specific application that will, over the long term:
-Satisfy human and fiber needs,
-Enhance environmental quality and the natural resource base upon which the agricultural economy depends,
-Make the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls,
-Sustain the economic viability of farm operations,
-Enhance the quality of life for farmers and society as a whole"
*(Sustainable Agriculture: Definitions and Terms. by Mary V. Gold, NAL Call # aS21.D27S64 no. 99-02; ISSN 1052-5368, last updated 20 Nov, 2009)*

Concept **Integrated Pest Management** ( *called "integrated control"*) introduced in 1959 *(Stern et al. 1959)*

Recently **IPM** is defined as:
"IPM is a decision support system for the selection and use of pest control tactics, singly or harmoniously coordinated into management strategy, based on cost/benefit analyses that take into account the interests of and impacts on producers, society and the environment" *(Kogan 1998)*

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# Compendium of IPM Definitions

*http://ippc.orst.edu/IPMdefinitions/*

Frequency of Occurrence of Terms or Expressions in IPM Definitions:

| | |
|---|---|
| 1) **Economics** as benefit to producers | (53.8%) |
| 2) **Environment benign** effect of control measures | (48.1%) |
| 3) **Pest populations** target of control tactics | (40.4%) |
| 4) **Pest control** goal of IPM system | (38.3%) |
| 5) **Methods or tactics** components of control actions | (26.9%) |
| 6) **Ecology or ecological system** impacted by IPM | (25.0 %) |
| 7) **System** ecological unit | (24.2%) |
| 8) **Combination** tactics or control methods | (19.2%) |
| 9) **Economic threshold/economic injury level** as the base for decision making | (17.3%) |
| 10) Optimization **benefi**t to producers, society | (13.5%) |
| 11) **Social benefits** and costs computation | (9.6%) |

*(Bajwa and Kogan 2002. IPPC, ORSU, Corvallis, Pub # 998)*

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# Use of insect sex pheromones in pest management…

How do insect pheromones function normally?

Wind direction

Female -
Pheromone gland

Pheromone Plume

Male
moth

*Insect pest monitoring*

- Detect the presence/absence of the pest
- Assess possible consequences
- Prevent unnecessary costs

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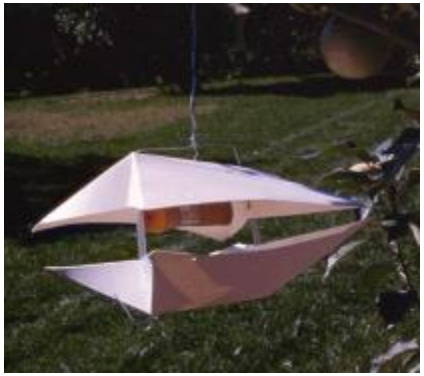
# Sex pheromone traps designs

*Various trap types*



Pherocon I traps

Pherocon II traps

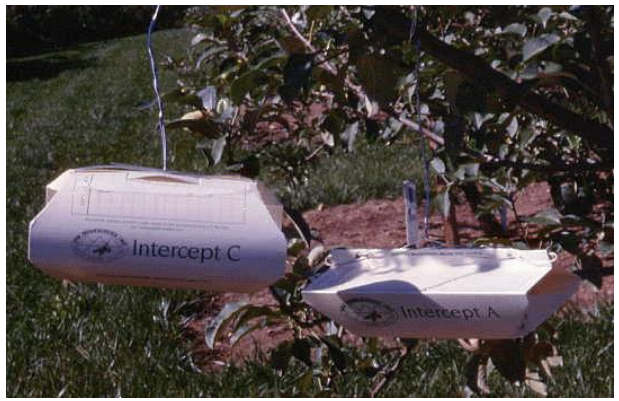
Pherocon III

Pherocon IV

The tree catch can for Japanese beetle

Multi-pher trap


Gypsy moth trap




Intercept A and C traps

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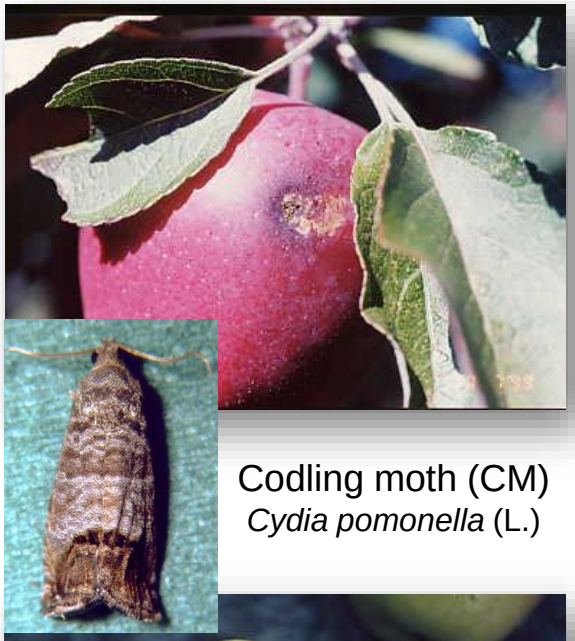
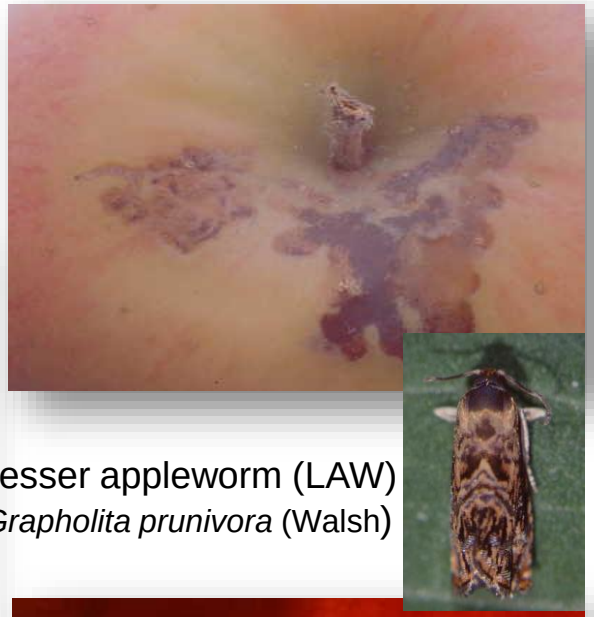
# Important Internal Fruit Feeding Lepidopteran Pests



Codling moth (CM)
*Cydia pomonella* (L.)

Oriental fruit moth (OFM)
*Grapholita molesta* (Busck)



Lesser appleworm (LAW)
*Grapholita prunivora* (Walsh)

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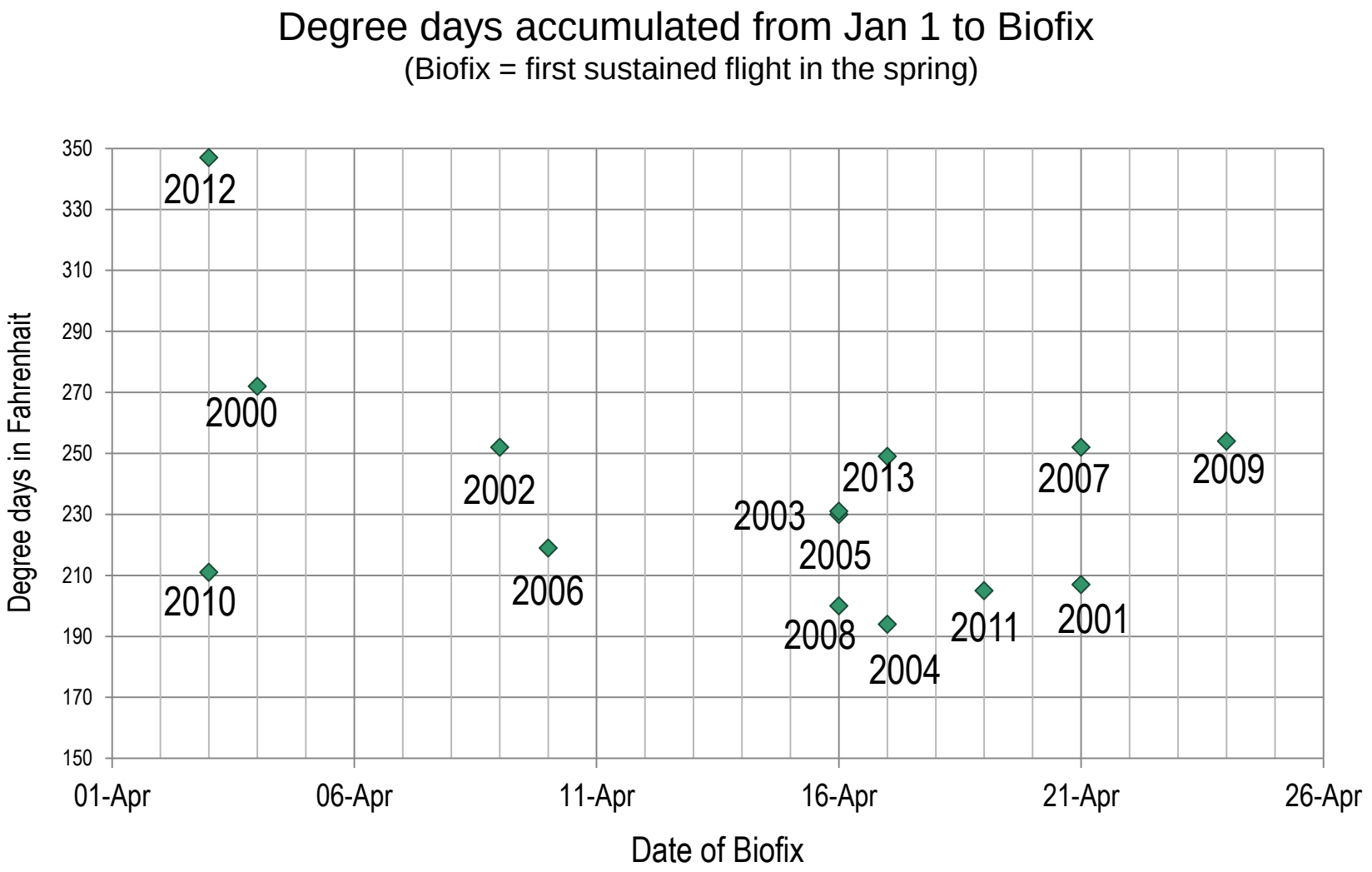
# *G. molesta* spring emergence




*OFM biofixes from 2000 to 2013 season (base 45°F)*

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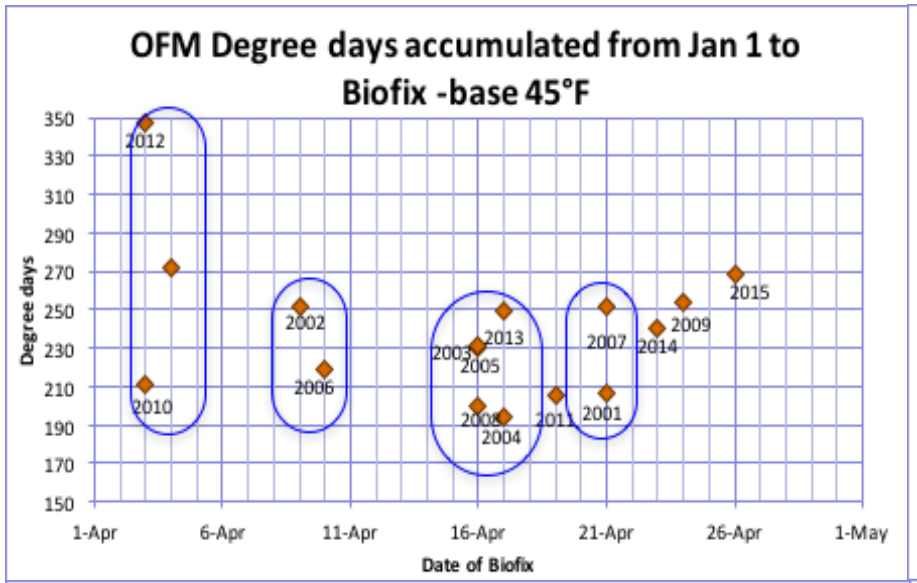
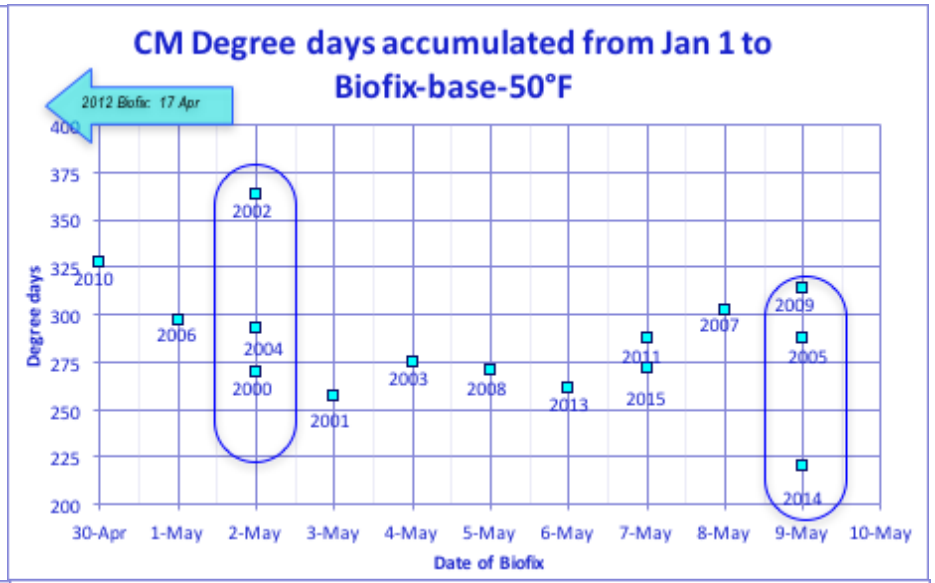
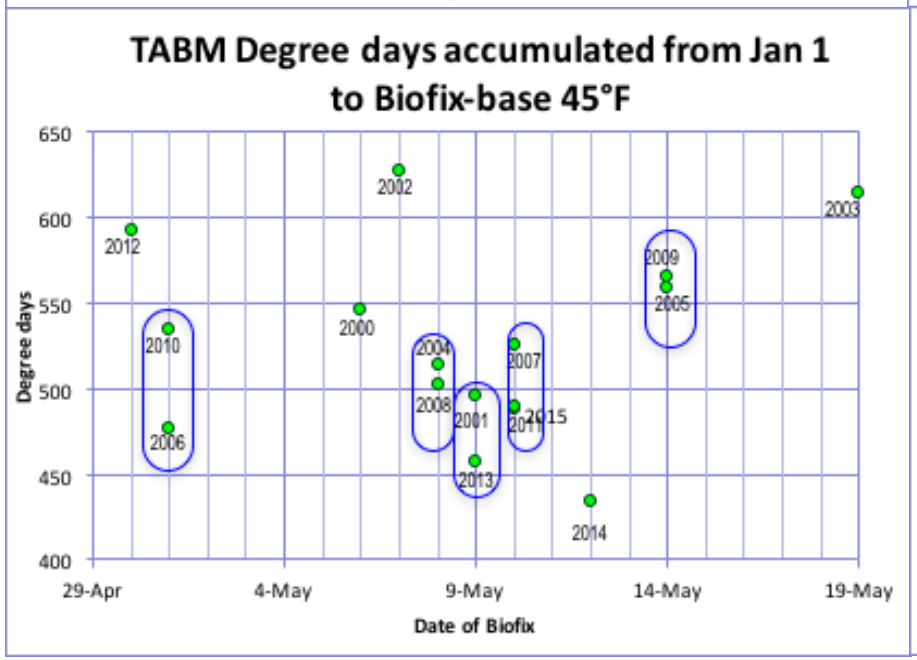
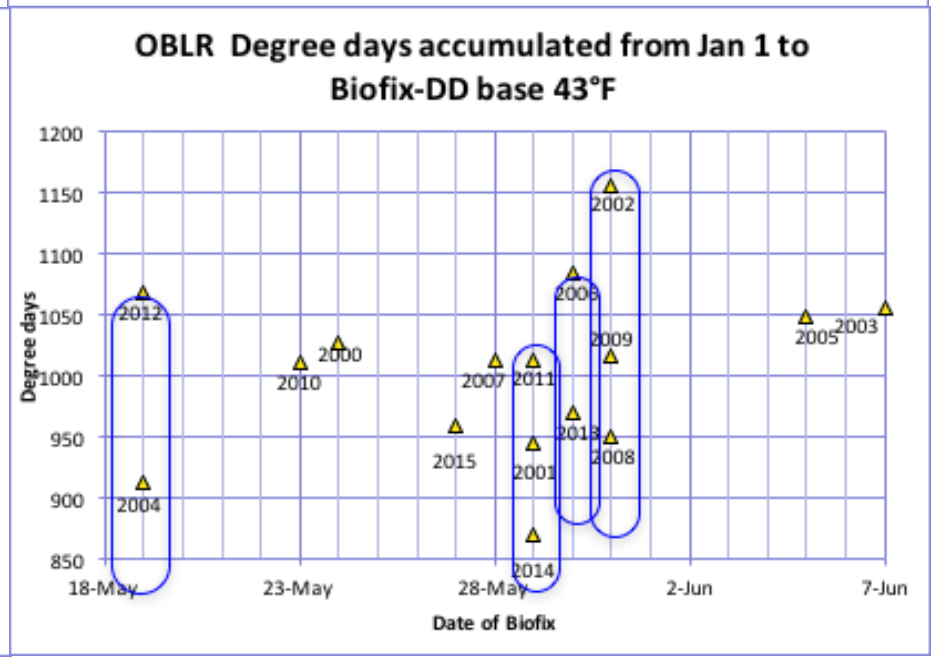
# Biofix dates for fruit pests - comparison




*The same location – PSU FREC Orchards*

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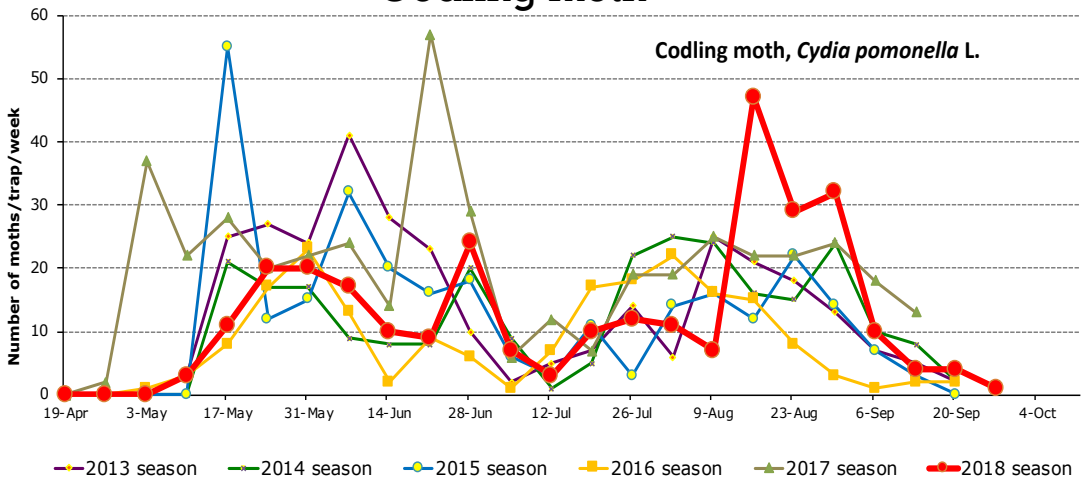
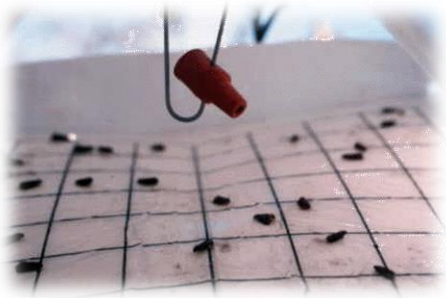
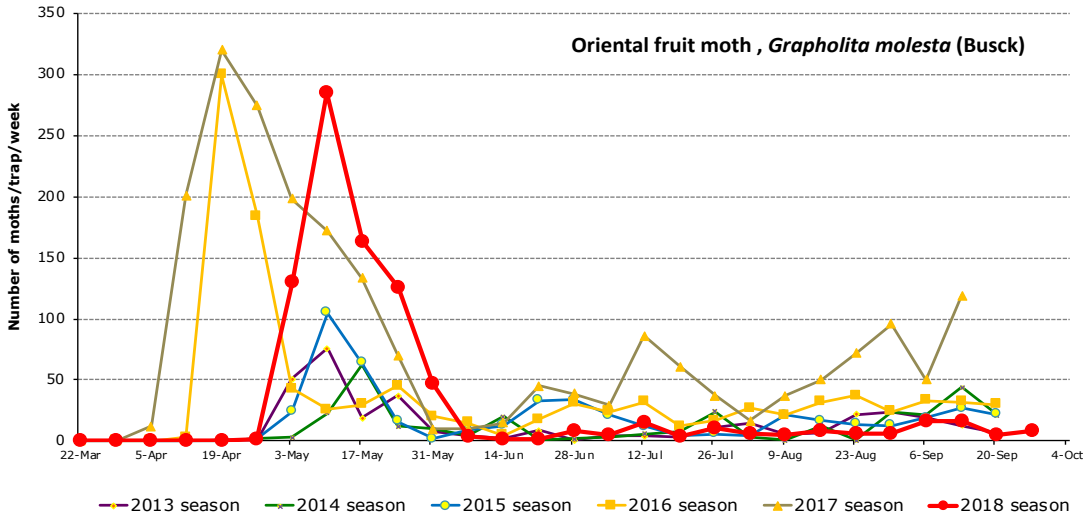
# Seasonal activity of *Cydia pomonella* and *Grapholita molesta*

## Codling moth



## Oriental fruit moth




Moth capture data collected from the the same PSU FREC Biglerville orchards

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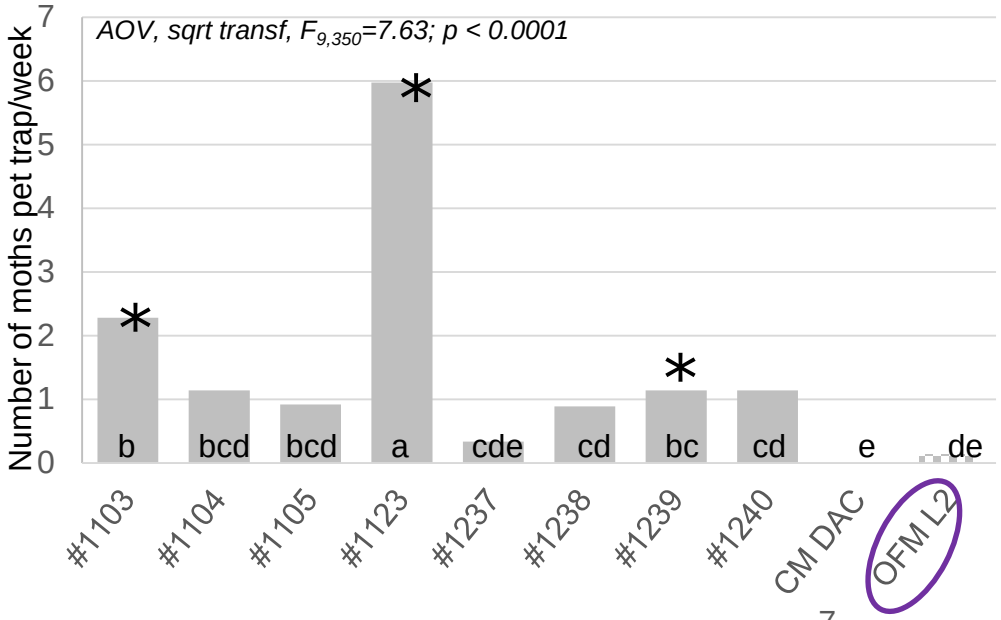
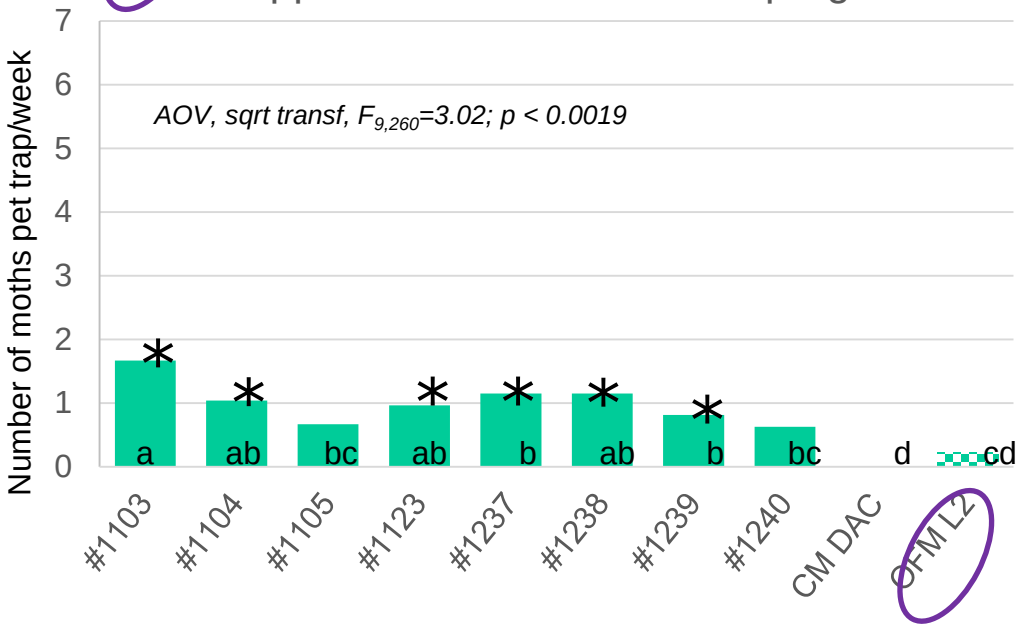
# Monitoring of *G. molesta* with experimental lures*: apples

## Apple orchards with MD program




## Apple orchards without MD program




* - OH- Z-8-Dodecen-1-ol; TA- terpenyl acetate; Z3 – (Z)-3-Hexenyl acetate; AA – acetic acid

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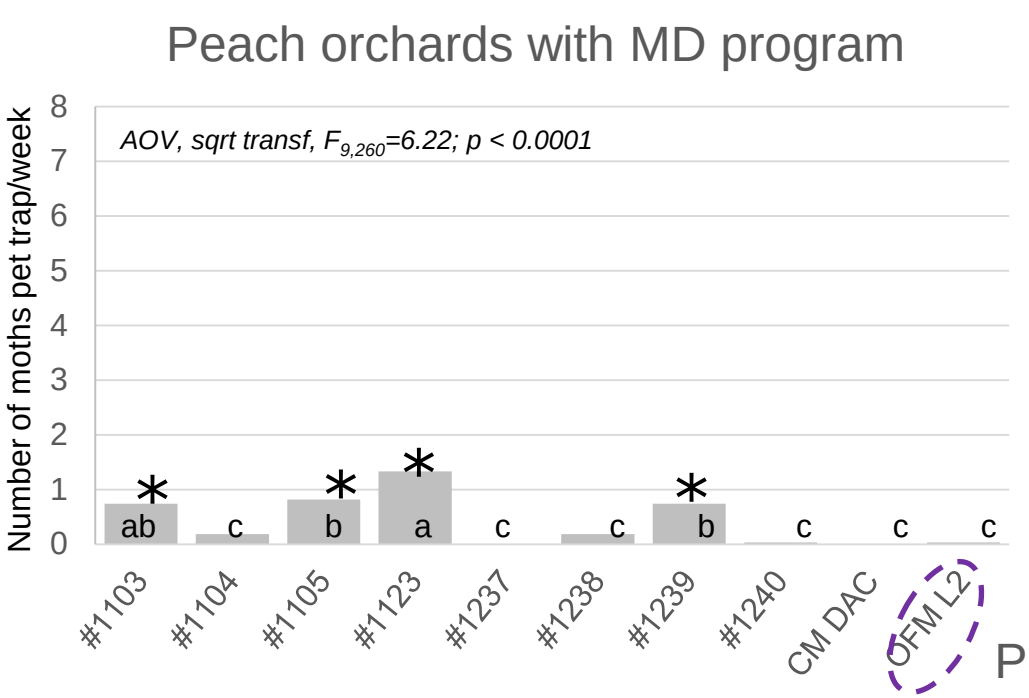
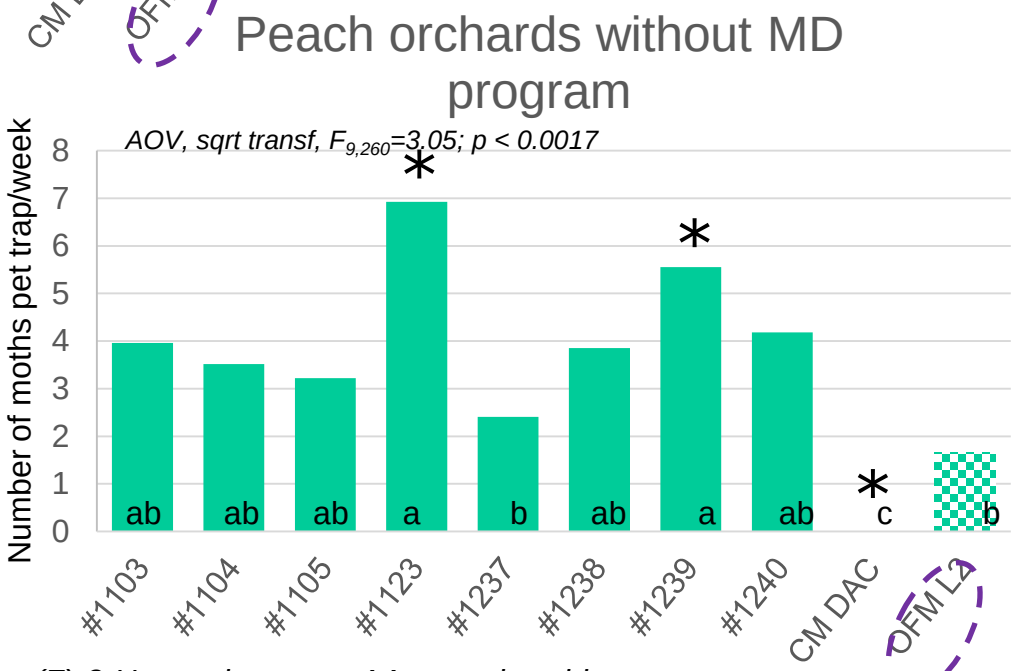
# Monitoring of *G. molesta* with experimental lures*: peaches




** - OH- Z-8-Dodecen-1-ol; TA- terpenyl acetate; Z3 – (Z)-3-Hexenyl acetate; AA – acetic acid*

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# OFM Pheromone Trap Catch Thresholds for Apple and Peach in Pennsylvania

| No. adult males/trap/week | | | |
|---|---|---|---|
| Brood 1* | | Broods 2-4* | |
| Apple | Peach | Apple & Peach | Recommended action |
| 0 – 15 | 0 – 5 | 0 - 5 | Not a problem |
| 16 – 30 | 6 – 15 | 6 – 10 | Potential problem |
| 31 – 60 | 16 – 30 | 11 – 25 | Treatment required |
| >60 | >30 | >25 | Severe problem |

*Capture of moths in the trap can be used as a trigger to initiate pest management activities*

**average moth captures from a minimum of 2 traps per 5-7 ha*
*(Recommendations from the 2018-2019 PSU Tree Fruit Production Guide)*

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# Z-Trap® technology for monitoring insect pests in orchards – field observations







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[2]Spensa Technologies, West Lafayette, IN.

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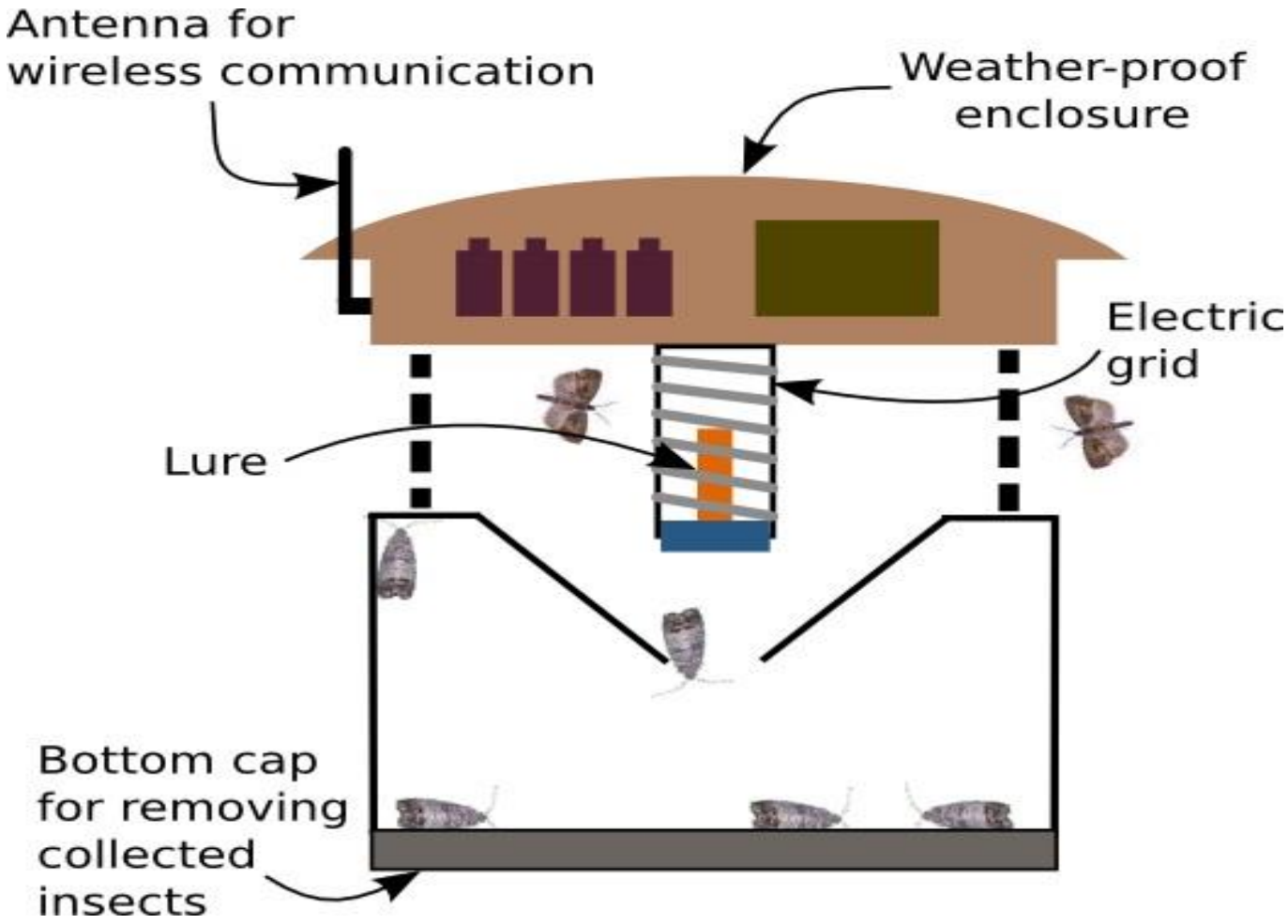
# Schematic interpretation of a bio-impedance based trap (Z-Trap)



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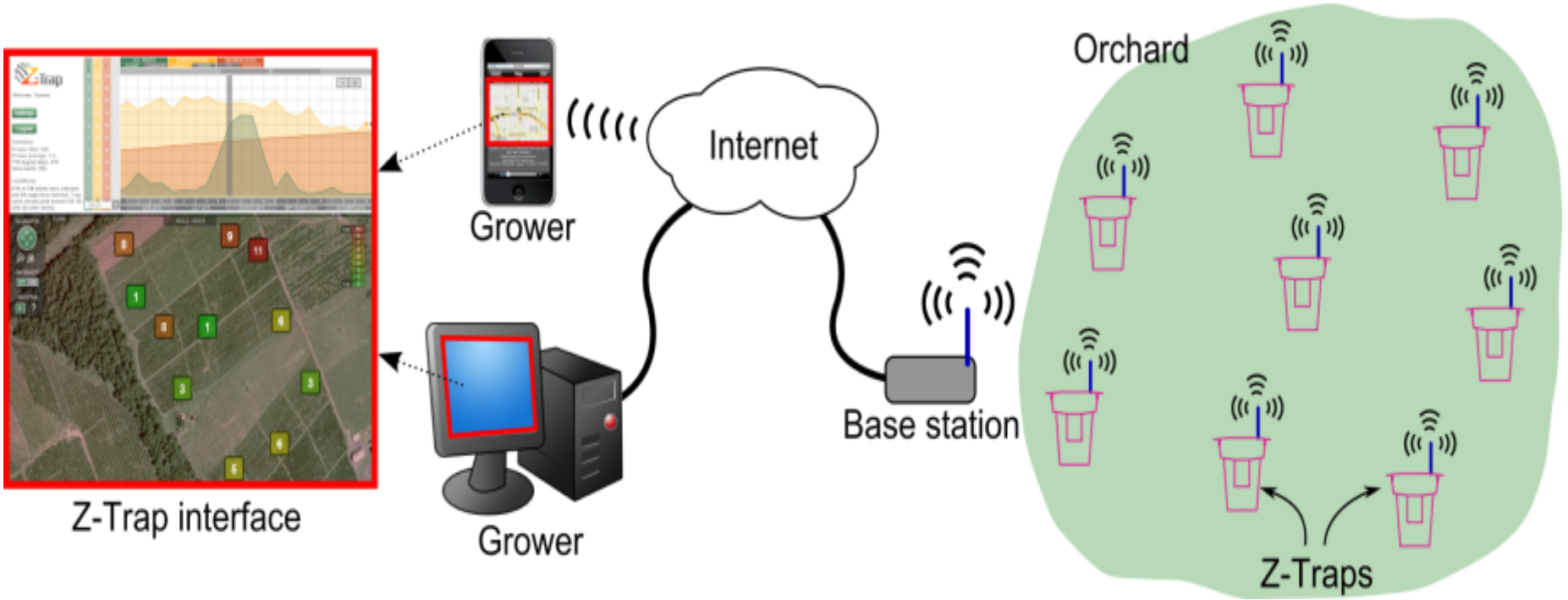
# Z-Trap User Interface



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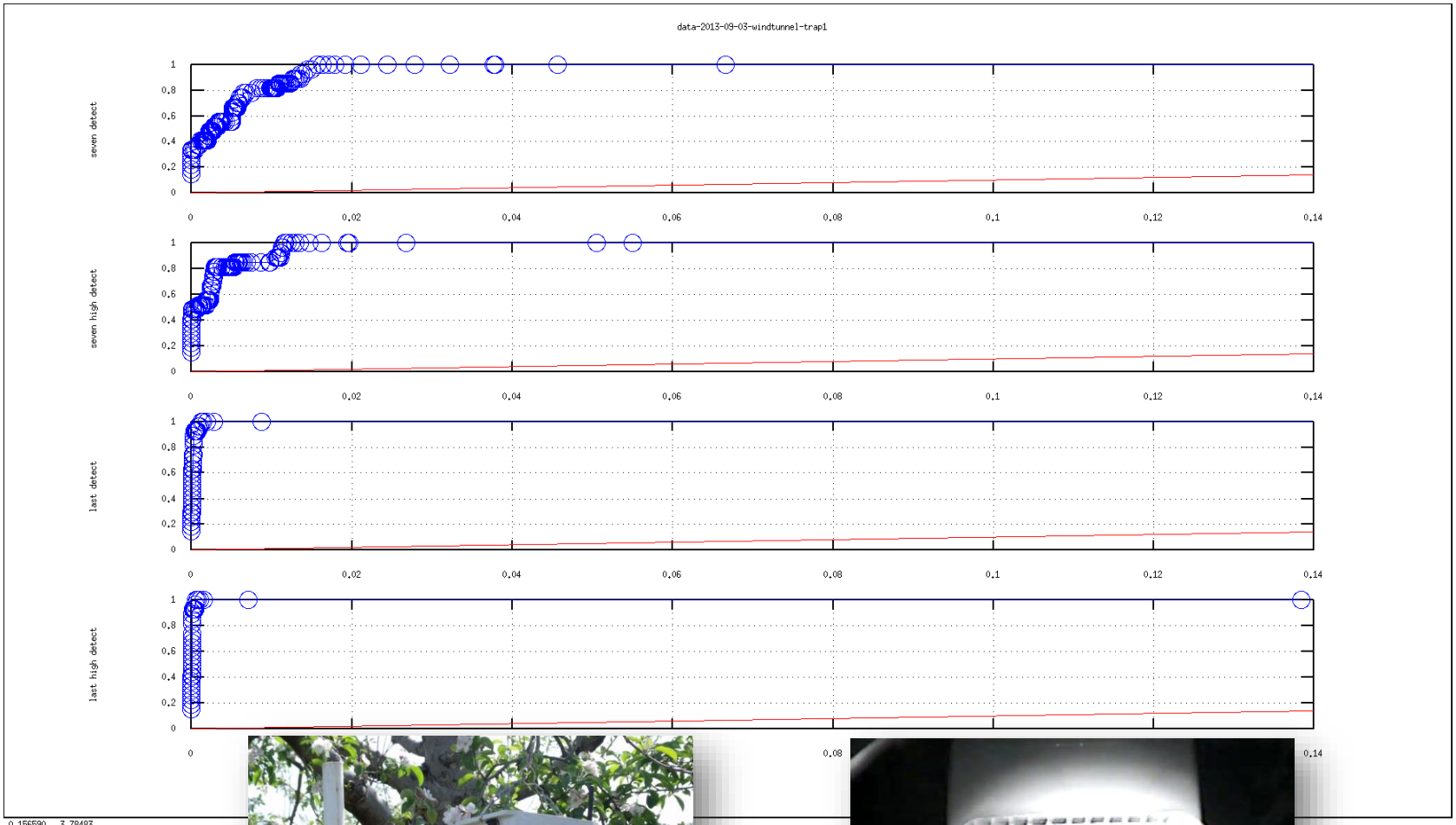
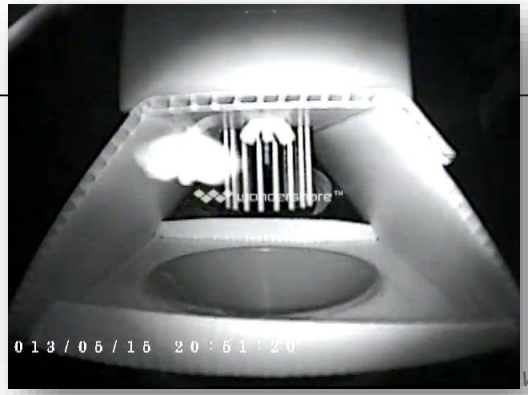
# Various species have different detection algorithms




wczyk, PSU FREC 2019

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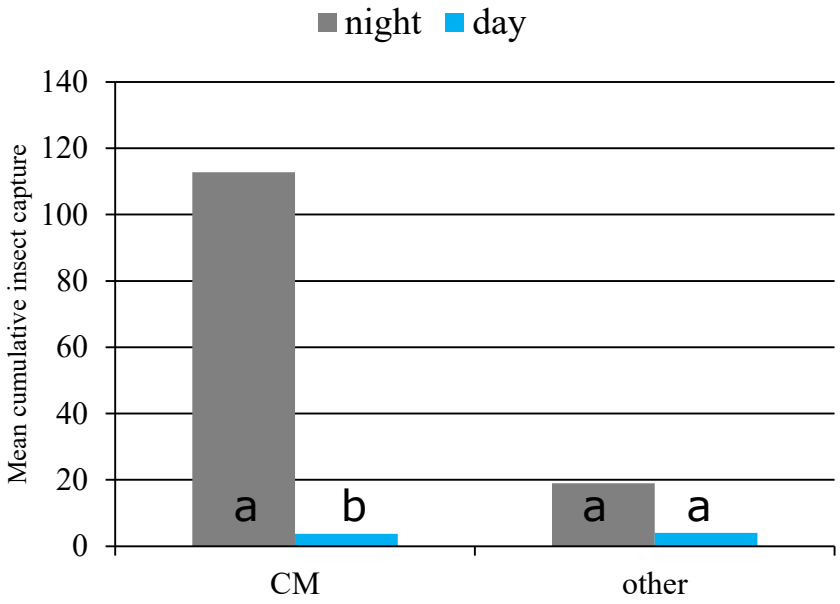
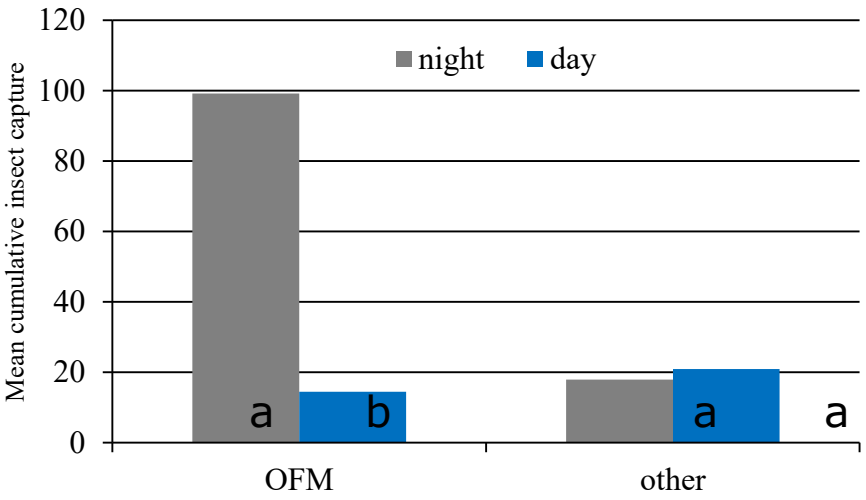
# Target species vs. non-target captures

## PSU FREC 2012




Codling moth




Oriental fruit moth

Note: Approximate sampling periods for night were from 15:30 to 07:30 and day were from 07:30 to 15:30.

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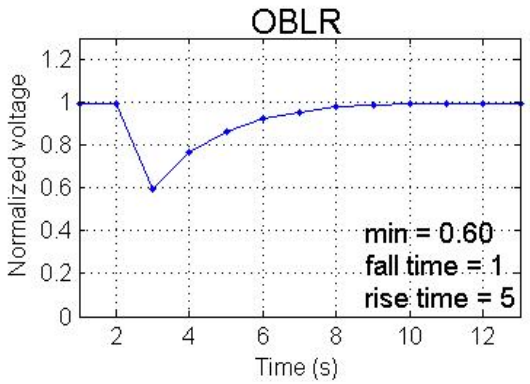
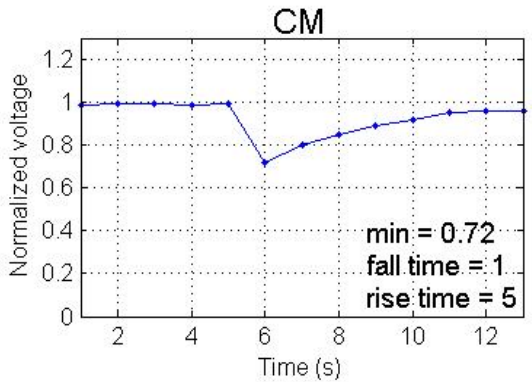
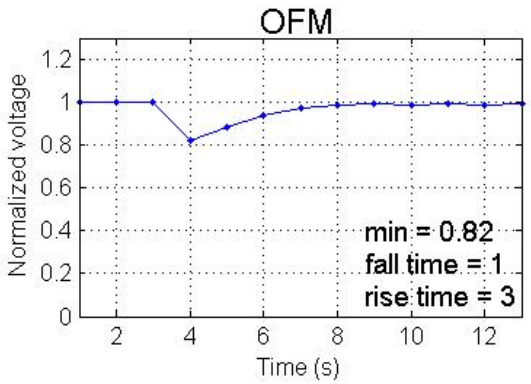
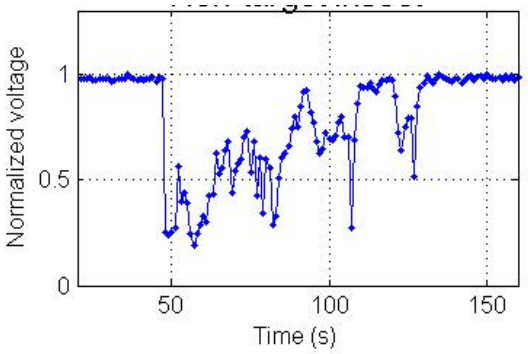
# Target insect and false detection signals

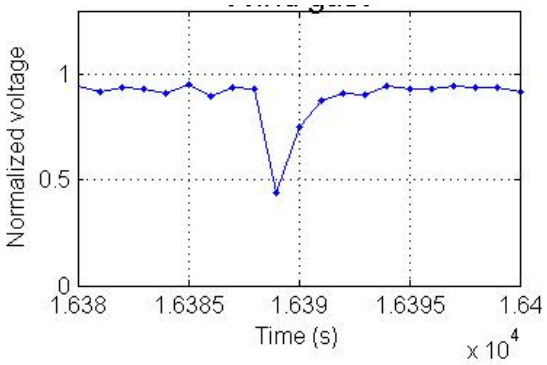


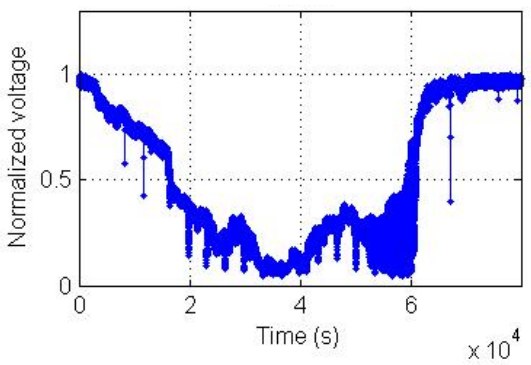




Insect specific signals (change in voltage)




Noise signals

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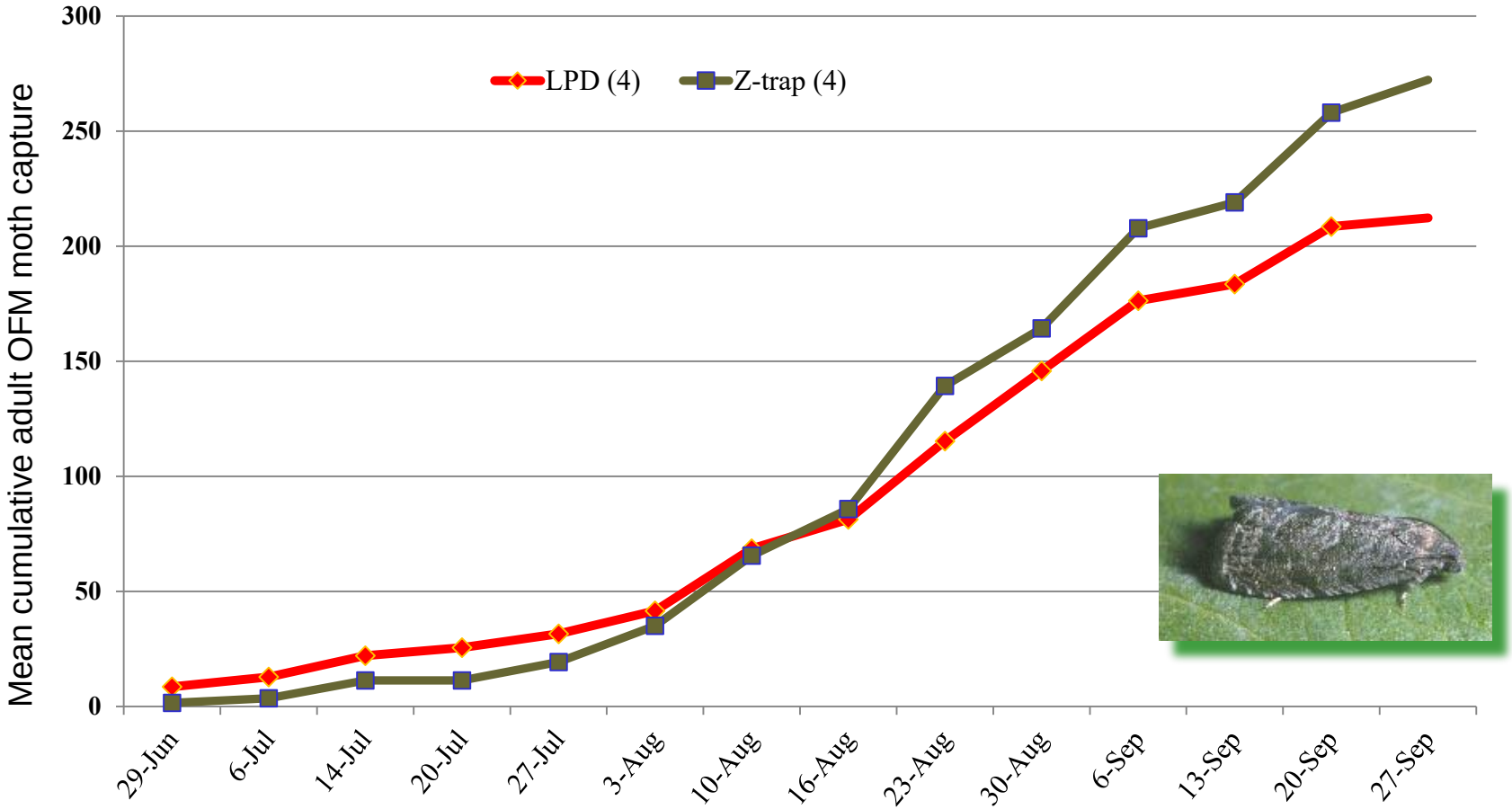
# Cumulative capture of *G. molesta*

Large plastic delta (LPD) vs. electronic (Z) traps
PSU FREC 2011




***Notes:***

*23-Aug: 2 Z-traps not working properly; data excluded*
*30-Aug: 1 Z-traps not working due to storm damage*
*1-Sep: OFM Z-traps not outside 1-Sep to 2-Sep, corresponding LPD traps were left outside.*

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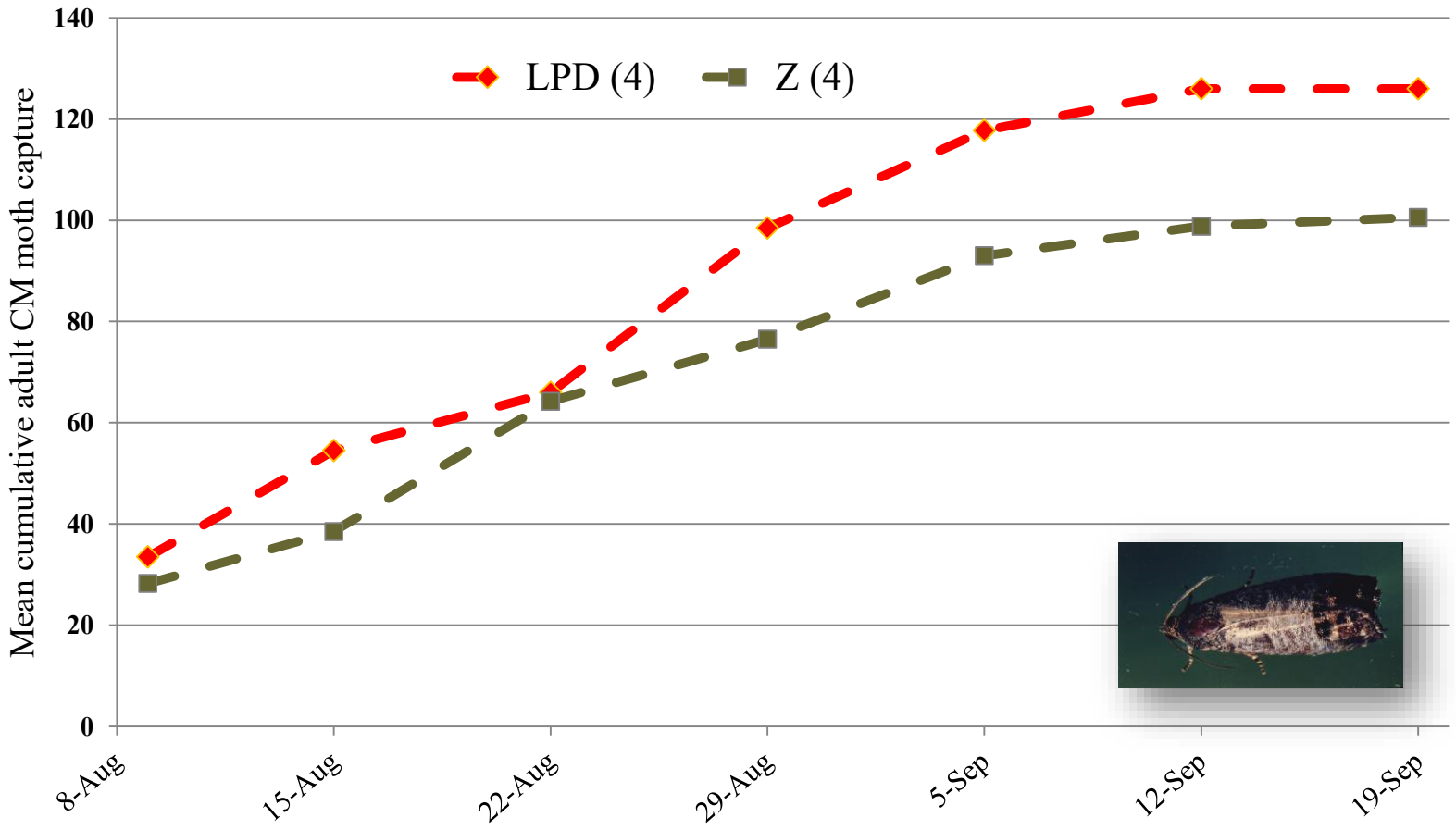
# Cumulative capture of *C. pomonella*

Large plastic delta (LPD) and electronic Z-Traps
PSU FREC, 2011




*30-Aug: only 3 Z-Traps due to storm damage*
*No data 6-Sep (9am) to 9-Sep (9am) due to stormy weather*

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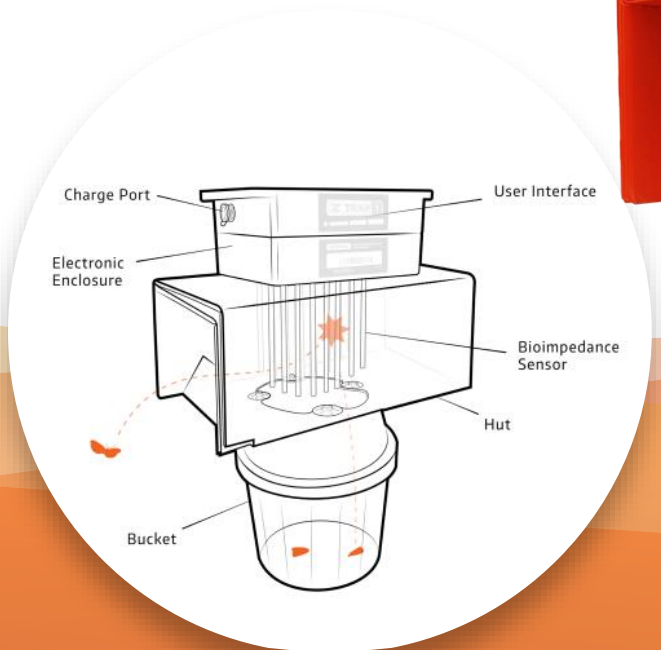
# Electronic Z-Trap® technology for monitoring insect pests in orchards

**$400+$250/YR**

**The Z-Trap** attracts, zaps, and measures insects, then delivers web-based heat maps of insect pressure in near-realtime

**OpenScout** is a mobile app that allows you to geo-tag pest issues in your field, interpolates trends, and presents them on a personalized web portal


Cellular Connection




Pattern Recognition

TARGET PEST VS NON-TARGET INSECTS

SPENSA

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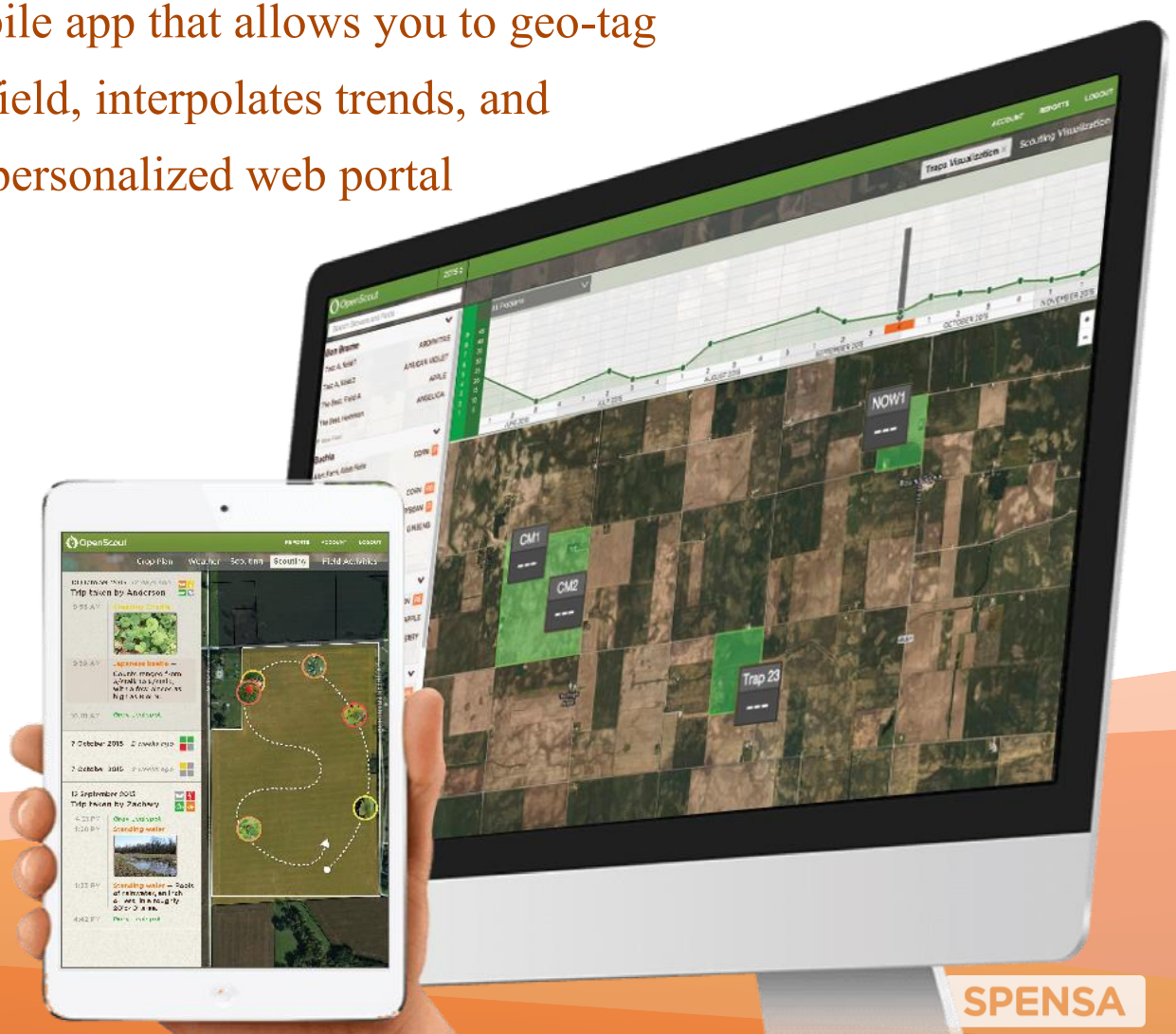
# SOFTWARE OpenScout

OpenScout is a mobile app that allows you to geo-tag pest issues in your field, interpolates trends, and presents them on a personalized web portal

**$300/user/yr**



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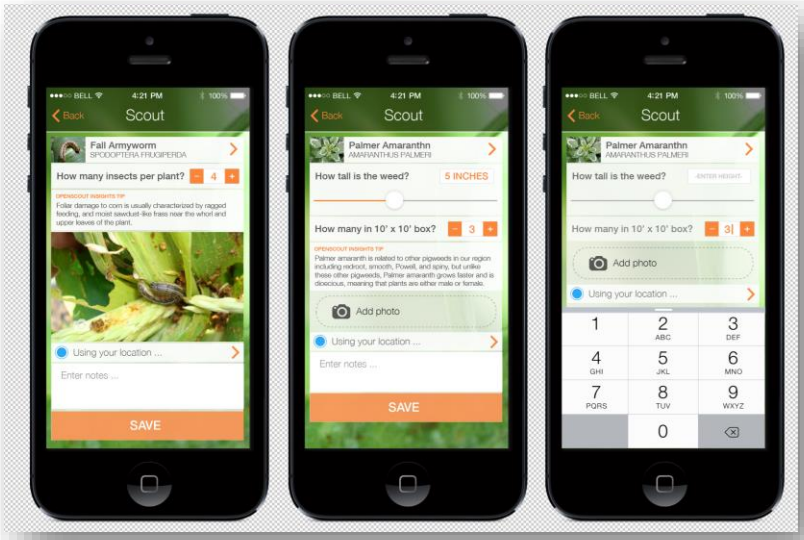
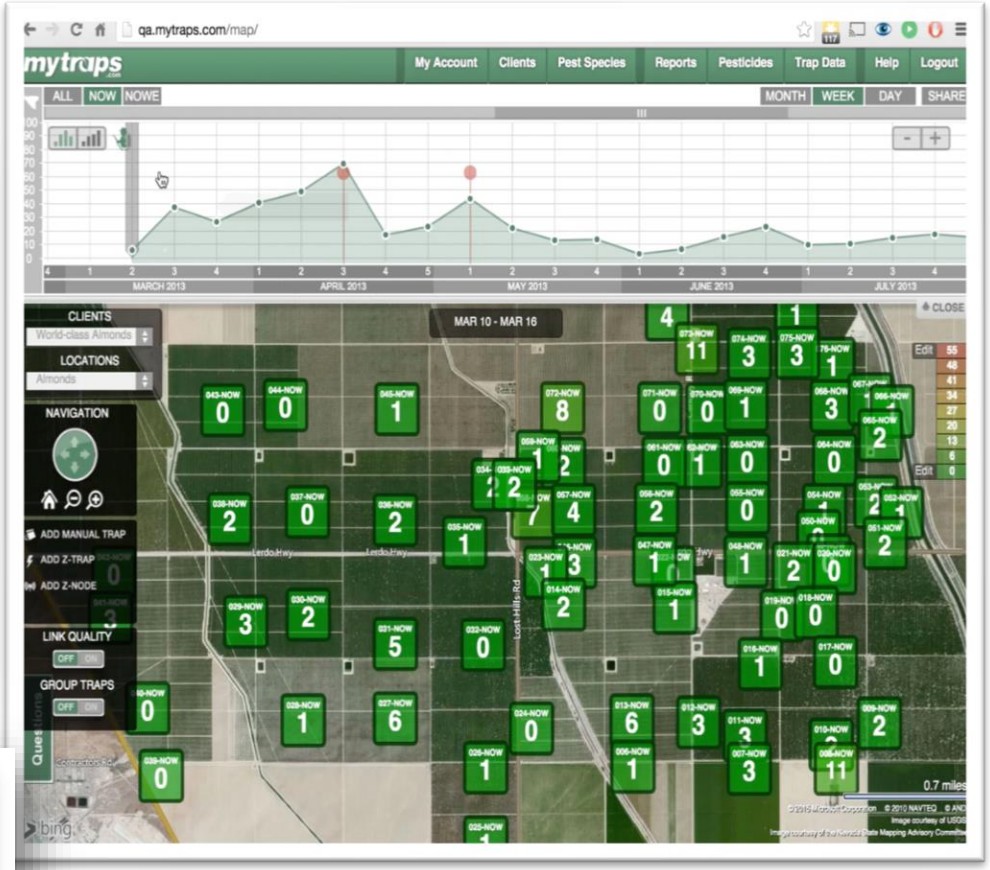
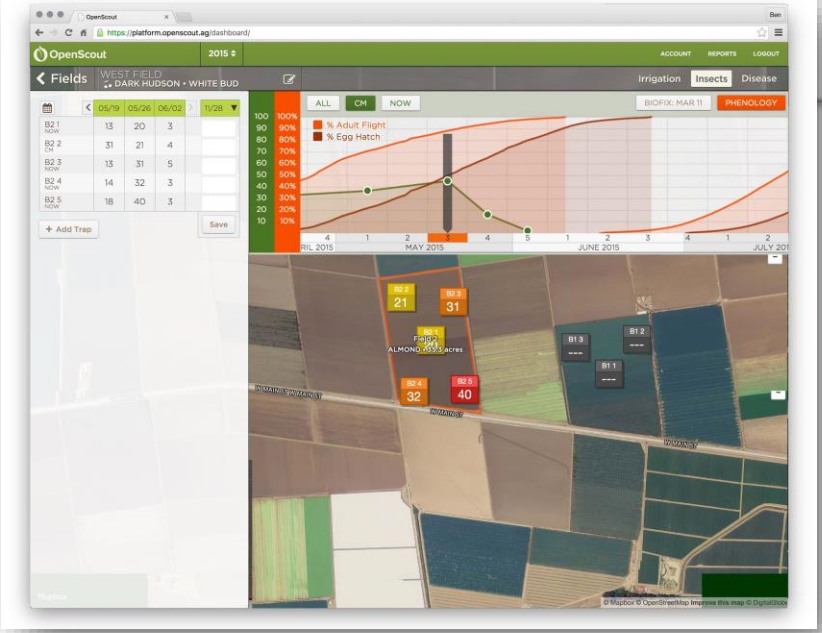
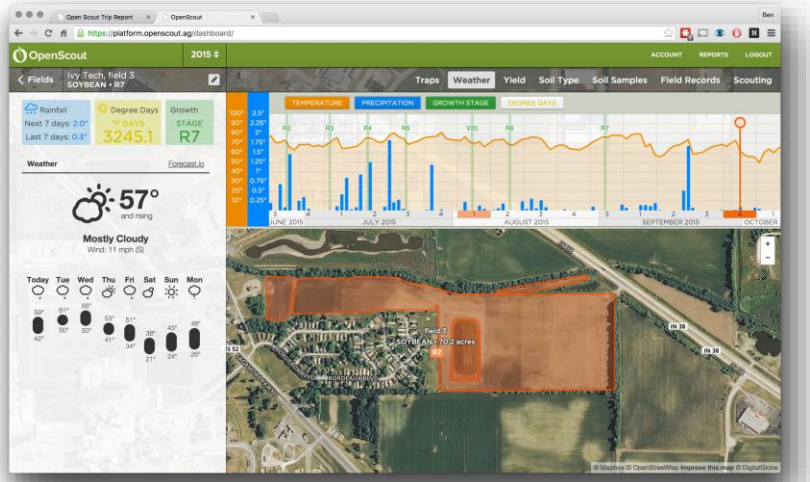
mytraps.com



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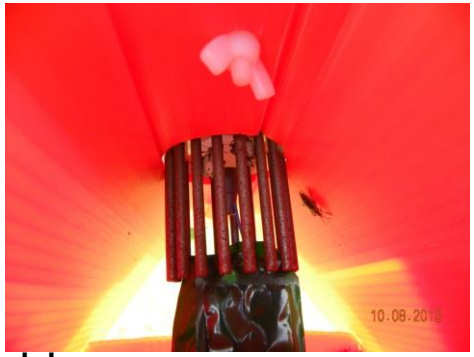
# Z-Trap Project summary

- Automated monitoring of various fruit pests with Z-Trap® has the potential to reduce labor input;
- The *Cloud* based system interface provides on demand pest info from and to any location;
- The improvement in battery life allows for a season long operation;
- Elimination of “false positive” and “false negative” detection issues are still work in progress based on the development and improvement of applied pest detection algorithms.
- Cellular communication a positive but also potentially limited factor



Next steps:

- monitoring of multiple species with a single trap;
- correlation of Z-Trap captures with established pest thresholds;
- automation of management recommendations based on developmental models;
- on site pest identification

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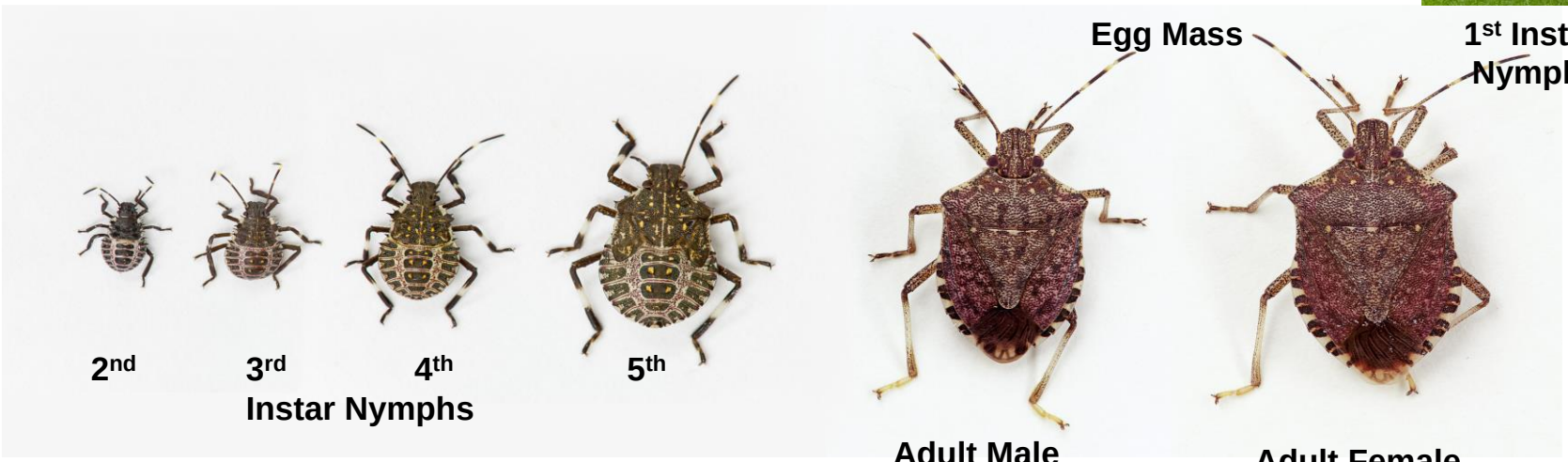
# Brown marmorated stink bug,

*Halyomorpha halys (Stål)* (Hemiptera: Pentatomidae)

- native to Japan, China and Korea
- important agricultural pest, feeding on fruit trees, vegetables and ornamentals
- eggs deposited in clusters of 21-35 eggs
- five nymphal instars, 6 weeks development
- overwintering adults emerge in the spring
- one to two full generations per season
- very serious household nuisance and economic agricultural pest


Egg Mass

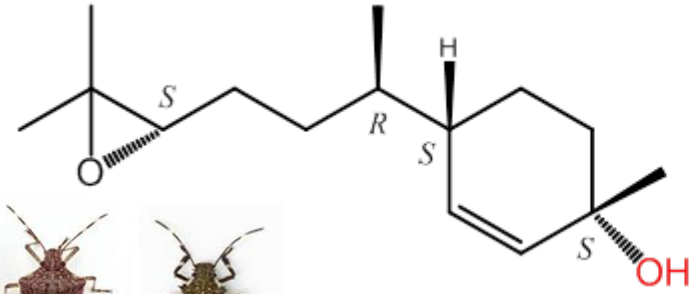
1st Instar Nymphs



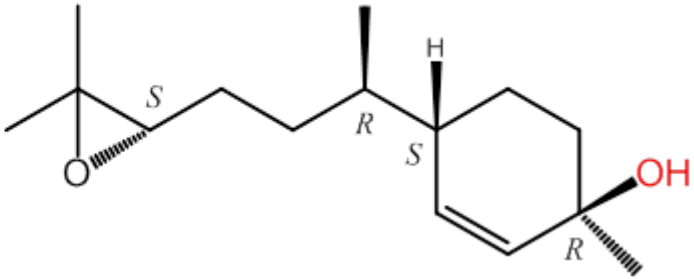
# BMSB attractant

*Slide courtesy of Dr. Tracy Leskey, USDA ARS*

Main component of BMSB aggregation pheromone
(3*S*,6*S*,7*R*,10*S*)-10,11-epoxy-1-bisabolen-3-ol

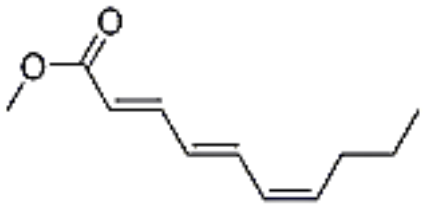



Minor component of BMSB aggregation pheromone
(3*R*,6*S*,7*R*,10*S*)-10,11-epoxy-1-bisabolen-3-ol




+

Methyl (*E*,*E*,*Z*)-2,4,6-decatrienoate (MDT) acts as a synergist for BMSB pheromone




= Synergism

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# Monitoring BMSB …

USDA ARS #10

AlphaScent SB lure

USDA ARS #20

Trece BMSB lure

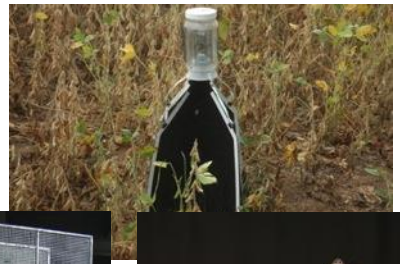
Ag-Bio *Smart lure*

Harlequin bug lure

Hercon lure

Rescue Stink Bug Attractant



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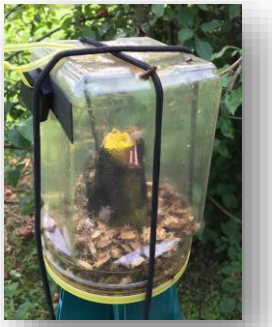
# Challenges with monitoring of BMSB

Trap placement?

Trap designs?

Light traps?



Experimental lures?

Over 150 BMSB traps serviced per each season

Treatment threshold development…?

Traps – 10 plus different traps designs
Lures – 7 plus BMSB lures

G. Krawczyk, PSU PREC 2019

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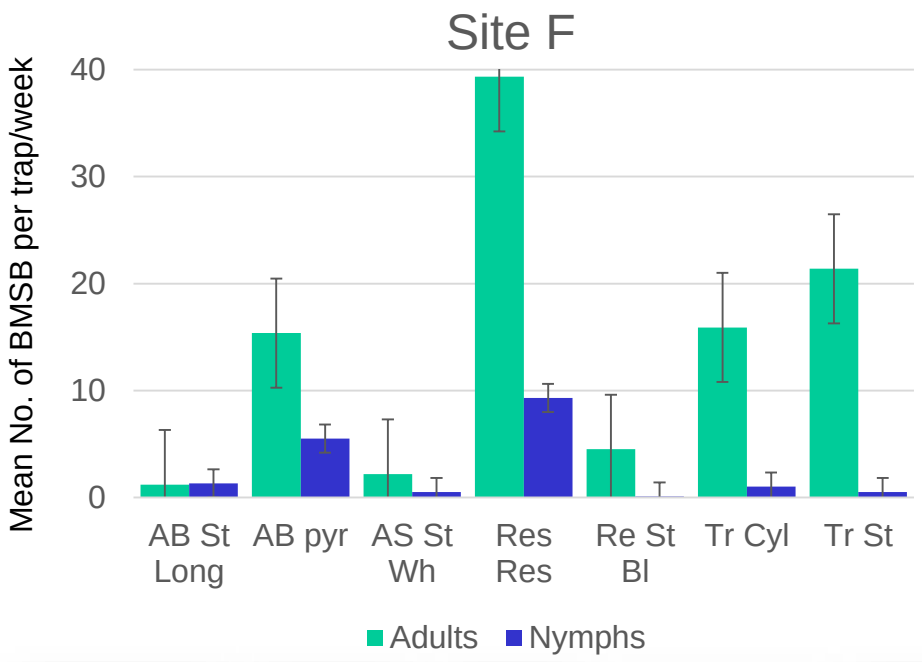
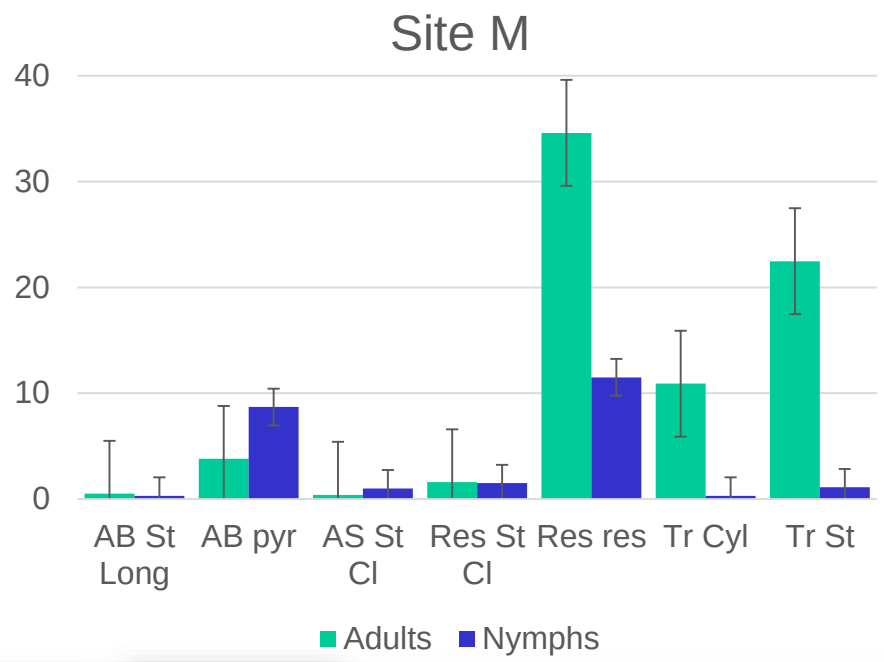
# 2016 BMSB trap comparison

Average BMSB captures per trap/week, PSU FREC 2016




AB pyr

Ag-Bio
Ag-Bio
*Pyramid*

AB ST Long

Ag-Bio
Ag-Bio
*Sticky long*

Re St Bl

AlphaScent
Rescue
*Sticky blue*

AS St Cl

AlphaScent
AlphaScent
*Sticky clear*

AS St Wh

AlphaScent
AlphaScent
*Sticky white*

Res St Cl

AlphaScent
Rescue
*Sticky clear*

Tr Cyl

Trece
Trece
*Cylinder*

Tr St

Trece
Trece
*Sticky clear*

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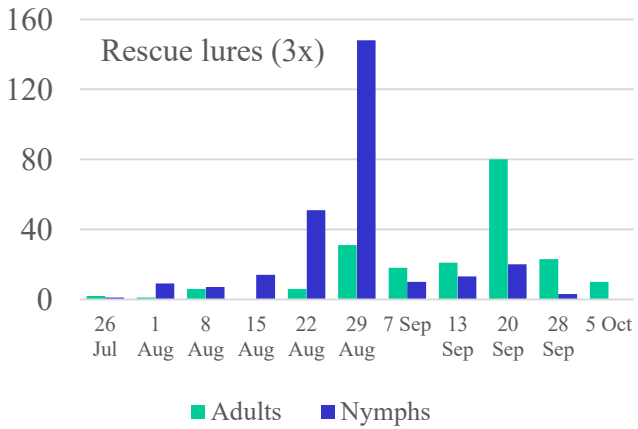
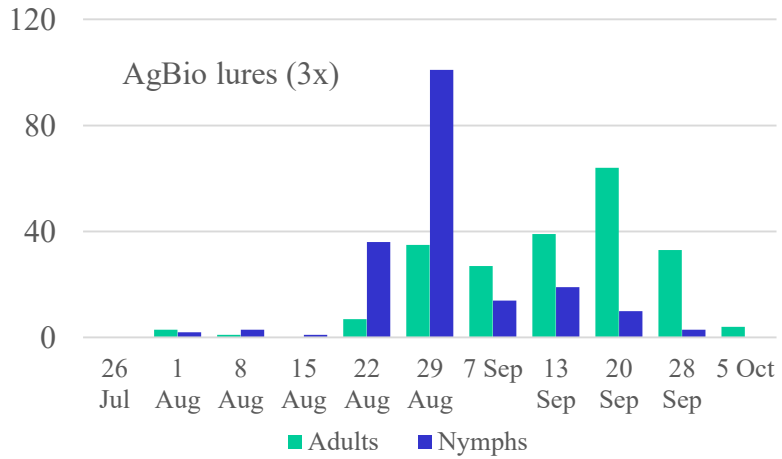
# Evaluation of “ghost “ net trapping

**2014** - Grower made insecticide treated net

**2015** - Nets treated with bifenthrin insecticide – season long project

**2016** – PermaNet® commercial net from Vestergaard Frandsen Inc.




*G. Krawczyk, PSU FREC 2019*

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# BMSB captures in “ghost” traps

A combination of monitoring and management practices
Invasive brown marmorated stink bug

*G. Krawczyk, PSU FREC 2019*

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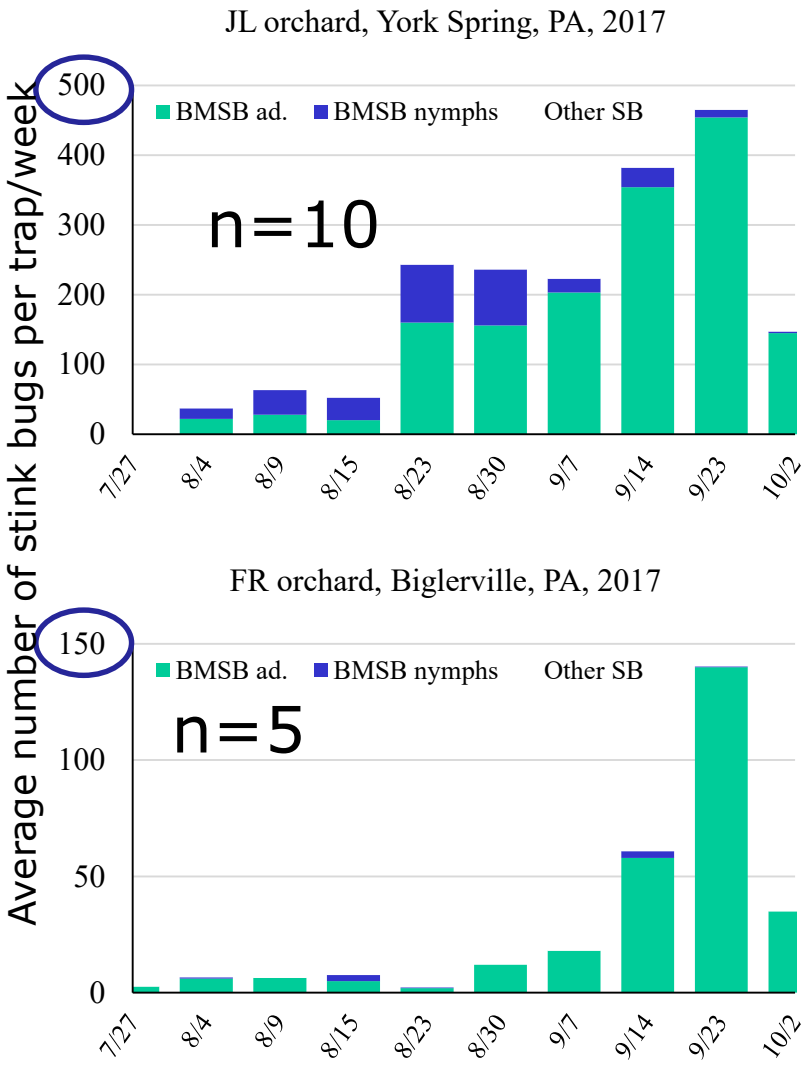
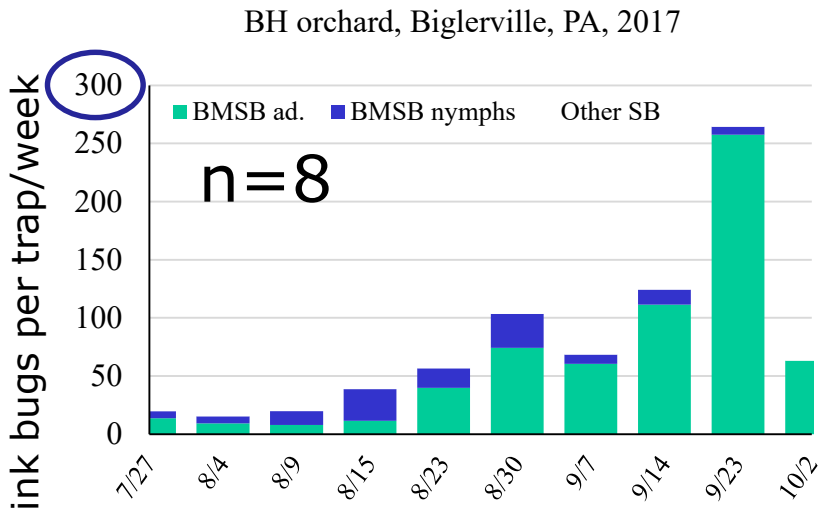
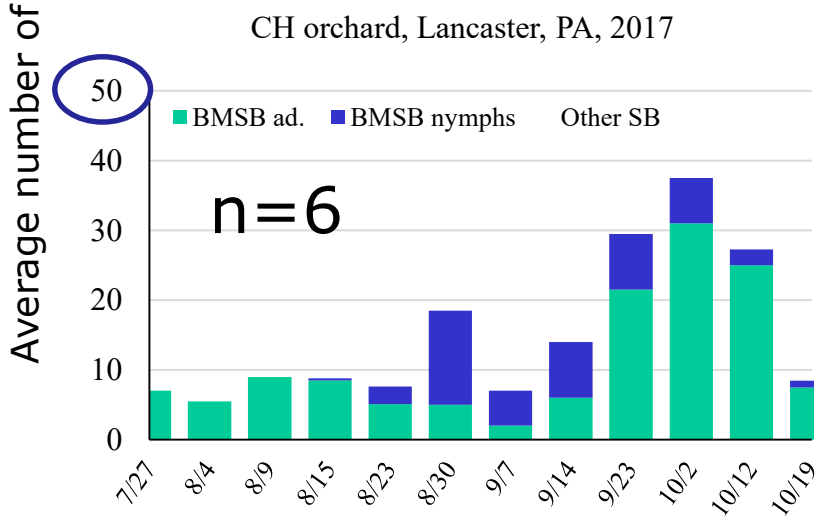
# Average SB captures in ghost traps









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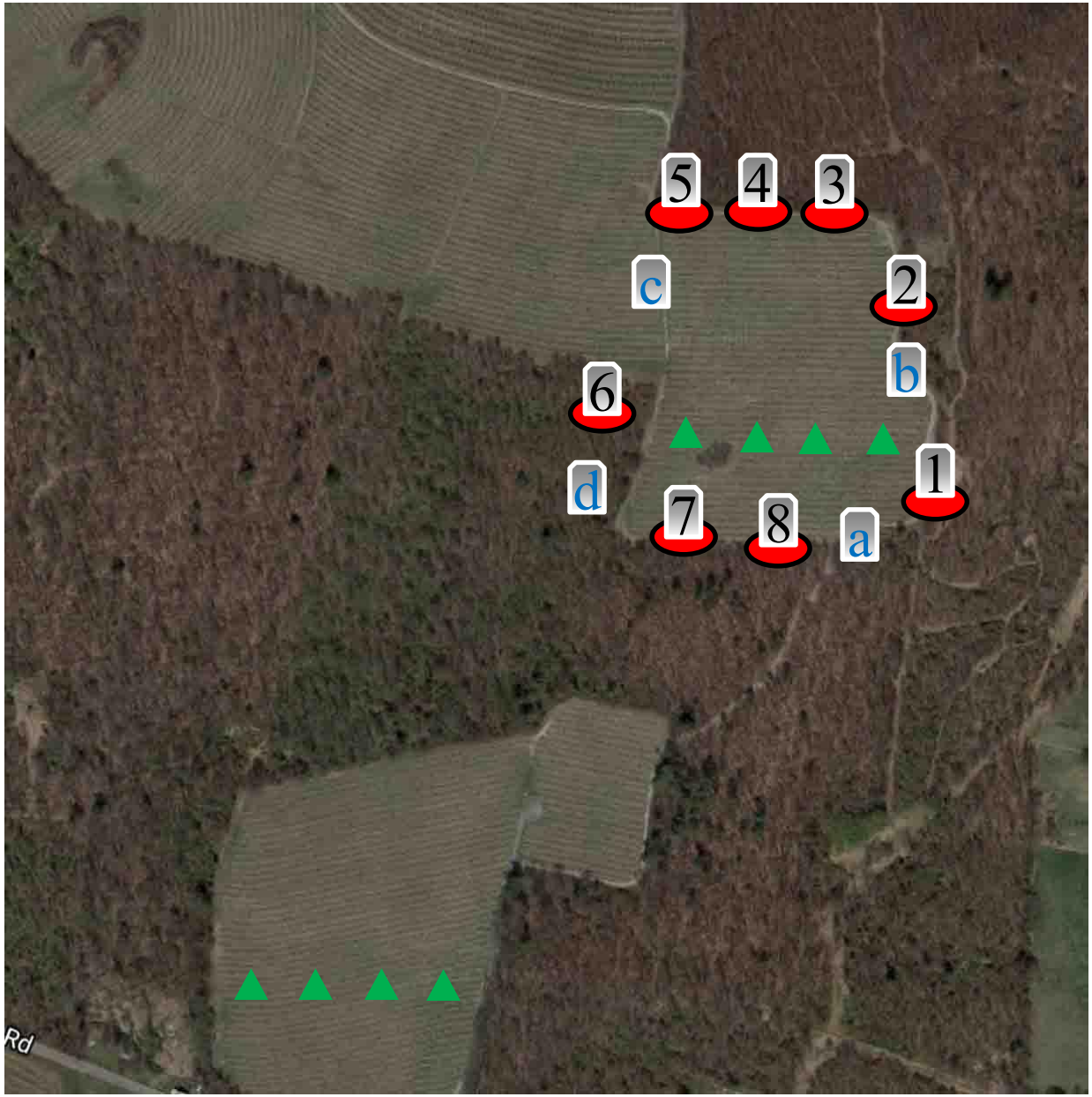
# BMSB captures in monitoring traps

| BMSB | Ghost traps | Control |
|---|---|---|
| Adults | **0.58 a** | **2.86 b** |
| Nymphs | **0.31 a** | **1.28 b** |

*Average BMSB captures per trap/week. Rescue traps baited with Ag Bio lures. Four traps per treatment*




a Ghost trap

1 Ghost trap with tarp

Monitoring trap

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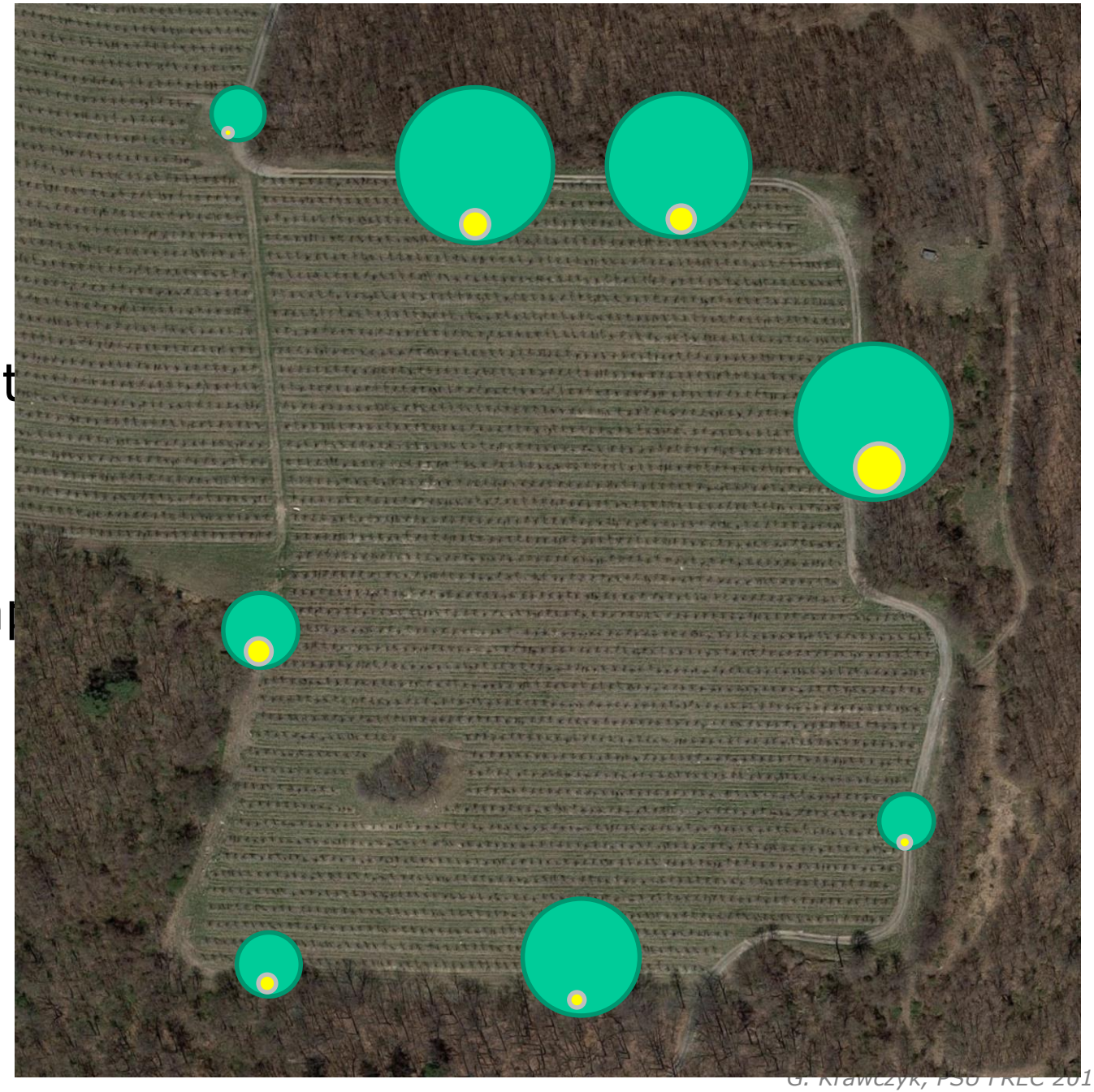
# BMSB captures in ghost traps

JL Orchard, 2017

235
1
BMSB adult

235
1
BMSB nymp

*Size equivalent of **2351** dead SB*



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# Summary

- Monitoring of insect pests is one of the most important elements of the Integrated Pest Management practices;

- Each insect species needs to be monitored individually;

- Utilized pest management practices need to be applied based on the potential economic importance of the pest;

- The least disruptive pest management strategies such as biological or cultural control tools should be utilized before using chemical control such as synthetic pesticides;

- If the use of pesticides is necessary, the products with the lowest environmental toxicity and the highest selectivity should be used as the primary options.