Challenges in Pollinator Conservation : Managing Invasive Insects in Small Fruit & Vegetable

CCE Pesticide Applicator Recertification Day
Latham, NY

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Challenges in Pollinator Conservation: Managing Invasive Insects in Small Fruit & Vegetable
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Spotted Wing Drosophila in Grape. 2016 Winter Fruit School, Kingston, NY. February 18th

Review of the 2015 Insect Pest Management Season in ENY

Update & Annual Meeting for the Hudson Valley Research Laboratory, Inc. Peter Jentsch, Superintendent, Cornell Hudson Valley Research Laboratory, Inc., Highland, NY February 16, 2016

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- February 2016
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Rouge Wave


BIODIVERSITY


Biodiversity


F2
C2
F3
C3
F1
C1
D2
D3
D1


Vancouver
Baker
Olympic Peninsula
Clear-cuts
Rainier


<6” precipitation annually (half is snow)
Direct sunlight (as opposed to diffuse)
300 days of sunlight each year
Irrigation: Columbia Basin Project
• 1952 first water received
• Over 670,000 Acres
• Farmers pay by acre based on land classification

Washington Agriculture
- $49 Billion Industry
- Over 300 Commodities

Washington Apple Industry
- $2 Billion industry
- 116.2 million boxes
- 155,000 bearing acres
- 1500 growers
- Avg orchard 100 acres, some 5000 acres

**only 16 growers/families control 80%*

Challenges in Pollinator Conservation : Managing Invasive Insects in Small Fruit & Vegetable Production Systems

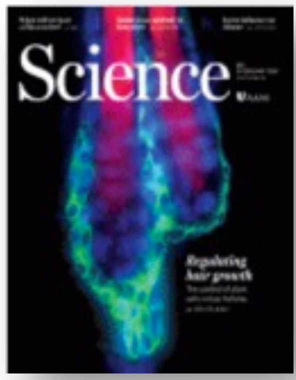
- **Honeybee Colony Collapse**
- **Native Pollinator Complex**
- **Two Invasive Insects in Small Fruit & Vegetable**
- **Management Practices of Invasive to Protect Pollinators**

Honey Bee Colony Collapse

The Mite That Jumped, The Bee That Traveled, The Disease That Followed.

Ethel M. Villalobos

Plant and Environmental Protection Sciences, University of Hawaii, Manoa, HI 96822, USA.



Science 05 Feb 2016:

Vol. 351, Issue 6273, pp. 554-556
DOI: 10.1126/science.aaf0938

http://bellnursery.com/bees/554_full.pdf

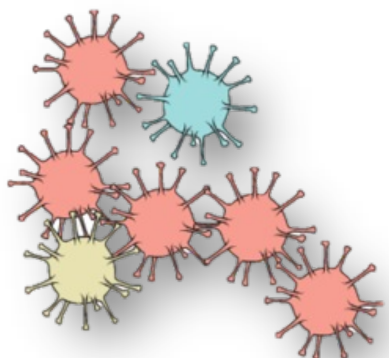
Honey Bee Colony Collapse

- **Deformed wing virus (DWV)** is an endemic pathogen of the European honeybee, *Apis mellifera*.

- One of 22 known viruses affecting the honeybee with a wide host range of other insect species.

- The Varroa mite (V. destructor) is native to Asia, a known host of DWV.

Apis mellifera



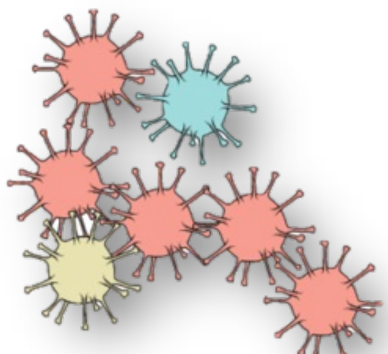
Deformed wing virus (DWV)

Varroa destructor

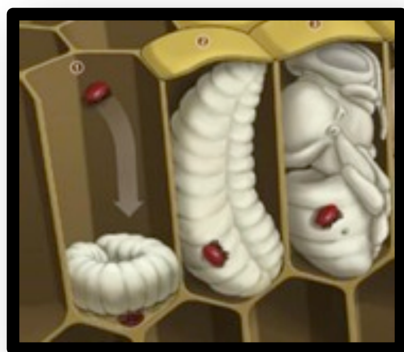
Honey Bee Colony Collapse

- **Deformed wing virus (DWV)** is suspected of causing the wing and abdominal deformities often found on adult honeybees in colonies infested with ***Varroa* mites**.

Apis mellifera



Deformed wing virus (DWV)



Varroa destructor

Honey Bee Colony Collapse

- European honey bees were first brought to the Americas during the 1st global expansion

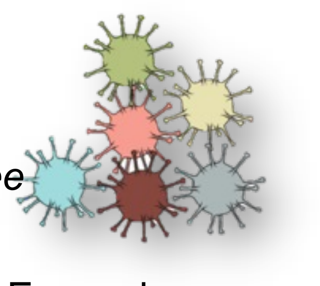
European Honey bee
Apis mellifera

1600-1800 Global Expansion

Honey Bee Colony Collapse

- European honey bees were infested with the DWV

Deformed wing virus (DWV)
1 haplotype

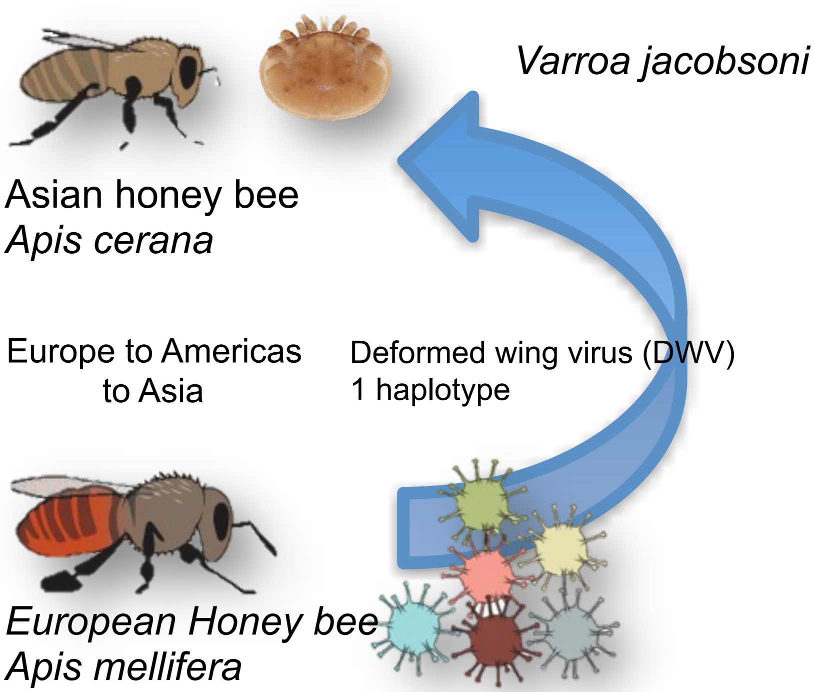


European Honey bee
Apis mellifera

1600-1800 Global Expansion

Honey Bee Colony Collapse

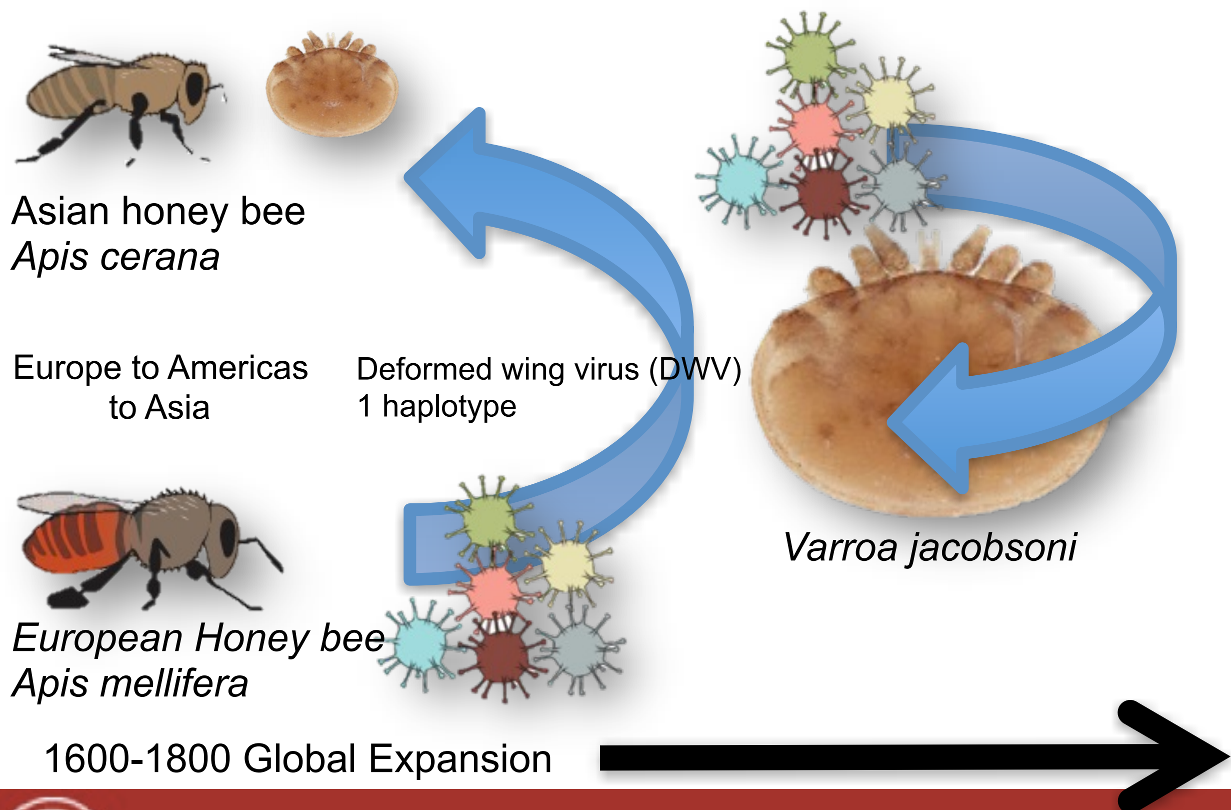
- European honey bees infested with the DWV, transmitting the virus to the V. jacobsoni mite to the Asian honey bee during the latter period of global expansion.



1600-1800 Global Expansion

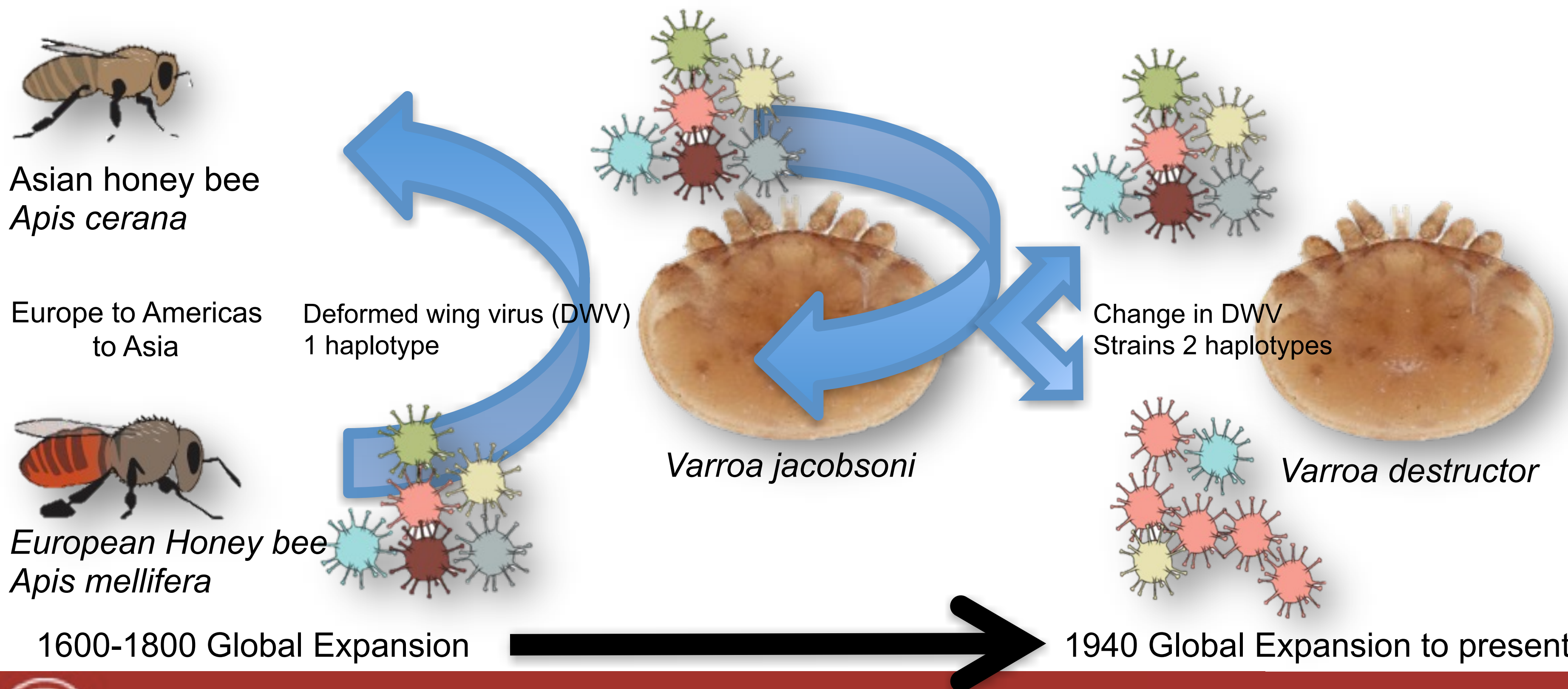
Honey Bee Colony Collapse

- **Deformed wing virus (DWV)** mutated within V. jacobsoni



Honey Bee Colony Collapse

- DMV mutated within V. jacobsoni to then cause infestations within V. destructor during the 1940 period of global expansion.



Honey Bee Colony Collapse

- **Natural genetic variation** in the brood parasite Varroa jacobsoni facilitated its jump from the Asian honeybee (Apis cerana) to the European honeybee (A. mellifera).

- Two haplotypes derived from V. jacobsoni have adapted to reproduction on A. Mellifera and within *the Varroa mite, Varroa destructor with g*reater virulence.

Current varroa mite distribution - 2010. Red areas indicate establishment of Varroa destructor.

Female varroa mite, *Varroa destructor* feeding on the hemolymph of immature and worker bee.


Low temperature scanning electron micrograph of *V. destructor* on a honey bee host

Honey Bee Colony Collapse

- ***Varroa destructor*** harbors greater levels of the virus than are found even in severely infected bees. Thus *V. destructor* may not only be a concentrating the virus but may also act as a replicating incubator, magnifying and increasing its effects on the bees and on the hive.

- ***Varroa destructor*** has caused the **increase frequency of deformed wing virus from 10 percent to 100 percent.**

Honey Bee Colony Collapse

- The combination of mites and DWV causes **immunosuppression** in the bees and increased susceptibility to other opportunistic pathogens and has been considered a significant factor in honey bee colony collapse disorder.

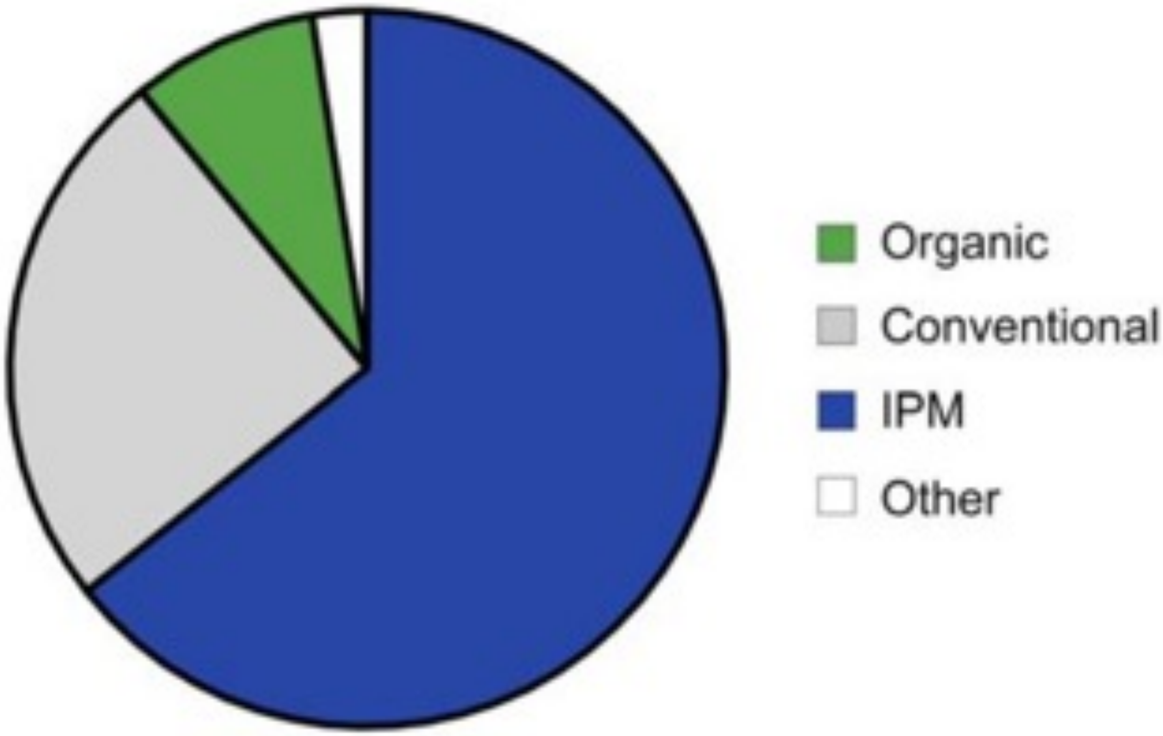
- *V. destructor* populations of 2000 mites can cause a colony containing 30,000 bees to die off. (6% infestation rate causes the demise of a colony).

S. J. Martin, A. C. Highfield, L. Brettell, E. M. Villalobos, G. E. Budge, M. Powell, S. Nikaido, D. C. Schroeder. **Global Honey Bee Viral Landscape Altered by a Parasitic Mite**. *Science*, 2012; 336 (6086): 1304 DOI: 10.1126/science.1220941

2009 NY Survey (Danforth Lab)
Native Pollinator Complex

- 262 Tree Fruit Growers from 43 Counties in NY State

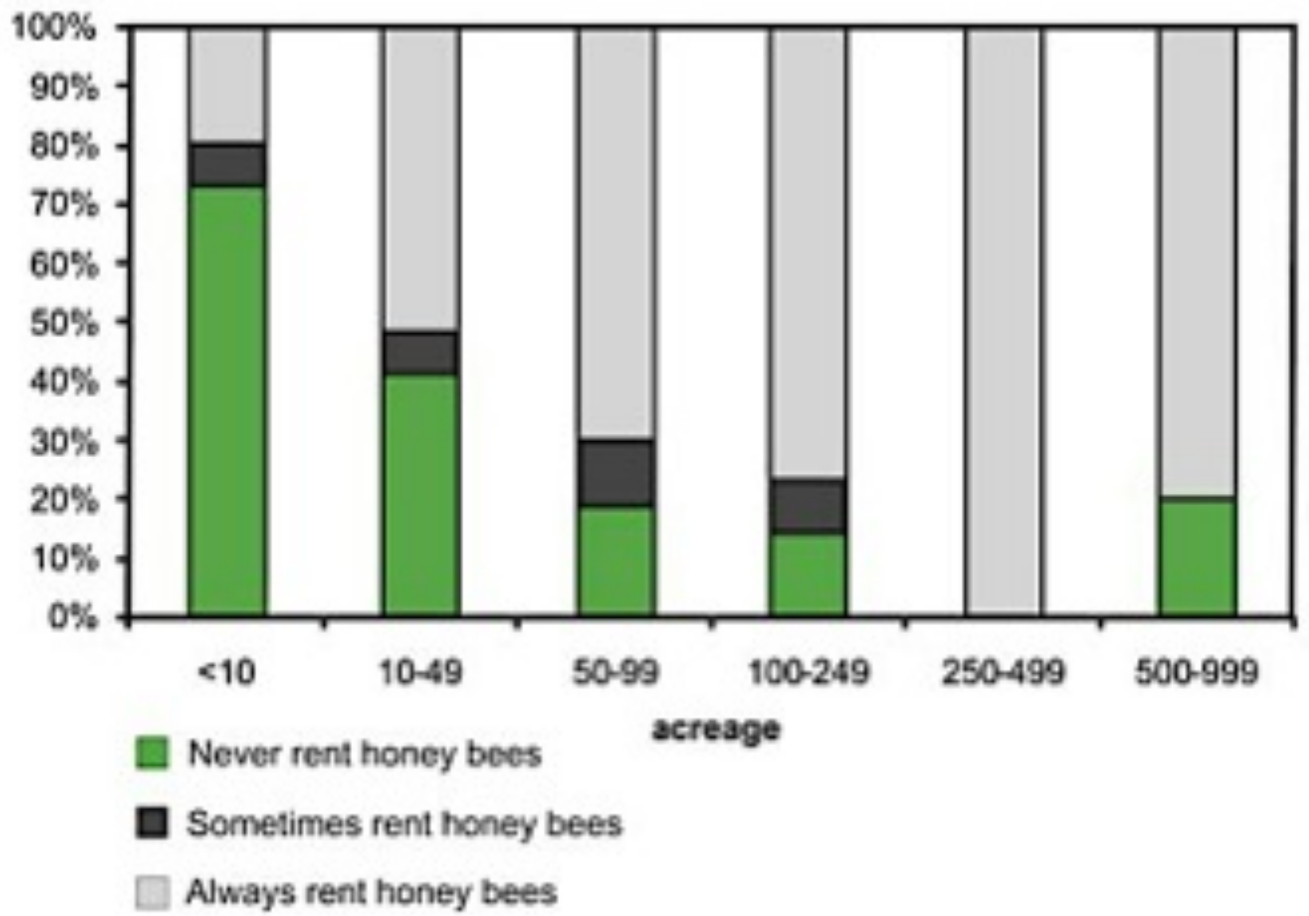
- 70% stated they used either IPM or Organic production practices with 25% using Conventional Practices



The Role of Native Bees in Apple Pollination. 2010 Park, M., Orr, M., Danforth, B., Cornell University

2009 NY Survey (Danforth Lab)
Native Pollinator Complex

- Smaller farms utilized native pollinators then did large farms



The Role of Native Bees in Apple Pollination. 2010 Park, M., Orr, M., Danforth, B., Cornell University

2009 NY Survey (Danforth Lab)
Native Pollinator Complex

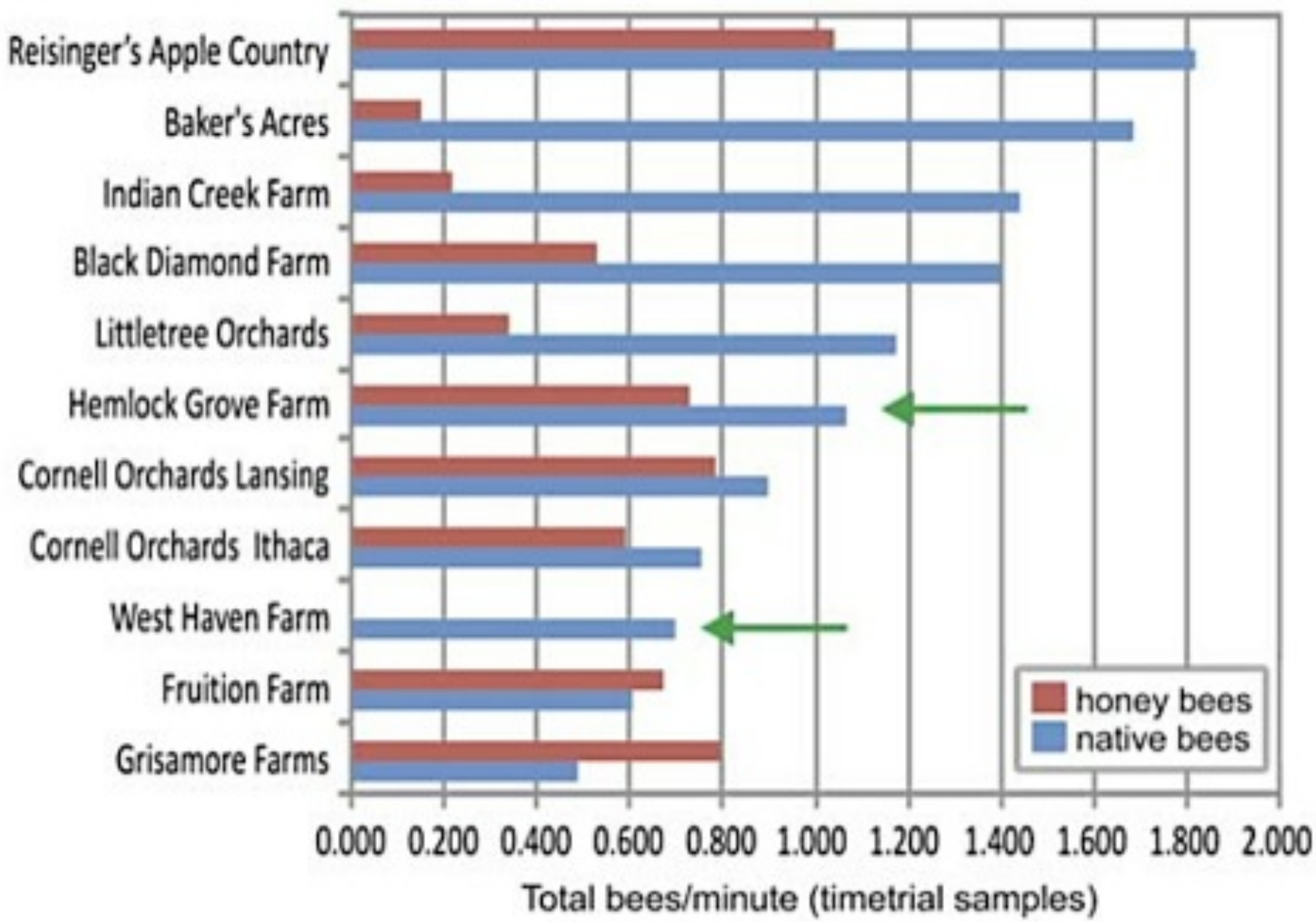
- Conventional farms (≥ 100A) have smaller ratio of edge to orchard, resulting in fewer flowering plants supporting wild flower populations.

- Deciduous woodlands foster fewer native pollinators then wildflower fields
- Conventional Ag. often views flowering plant diversity leading to pest abundance
- Mowed and clean edges, elimination of broad-leaf plants reduce plant bug pressure.

The Role of Native Bees in Apple Pollination. 2010 Park, M., Orr, M., Danforth, B., Cornell University

2009 NY Survey (Danforth Lab)
Native Pollinator Complex

- Relative abundance of native (blue bars) and honey bees (red bars) in 11 apple orchards.



IPM and Conventional Farms had strong native bee populations

Organic farms were mid-range of bee presence (green arrow)

2009 NY Survey (Danforth Lab)
Native Pollinator Complex

2009 NY Survey
Native pollinators

11 Central NY Orchards

- Capture and identification of pollinators visiting flowers
- 5 families of pollinators
- 80 different bee species

Genus (subgenus) species	Author	Family
Andrena (Andrena) mandibularis	Robertson, 1892	Andrenidae
Andrena (Andrena) milwaukeensis	LaBerge 1980	Andrenidae
Andrena (Andrena) rufosignata	Cockerell, 1902	Andrenidae
Andrena (Andrena) thaspii	Graenicher, 1903	Andrenidae
Andrena (Euandrena) algida	Smith, 1853	Andrenidae
Andrena (Gonandrena) integra	Smith, 1853	Andrenidae
Andrena (Holandrena) cressonii	LaBerge 1986	Andrenidae
Andrena (Larandrena) miserabilis	Ribble 1967	Andrenidae
Andrena (Leucandrena) barbilabris	LaBerge, 1987	Andrenidae
Andrena (Leucandrena) erythronii	Robertson, 1891	Andrenidae
Andrena (Melandrena) carlini	Cockerell, 1901	Andrenidae
Andrena (Melandrena) commoda	Smith, 1879	Andrenidae
Andrena (Melandrena) dunningi	Cockerell, 1898	Andrenidae
Andrena (Melandrena) nivalis	Smith, 1853	Andrenidae
Andrena (Melandrena) pruni	Robertson, 1891	Andrenidae
Andrena (Melandrena) regularis	Malloch, 1917	Andrenidae
Andrena (Melandrena) vicina	Smith, 1853	Andrenidae
Andrena (Plastandrena) crataegi	Robertson, 1893	Andrenidae
Andrena (Ptilandrena) erigeniae	Robertson, 1891	Andrenidae
Andrena (Scrapteropsis) imitatrix	LaBerge 1971	Andrenidae
Andrena (Scrapteropsis) morrisonella	Viereck, 1917	Andrenidae
Andrena (Simandrena) nasonii	LaBerge 1989	Andrenidae
Andrena (Thysandrena) bisalicis	LaBerge 1977	Andrenidae
Andrena (Trachandrena) forbesii	LaBerge 1973	Andrenidae
Andrena (Trachandrena) hippotes	LaBerge 1973	Andrenidae
Andrena (Trachandrena) nuda	LaBerge 1973	Andrenidae
Andrena (Trachandrena) rugosa	LaBerge 1973	Andrenidae
Andrena (Tylandrena) perplexa	Smith, 1853	Andrenidae
Apis mellifera	Linnaeus, 1758	Apidae
Bombus bimaculatus	Cresson, 1863	Apidae
Bombus griseocollis	(DeGeer, 1773)	Apidae
Bombus impatiens	Cresson, 1863	Apidae
Bombus perplexus	Cresson, 1863	Apidae
Bombus ternarius	Say, 1837	Apidae
Bombus vagans	Smith, 1854	Apidae
Ceratina calcarata	Robertson, 1900	Apidae
Ceratina dupla	Say, 1837	Apidae
Nomada ceanothi	Cockerell, 1907	Apidae
Nomada dreisbachi	Mitchell, 1962	Apidae
Nomada gracilis	Cresson, 1863	Apidae

Genus (subgenus) species	Author	Family
Nomada pygmaea	Cresson, 1863	Apidae
Xylocopa virginica	(Linnaeus, 1771)	Apidae
Colletes inaequalis	Say, 1837	Colletidae
Agapostemon sericeus	(Forster, 1771)	Halictidae
Augochlora pura	(Say, 1837)	Halictidae
Augochlorella aurata	(Smith, 1853)	Halictidae
Augochloropsis metallica	(Fabricius, 1793)	Halictidae
Halictus (Halictus) ligatus	Say, 1837	Halictidae
Halictus (Halictus) rubicundus	(Christ, 1791)	Halictidae
Halictus (Seladonia) confusus	Smith, 1853	Halictidae
Lasioglossum (Dialictus) atlanticum	(Mitchell, 1960)	Halictidae
Lasioglossum (Dialictus) coeruleum	(Robertson, 1893)	Halictidae
Lasioglossum (Dialictus) cressonii	(Robertson, 1890)	Halictidae
Lasioglossum (Dialictus) foxii	(Robertson, 1895)	Halictidae
Lasioglossum (Dialictus) imitatum	(Smith, 1853)	Halictidae
Lasioglossum (Dialictus) laevissimum	(Smith, 1853)	Halictidae
Lasioglossum (Dialictus) lineatulum	(Crawford, 1906)	Halictidae
Lasioglossum (Dialictus) obscurum	(Robertson, 1892)	Halictidae
Lasioglossum (Dialictus) paradmirandum	(Knerer & Atwood, 1966)	Halictidae
Lasioglossum (Dialictus) perpunctatum	(Ellis, 1913)	Halictidae
Lasioglossum (Dialictus) pilosum	(Smith, 1853)	Halictidae
Lasioglossum (Dialictus) subviridatum	(Cockerell, 1938)	Halictidae
Lasioglossum (Dialictus) versans	(Lovell, 1905)	Halictidae
Lasioglossum (Dialictus) versatum	(Robertson, 1902)	Halictidae
Lasioglossum (Dialictus) viridatum	(Lovell, 1905)	Halictidae
Lasioglossum (Dialictus) zephyrum	(Smith, 1853)	Halictidae
Lasioglossum (Evylaeus) cinctipes	(Provancher, 1888)	Halictidae
Lasioglossum (Evylaeus) quebecense	(Crawford, 1907)	Halictidae
Lasioglossum (Evylaeus) truncatum	(Robertson, 1901)	Halictidae
Lasioglossum (Lasio.) leucozonium	(Schrank, 1781)	Halictidae
Sphecodes cressonii	(Robertson, 1903)	Halictidae
Sphecodes dichrous	Smith, 1853	Halictidae
Osmia albiventris	Cresson, 1864	Megachilidae
Osmia bucephala	Cresson, 1864	Megachilidae
Osmia collinsiae	Robertson, 1905	Megachilidae
Osmia cornifrons	(Radoszkowski, 1887)	Megachilidae
Osmia lignaria	Say, 1837	Megachilidae
Osmia pumila	Cresson, 1864	Megachilidae
Osmia subfasciata	Cresson, 1872	Megachilidae
Osmia taurus	Smith, 1873	Megachilidae

Historical Invasive Insect Pests Of Fruit In Eastern New York

Grape berry moth, *Lobesia botrana* ([Dennis & Schiffermuller])	Tortricidae; Lepidoptera
Oriental fruit moth, *Grapholita molesta* (Busck)	Tortricidae; Lepidoptera
Apple maggot, *Rhagoletis pomonella* (Wash, 1867)	Tephritidae; Diptera
Oystershell scale, *Lepidosaphes ulmi* (Linnaeus)	Diaspididae; Hemiptera
San Jose scale, *Quadraspidiotus perniciosus* (Comstock)	Diaspididae; Hemiptera
Rose leafhopper, *Edwardsiana rosae* (Linnaeus)	Cicadellidae; Homoptera
Japanese beetle, *Popillia japonica* Newman,	Scarabaeidae; Coleoptera
Pear psylla, *Cacopsylla pyricola* Foerster,	Homoptera: Psyllidae
European red mite, *Panonychus ulmi,*	*Acari*: Tetranychidae

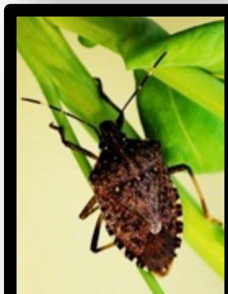
Factors Contributing to Invasive Insect Success

- Size of the introduced population (the larger the number, the higher the probability of establishment).
- Aggressiveness (how well it out competes native species)
- Ecological niche with suitable climate and available food
- Absence natural enemy complex (parasites and predators)

Emerging Insect Problems On Tree Fruit In Eastern New York

Newly Invasive Insects Presently Causing Damage to Fruit

Black Stem
Borer (BSB)
1932



Brown Marmorated
Stink Bug (BMSB)
2008

Spotted Wing
Drosophila (SWD)
2011

Emerging Insect Problems On Tree Fruit In Eastern New York

Newly Invasive Insects Presently Causing Damage to Fruit

Black Stem
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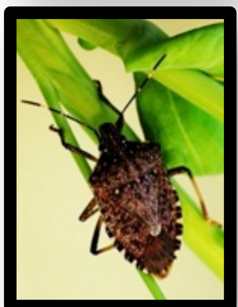
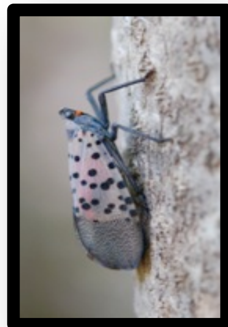


Brown Marmorated
Stink Bug (BMSB)
2008

Spotted Wing
Drosophila (SWD)
2011

Newly Invasive Insects & Disease with High Potential to Damage Tree Fruit



Spotted Lanternfly (SLF)
E.PA   2013

High Potential to Become Invasive

Apple Proliferation Phytoplasma (APP)
Candidatus Phytoplasma mali
Apple psyllid: Europe   2012

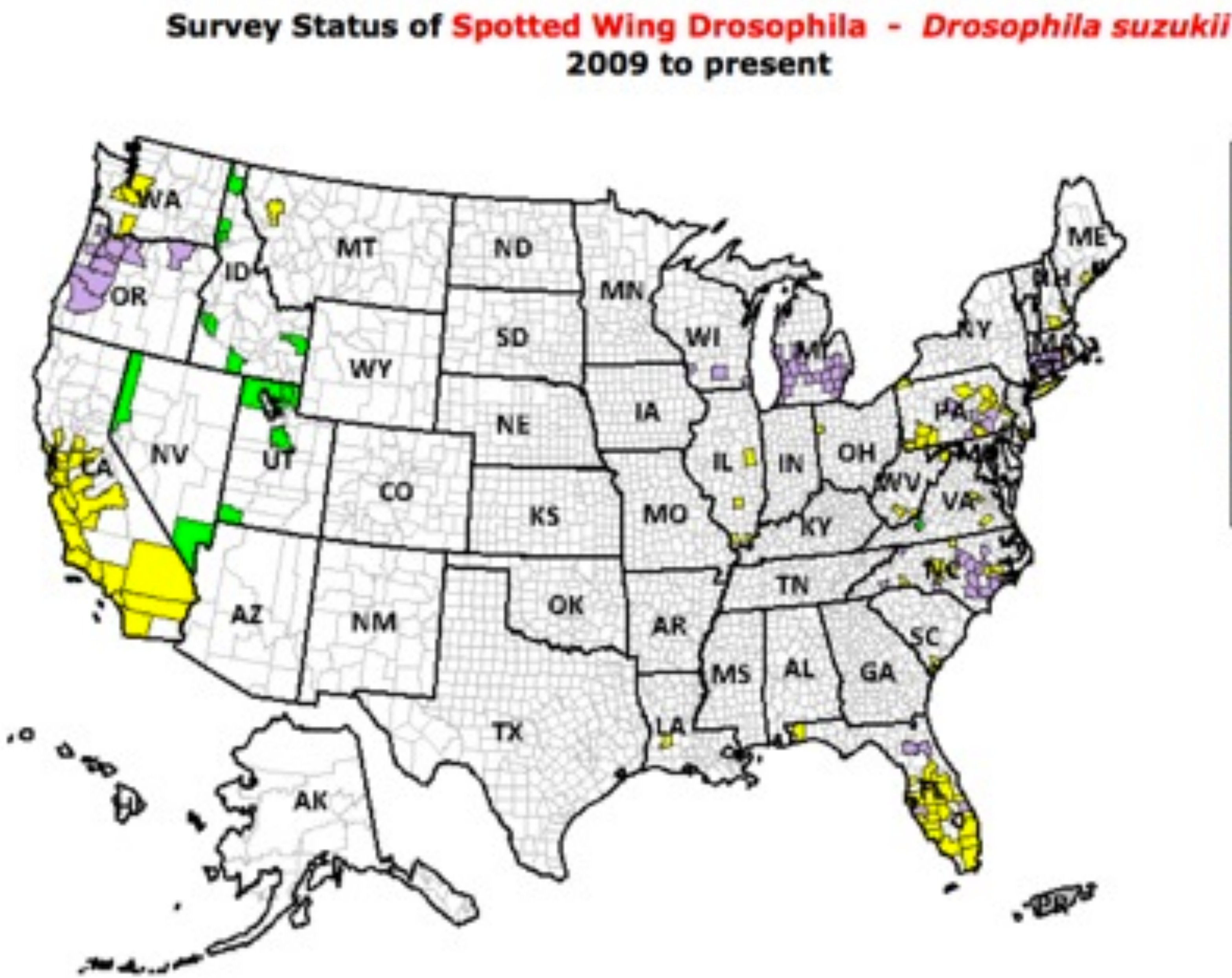
Invasive Insects Small Fruit & Vegetable Production

Spotted wing drosophila

Brown marmorated stink bug

Originally from Asia. Where has SWD spread?

SWD found in:
- Italy 2009
- Russia 2009
- Spain 2009
- France 2010



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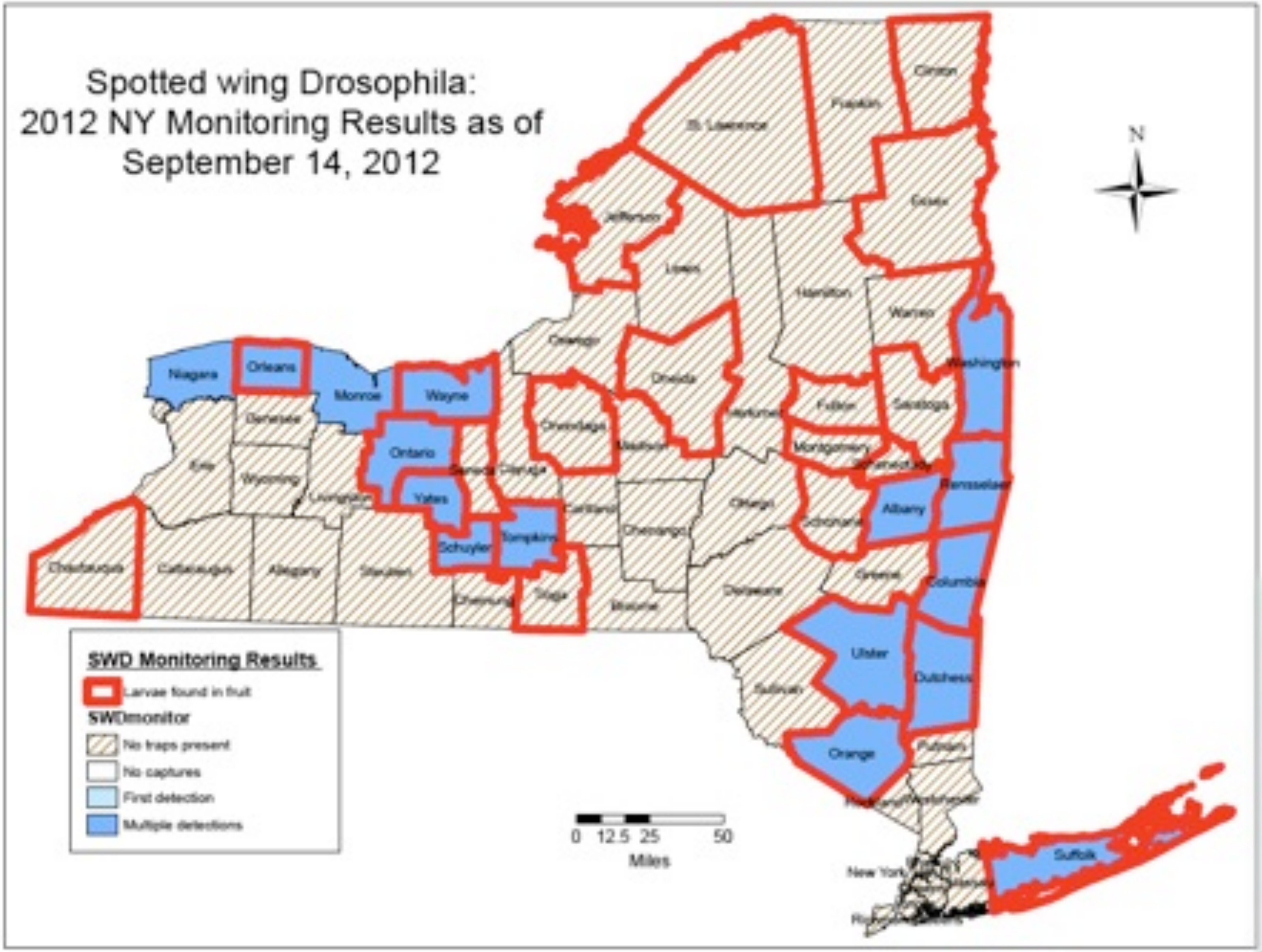
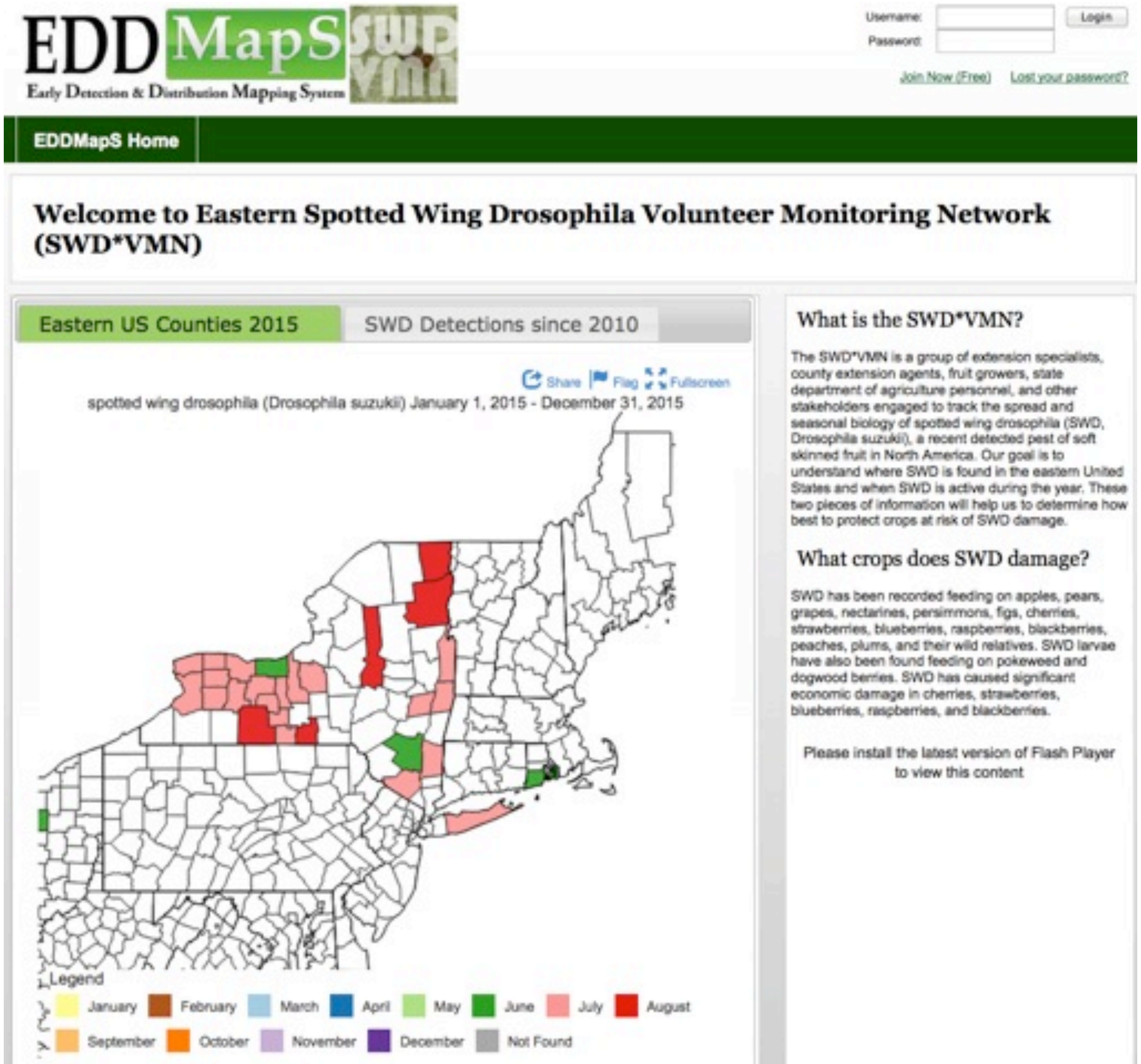


SWD State-Wide Monitoring, 2015



http://www.eddmaps.org/project/project.cfm?proj=9

Use of EDDMap Site

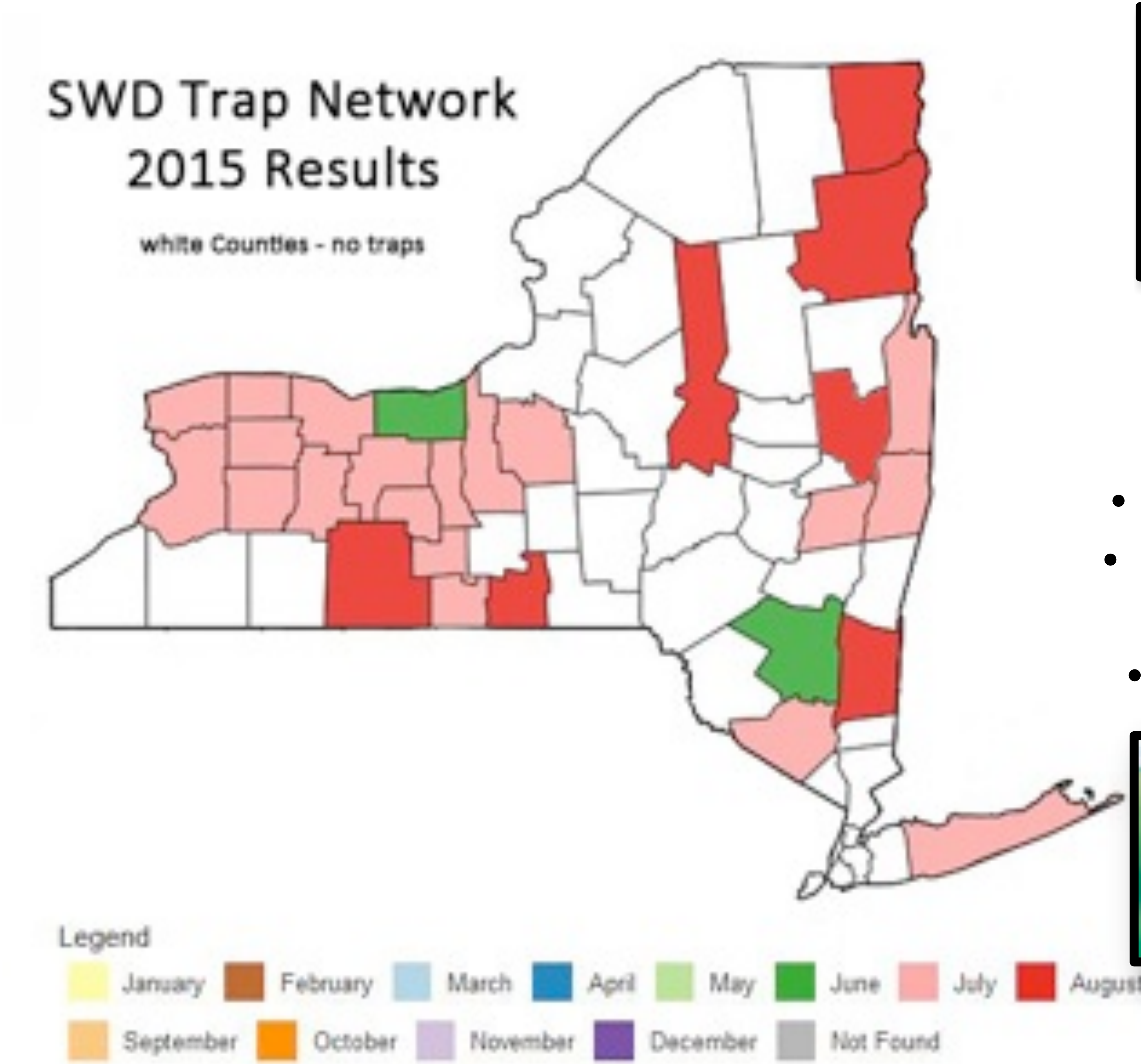
- Digital communication to growers

ENY Trap Sites: 15
HVRL & ENY Hort. Team

- Albany
- Central Washington
- Columbia
- Dutchess (3 sites)
- Orange
- Rensselaer (3 sites)
- Saratoga
- South Clinton
- Ulster (3 sites)

Cornell University
College of Agriculture and Life Sciences

Hudson Valley Research Laboratory



2015

- ACV
- Whole wheat
- Brewers yeast Synthetic
- Trece Traps

Spotted Wing Drosophila

A new invasive pest

Order: Diptera

Family: Drosophilidae

Genus: Drosophila

"vinegar fly" attack rotting fruit

Species: *D. melanogaster*

Common name:

Common fruit fly or Vinegar fly

Species: *D. suzukii*

Common name:

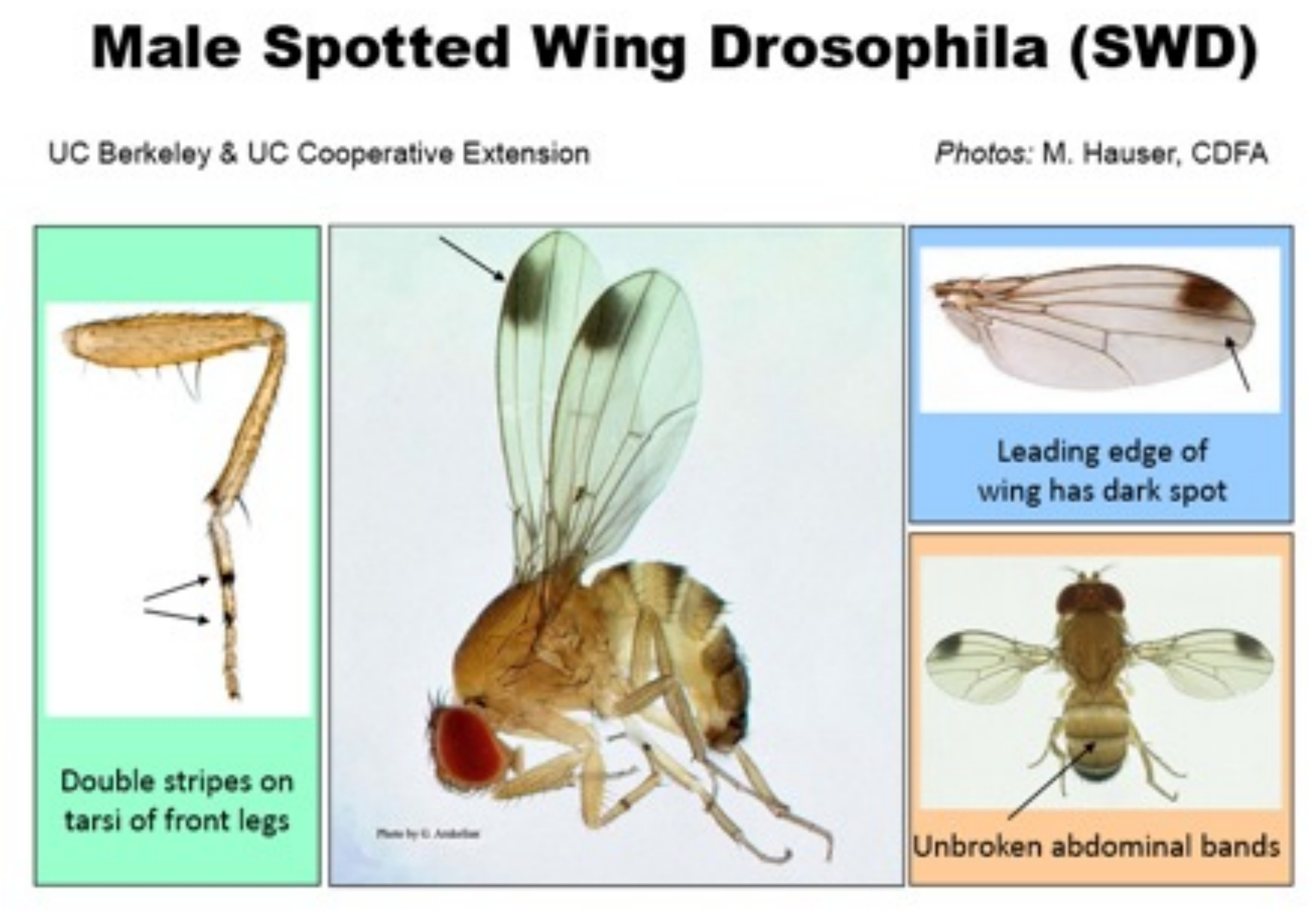
Spotted Wing Drosophila

Spotted Wing Drosophila

A new invasive pest

Spotted Wing Drosophila

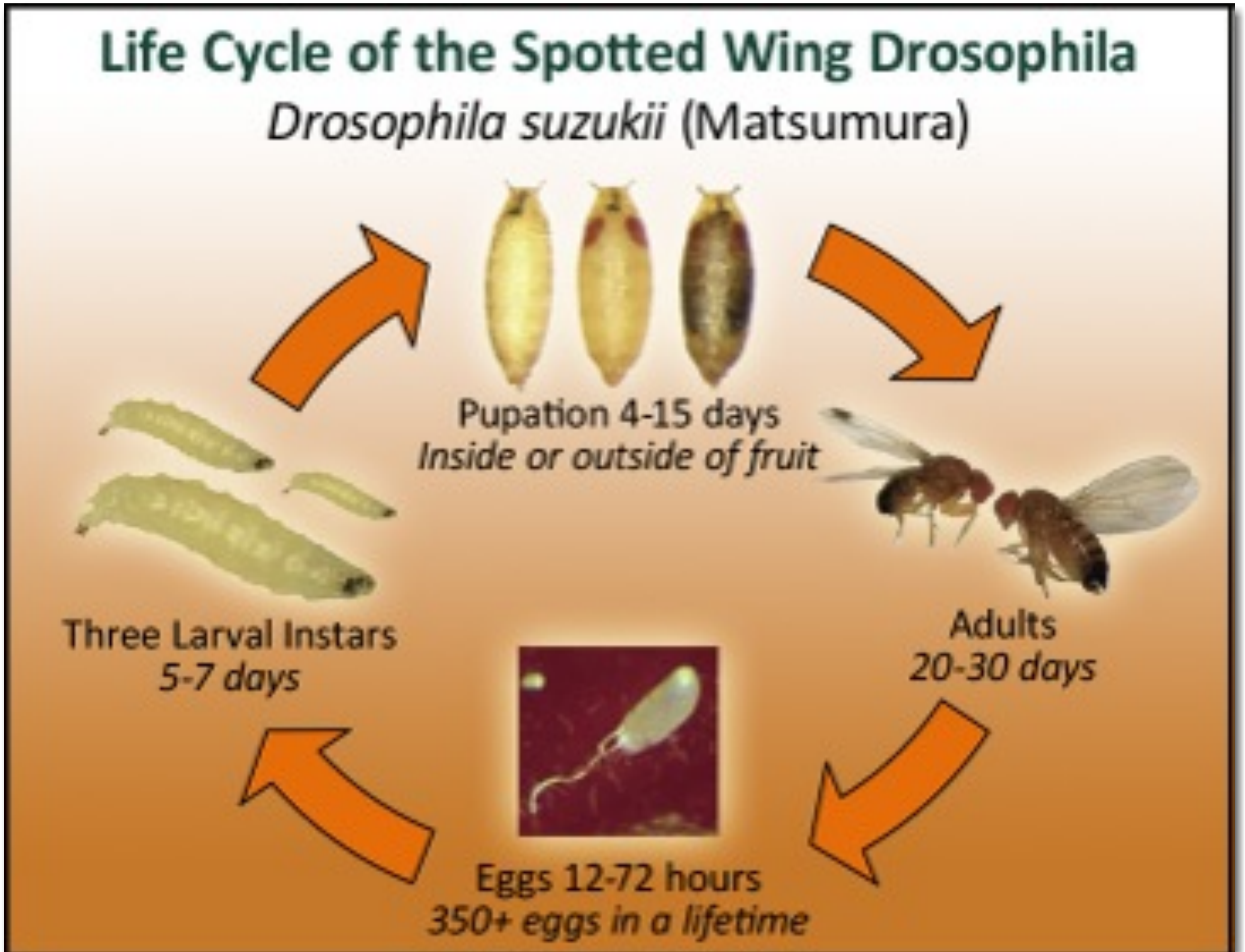
A new invasive pest



SWD Look-a like wing patterns = Biodiversity

Nicolas Gompel and Benjamin Prud'homme, UW-Madison

Invasive Insects Small Fruit Production



- Optimal development is at 65-70^{o}F, **~12 day** generation time.
- Adult flies live for 3-6 weeks, and females can lay over 300 eggs.
- Limited by high heat in summer and by winter cold. But, SWD populations are found in cold regions of Japan.
- 3-10 generations in NY


Drosophila parasitoid, a pteromalid wasp attacks the pupal stage of the spotted wing drosophila.
Dr. Peter Shearer, OSU's Mid-Columbia Agricultural Research and Extension Center at Hood River

Fruit Affected by SWD

Highest risk

Strawberries

Raspberries

Cherries (Late var,)

Nectarines

Blueberries

Blackberries

Moderate risk

Peaches

Grapes

Pears

Apples

Tomato

Alternate hosts

Wild plants with berries, such as…

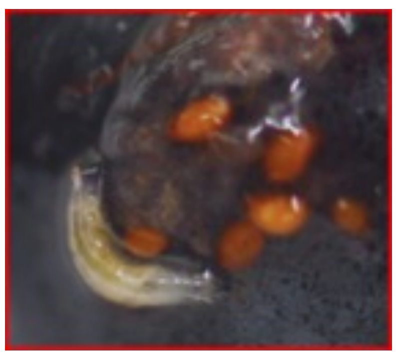
Tartarian Honeysuckle

Snowberry

Elderberry

Pokeweed

Dogwood



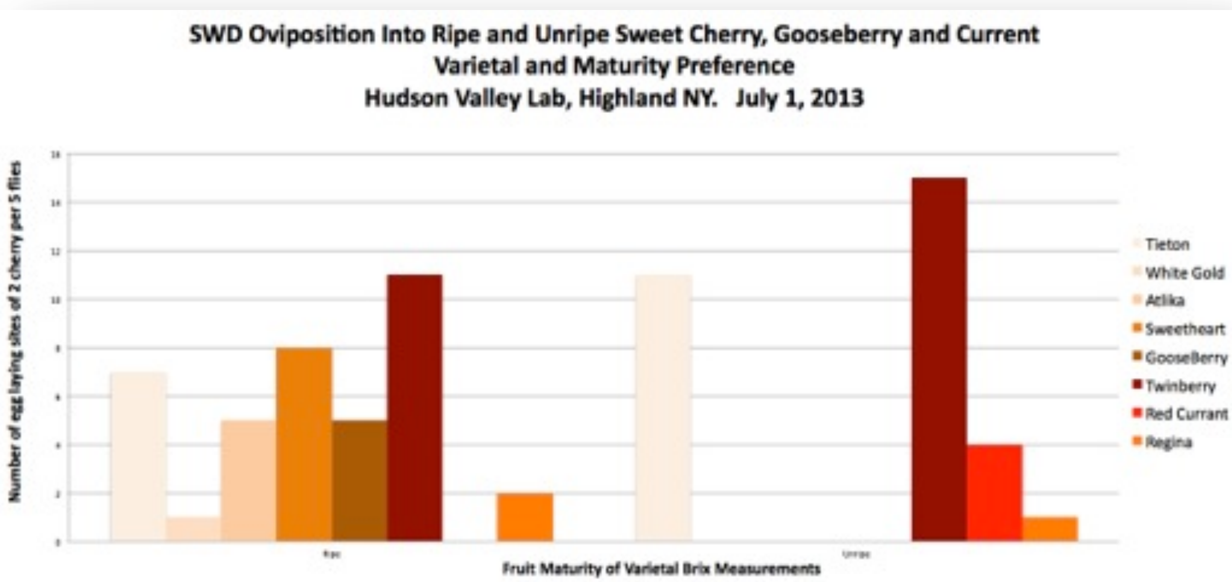
SWD Alternate Host: Population Development in the HV

- Honeysuckle is a primary host for SWD; *L. tartarica* fruit favored over raspberry in June-August.

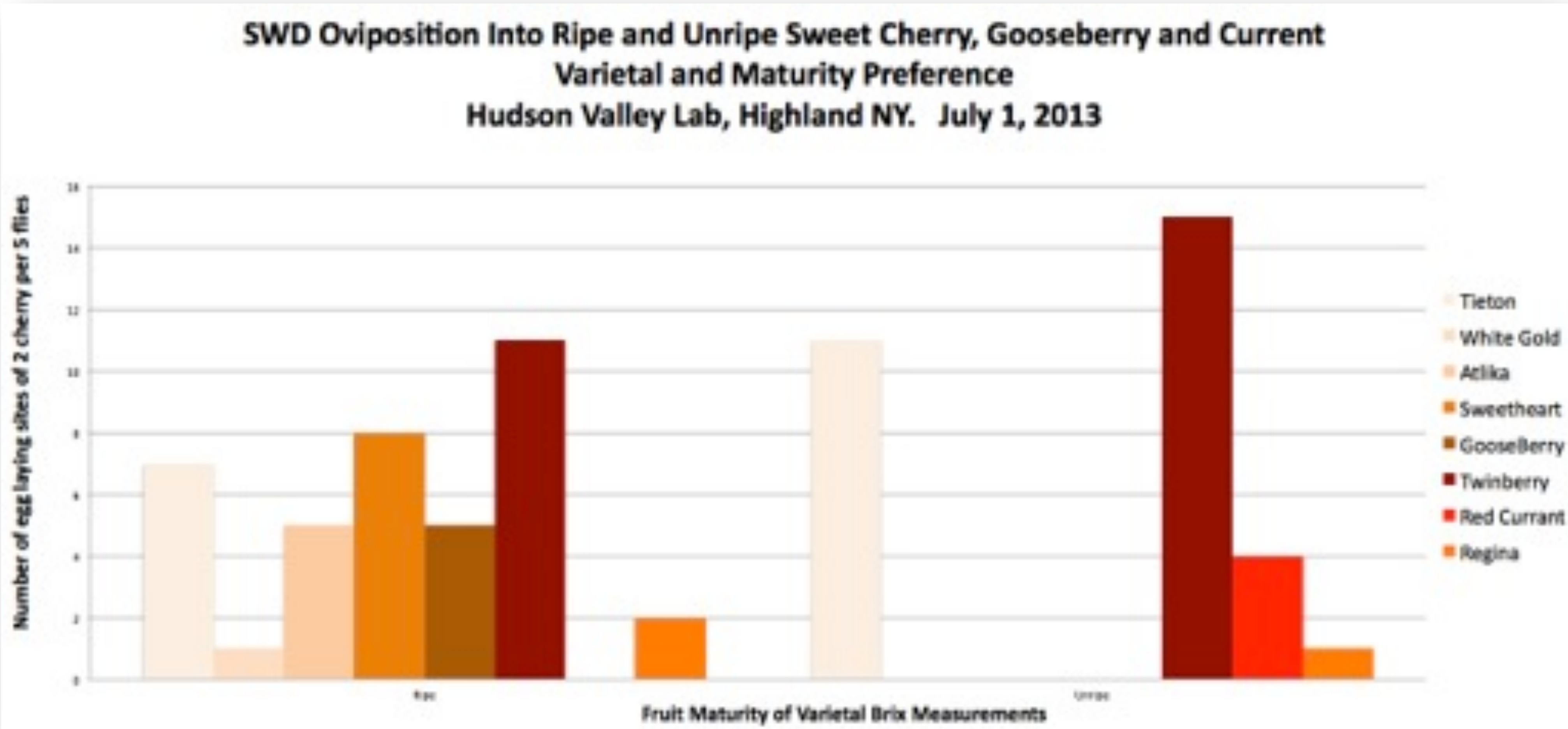
SWD Preference Studies

SWD oviposition during pre-harvest and ripened fruit development.

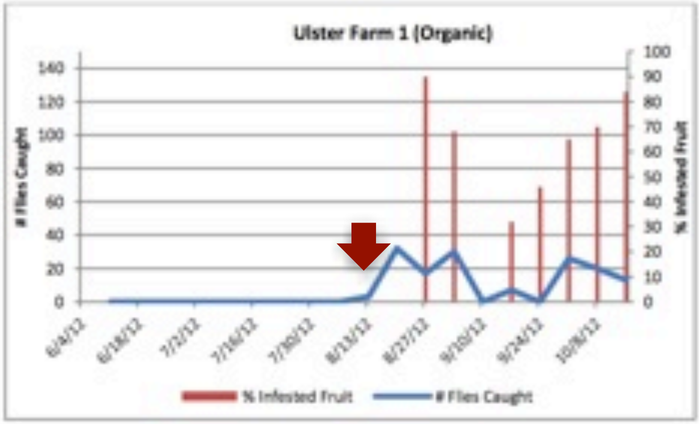
- 5 Male and 5 Female flies were introduced to fruit, and allowed 48 hours to oviposit
- Each fruit was isolated with 2 cherry of each V. and
- Fruit were removed and eggs were counted.

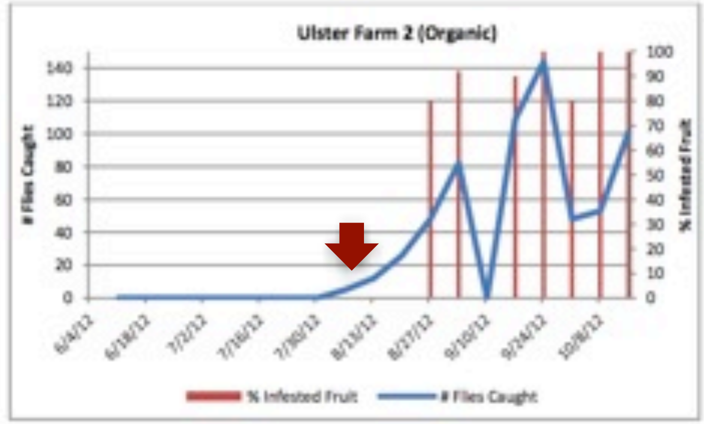


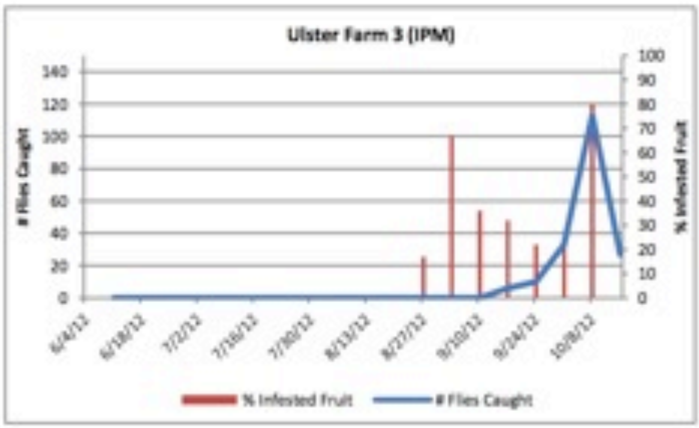
SWD Preference Studies

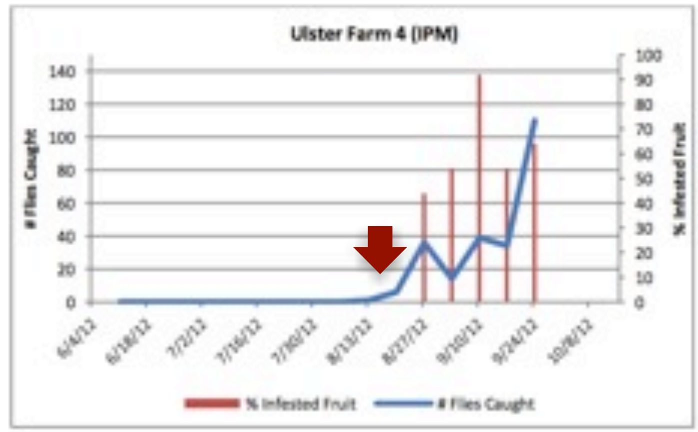


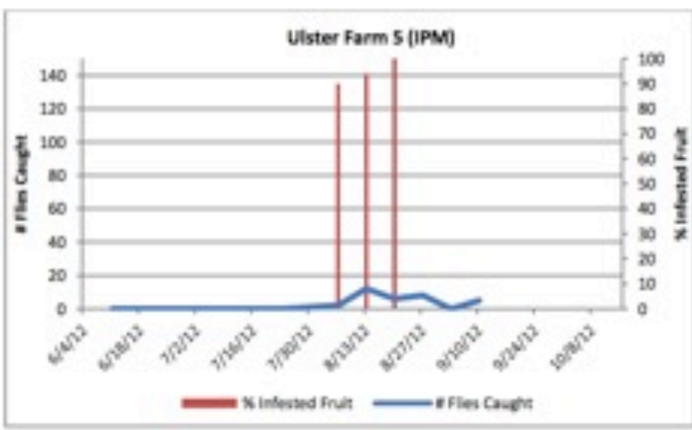
D. suzukii Monitoring Using ACV Results of 6 Farms in the Hudson Valley of Eastern, NY - 2012

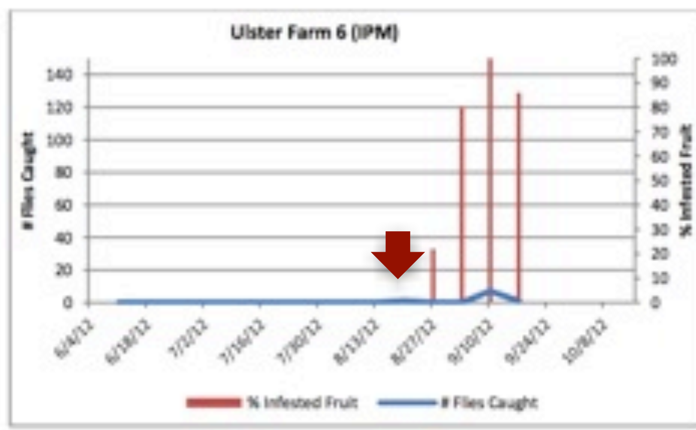






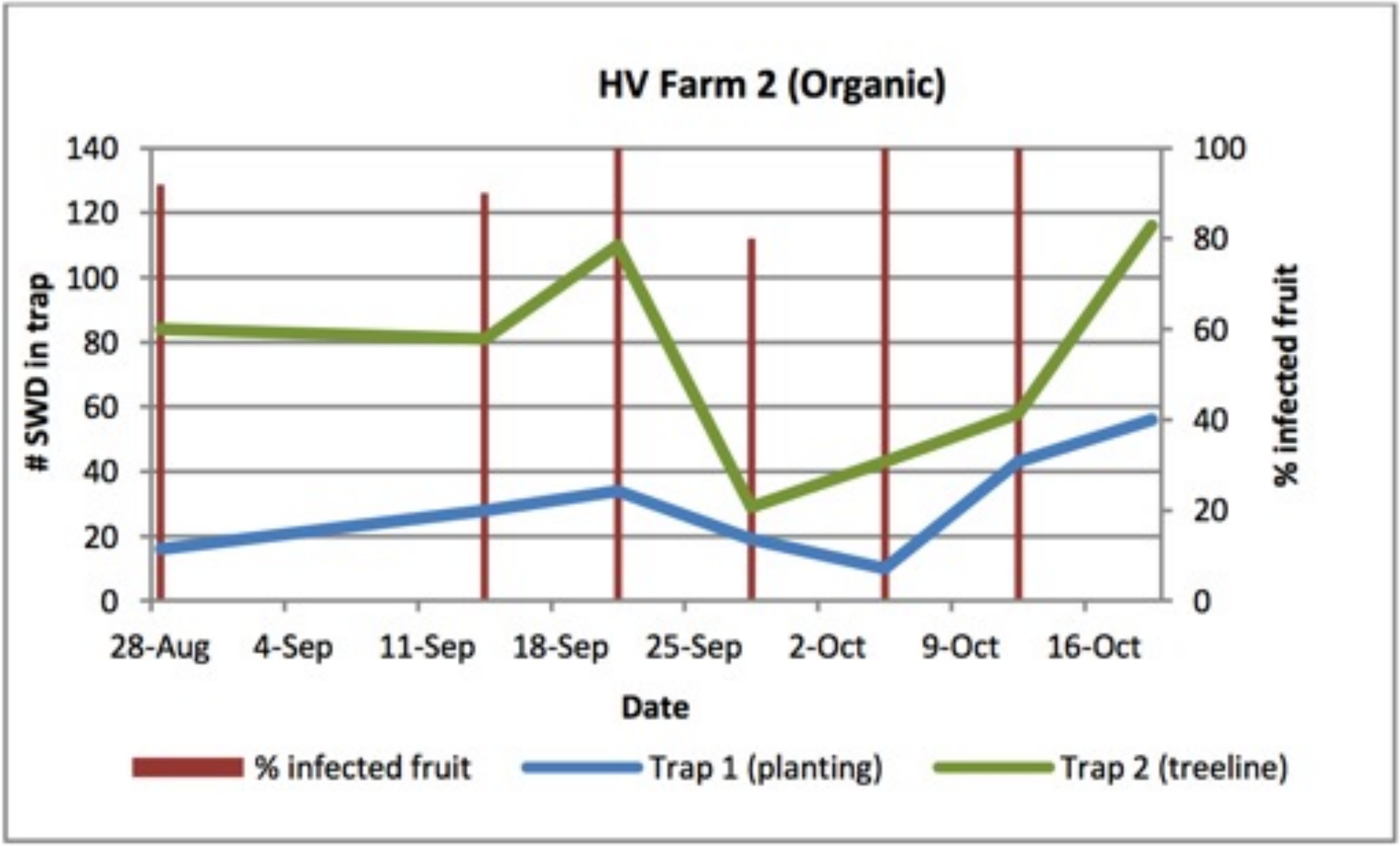






Raspberry Plantings: Emily Cook, James O'Connell; ENYHP

D. suzukii Monitoring Results in the Hudson Valley of Eastern, NY - 2012



Raspberry Plantings: Emily Cook; ENYHP

Managing Insecticide Resistance: www.fruit.cornell.edu/

RASPBERRIES & BLACKBERRIES											
PRODUCT	AI[1]	IRAC group	EPA#	RATE/A	REI[3]	DTH[4]	Max. Prod/A/yr (ai)	Total applic's	Spray Interval	Probable efficacy
Entrust Naturalyte (2ee)	spinosad	5	62719-282	1.25-2 oz	4 hr	1 d	9 oz (0.45 lb)	3 per crop	6 d	Good to Excellent
Entrust SC (2ee)	spinosad	5	62719-621	4-6 fl oz	4 hr	1 d	29 fl oz (0.45 lb)	3 per crop	6 d	Good to Excellent
Delegate WG (2ee)	spinetoram	5	62719-541	3-6 oz	4 hr	1 d	19.5 oz (0.305 lb)	6	4 d	Excellent
Brigade WSG (2ee)	bifenthrin	3A	279-3108	8.0-16 oz	12 hr	3 d	2 lb (0.2 lb)	1 post bloom	-	Excellent
Brigade EC (2ee)	bifenthrin	3A	279-3313	3.2-6.4 fl oz	12 hr	3 d	12.8 fl oz (0.2 lb)	1 post bloom	-	Excellent
Danitol 2.4EC	fenpropathrin	3A	59639-35	16 fl oz	24 hr	3 d	32 fl oz (0.6 lb)	2	-	Excellent
Mustang Max Insecticide (2ee)	zeta-cypermethrin	3A	279-3249	4 fl oz	12 hr	1 d	24 fl oz (0.15 lb)	6	7 d	Excellent
Triple Crown	bifenthrin, imidacloprid, zeta-cypermethrin	3A,4A	279-3440	6.4-10.3 fl oz	12 hr	3 d	10.3 fl oz (0.181 lb)	1 post bloom	7 d	Good to excellent
Malathion 5EC (2ee)	malathion	1B	19713-217	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Malathion 5EC (2ee)	malathion	1B	66330-220	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Malathion 8 Aquamul (2ee)	malathion	1B	34704-474	2.0 pts	12 hr	1 d	6 pts (6.0 lb)	3	7 d	Good
Malathion 57 (2ee)	malathion	1B	67760-40-53883	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Assail 30SG	acetamiprid	4A	8033-36-70506	4.5-5.3 oz	12 hr	1 d	26.7 oz (0.5 lb)	5	7 d	Good
Pyganic EC 1.4	pyrethrin	3A	1021-1771	1 pt – 2 qts	12 hr	0 d	-	-	-	Fair to Poor
Pyganic EC 5.0	pyrethrin	3A	1021-1772	4.5 – 18 fl oz	12 hr	0 d	-	-	-	Fair to Poor
AzaSol	azadirachtin	UN	81899-4	6 oz in 50 gal	4 hr	0	-	-	-	Fair to Poor

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Danitol 2.4EC	fenpropathrin	3A	59639-35	16 fl oz	24 hr	3 d	32 fl oz (0.6 lb)	2	-	Excellent
Mustang Max Insecticide (2ee)	zeta-cypermethrin	3A	279-3249	4 fl oz	12 hr	1 d	24 fl oz (0.15 lb)	6	7 d	Excellent
Triple Crown	bifenthrin, imidacloprid, zeta-cypermethrin	3A,4A	279-3440	6.4-10.3 fl oz	12 hr	3 d	10.3 fl oz (0.181 lb)	1 post bloom	7 d	Good to excellent
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Malathion 8 Aquamul (2ee)	malathion	1B	34704-474	2.0 pts	12 hr	1 d	6 pts (6.0 lb)	3	7 d	Good
Malathion 57 (2ee)	malathion	1B	67760-40-53883	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Assail 30SG	acetamiprid	4A	8033-36-70506	4.5-5.3 oz	12 hr	1 d	26.7 oz (0.5 lb)	5	7 d	Good
Pyganic EC 1.4	pyrethrin	3A	1021-1771	1 pt – 2 qts	12 hr	0 d	-	-	-	Fair to Poor
Pyganic EC 5.0	pyrethrin	3A	1021-1772	4.5 – 18 fl oz	12 hr	0 d	-	-	-	Fair to Poor
AzaSol	azadirachtin	UN	81899-4	6 oz in 50 gal	4 hr	0	-	-	-	Fair to Poor

5 Classes

Managing Insecticide Resistance: www.fruit.cornell.edu/

RASPBERRIES & BLACKBERRIES										
PRODUCT	AI	IRAC group	EPA#	RATE/A	REI	DTH	Max. Prod/A/yr (ai)	Total applic's	Spray Interval	Probable efficacy
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Danitol 2.4EC	fenpropathrin	3A	59639-35	16 fl oz	24 hr	3 d	32 fl oz (0.6 lb)	2	-	Excellent
Mustang Max Insecticide (2ee)	zeta-cypermethrin	3A	279-3249	4 fl oz	12 hr	1 d	24 fl oz (0.15 lb)	6	7 d	Excellent
Triple Crown	bifenthrin, imidacloprid, zeta-cypermethrin	3A,4A	279-3440	6.4-10.3 fl oz	12 hr	3 d	10.3 fl oz (0.181 lb)	1 post bloom	7 d	Good to excellent
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Assail 30SG	acetamiprid	4A	8033-36-70506	4.5-5.3 oz	12 hr	1 d	26.7 oz (0.5 lb)	5	7 d	Good

4 Classes

Managing Insecticide Resistance: www.fruit.cornell.edu/

RASPBERRIES & BLACKBERRIES										
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[o]Entrust Naturalyte (2ee)	spinosad	5	62719-282	1.25-2 oz	4 hr	1 d	9 oz (0.45 lb)	3 per crop	6 d	Good to Excellent[e]
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Triple Crown	bifenthrin, imidacloprid, zeta-cypermethrin	3A,4A	279-3440	6.4-10.3 fl oz	12 hr	3 d	10.3 fl oz (0.181 lb)	1 post bloom	7 d	Good to excellent
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R

Managing Insecticide Resistance: Raspberry

Example of IRM conventional program: Mode of Action (MoA)

MoA-w – Pyrethroids: IRAC 3A

Baythroid XL, Brigade 2EC, Danitol, TripCr, Mustang Max (7d / 6 apps.)

MoA-x – Organophosphates: IRAC 1B

Malathion (7d / 3 apps.)

MoA-y – Spinetoram: IRAC 5

Entrust, Delegate (4d / 6apps.)

MoA-z – Neonicotinoids: IRAC 4A

Provado (Pre-mix), Assail (7d / 5apps.)

Managing Insecticide Resistance: Raspberry

<u>Example of a IRM conventional program:</u>

MoA-w – Pyrethroids: IRAC 3A

Baythroid XL, Brigade 2EC, Danitol, TripCr, <u>Mustang Max</u> (7d / 6 apps.)

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Delegate (4d / 6apps.)

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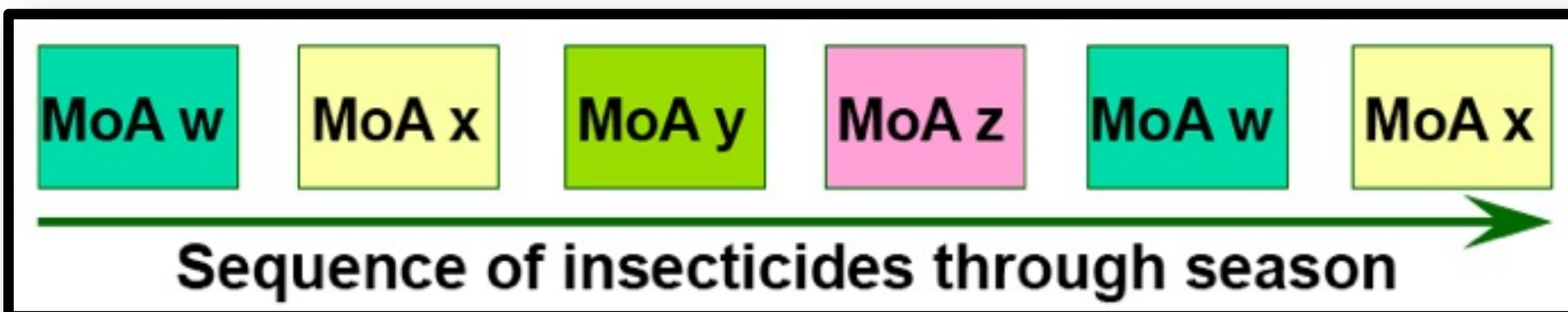

Managing Insecticide Resistance: Raspberry

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Delegate (4d / 6apps.)

MoA-z – Neonicotinoids: IRAC 4A

Provado (Pre-mix), Assail (7d / 5apps.)

MoA w	MoA x	MoA y	MoA z	MoA w	MoA x

Sequence of insecticides through season

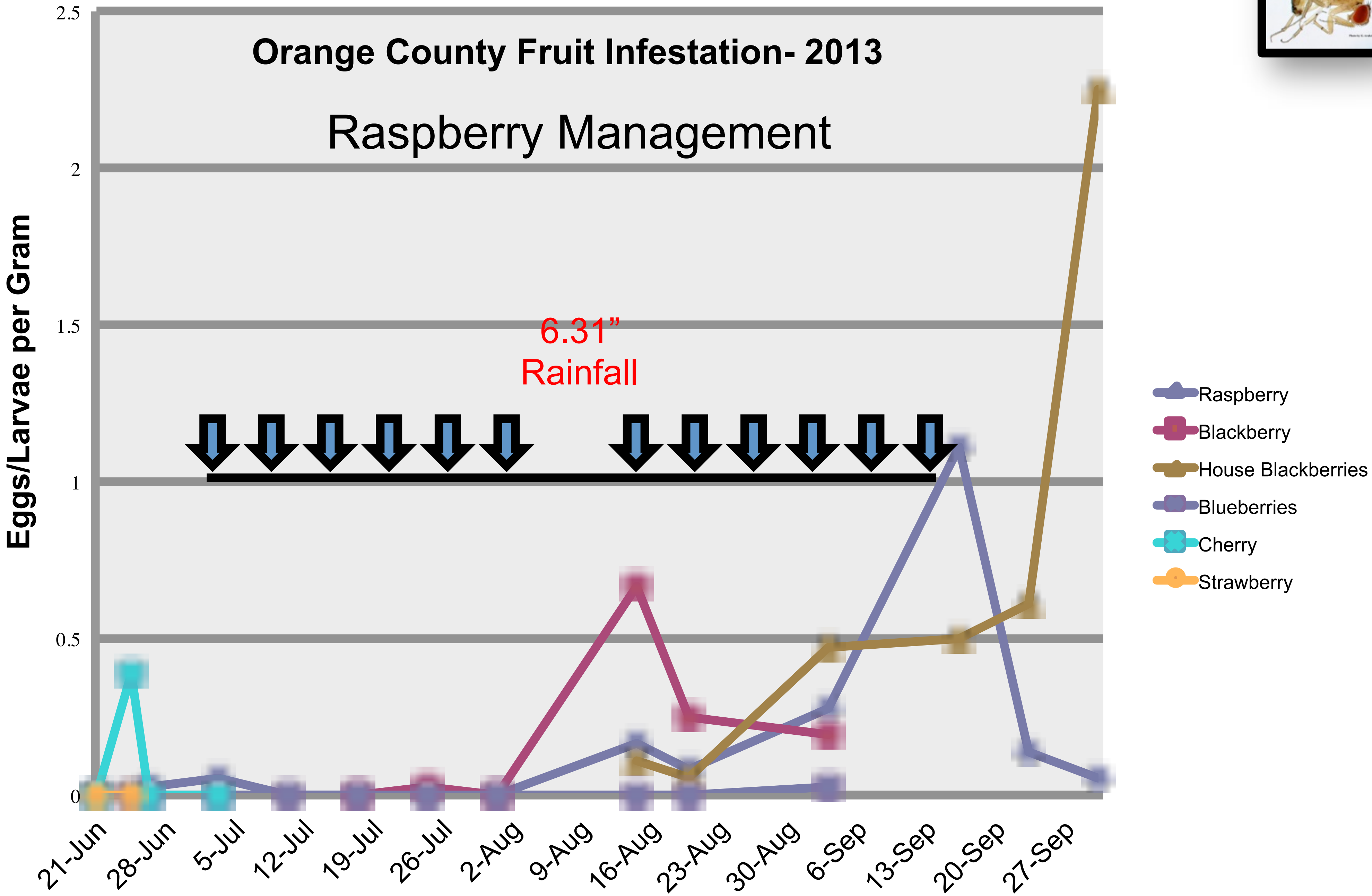
J 10 15 19 23 27 30 A 3 7 11 15 19 23 27 S 1 5 9 13 17 21 25

Managing Insecticide Resistance: Raspberry

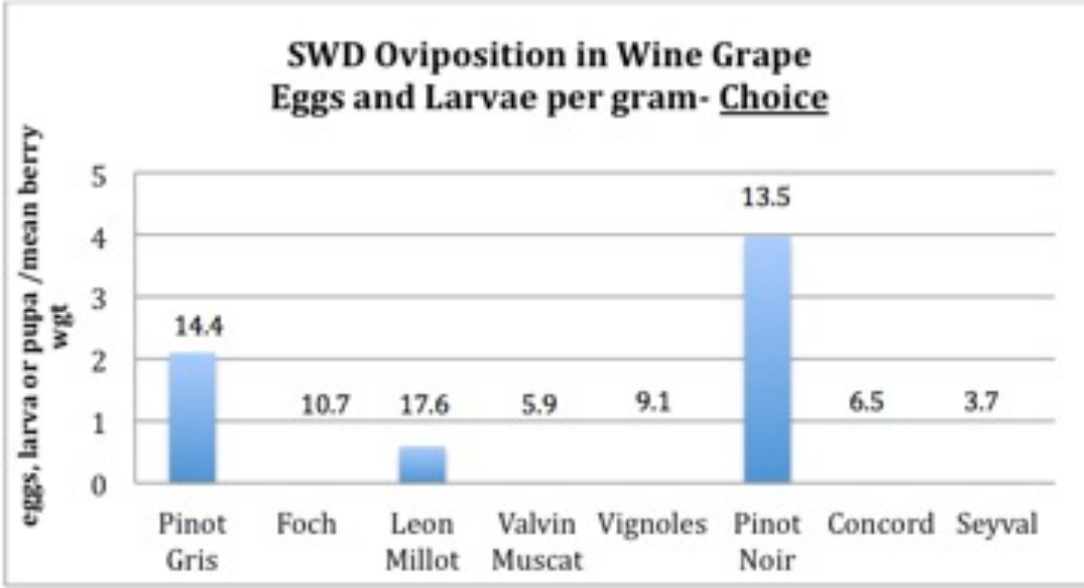
SWD Control in Mixed Small Fruit; Orange Co. 2012

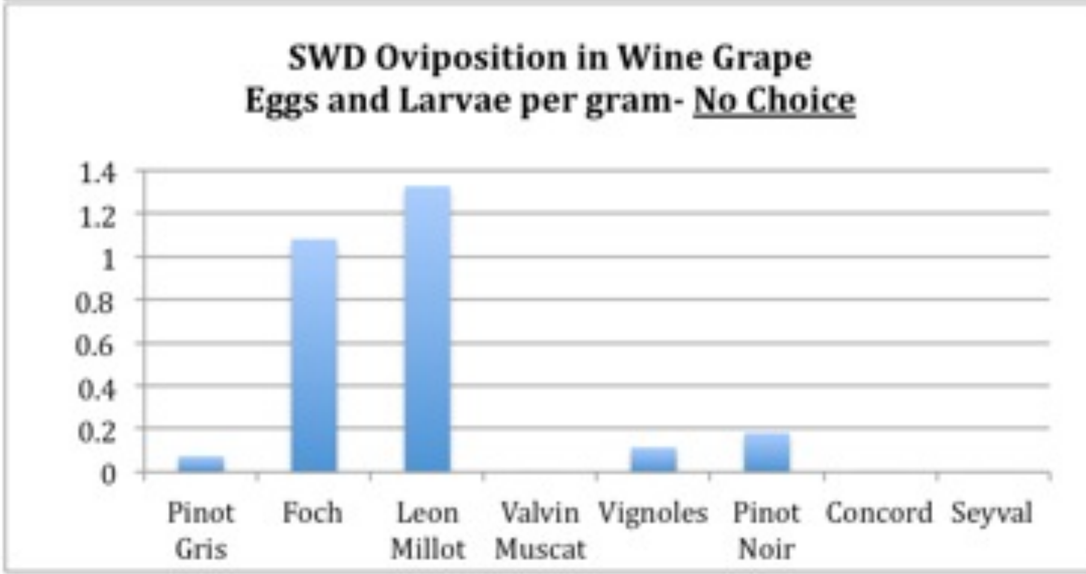
Date	Material	Rate	Commodity
27 June	Malathion 57	2 pts./A	Raspberry
1 July	Assail 30SG	5 oz./A	Raspberry
5 July	Malathion 57	2 pts./A	Raspberry
12 July	Delegate 25WDG	3 oz./A	Raspberry
14 July	Brigade	8 oz./A	Raspberry
19 July	Assail 30SG	5 oz./A	Raspberry
22 July	Danitol	16 oz./A	Raspberry
27 July	Mustang Max	4 oz./A	Raspberry
30 July	Assail 30SG	5 oz./A	Raspberry
6.31" Rainfall; 6 day application interval			
5 August	Delegate 25WDG	3 oz./A	Raspberry
19 August	Brigade	8 oz./A	Raspberry

Managing Insecticide Resistance: Raspberry



Spotted Wing Drosophila Infestation of Grape





Choice Test

Variable ripeining (Brix#)

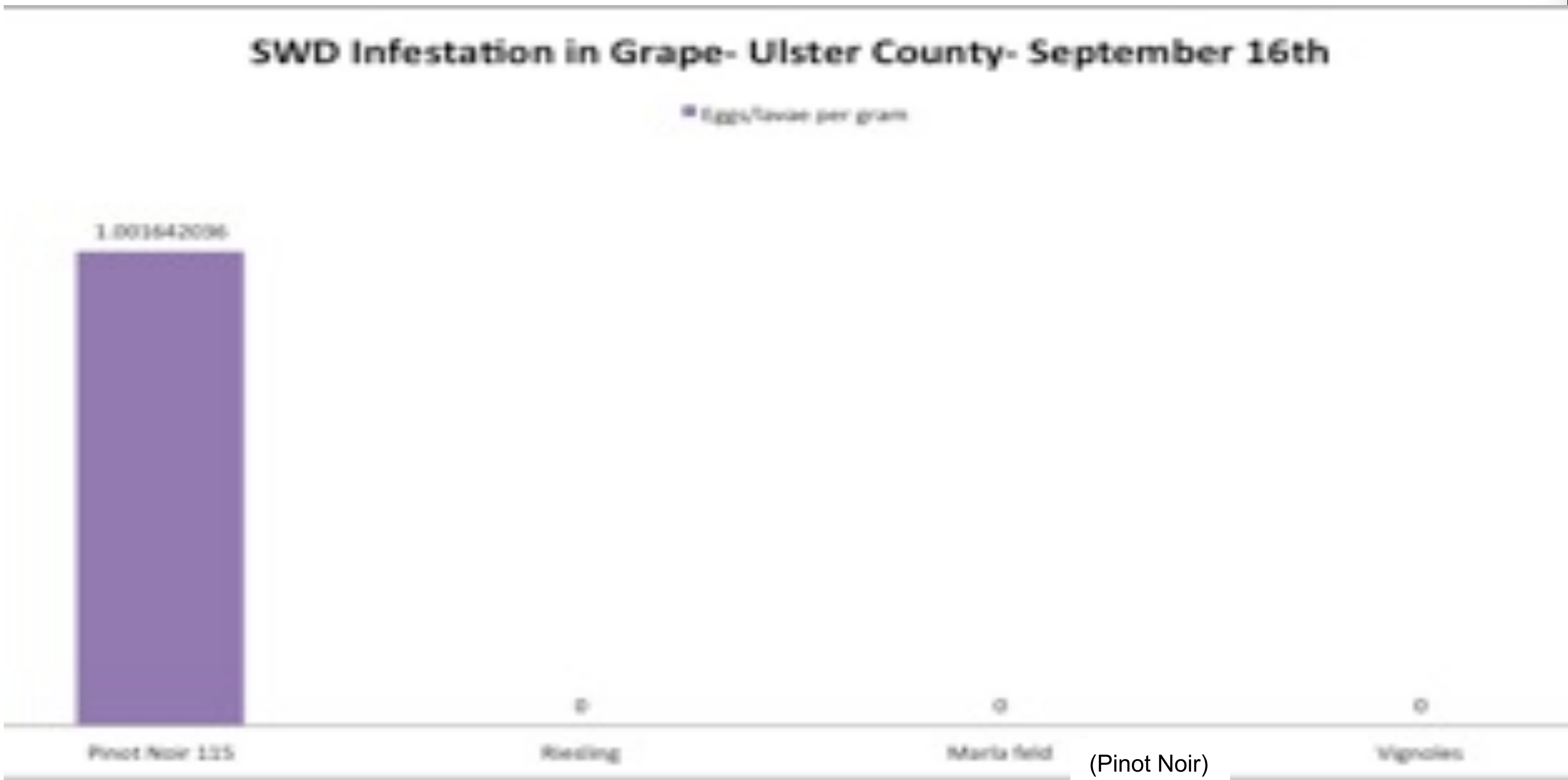
- Grape varieties placed in same container.
- 40 female SWD

No-Choice Test

- Grapes varieties placed in individual containers.
- 5 female SWD

- SWD ovipositional preference in pre-ripened grape varieties.
- Allowed 48 hours to oviposit.

Managing SWD in Grape



- Grapes collected and analyzed from an Ulster County vineyard indicated that Pinot Noir 115 is at high risk of SWD infestation.

Managing Pollinators & SWD in Small Fruit

- By law, and as described in the restrictions on labels, the use of insecticides toxic to bees is restricted during crop bloom when bees are actively foraging.
- Each label will provide specific guidance on the restrictions, which are based on the insecticide's toxicity to bees.
- 2016 Cornell Guidelines includes insecticide bee toxicity warning symbols

Insecticide Toxicity to Pollinators

Level of Direct Toxicity

CHEMICAL CLASS/GROUP	EXAMPLES OF COMMON NAMES	EXAMPLES OF TRADE NAMES	NON	LOW	MODERATE	HIGH
CARBAMATES	oxamyl	Vydate			■	
	carbaryl, methomyl	Sevin, Lannate				■
NICOTINOIDS	clothianidin, imidacloprid, thiamethoxam	Clutch, Provado, Actara				■
	acetamiprid, thiacloprid	Assail, Calypso		■		
ORGANOPHOSPHATES	azinphos-methyl, chlorpyrifos, diazinon, dimethoate, malathion, methidathion, phosmet	Guthion, Lorsban, Diazinon, Dimethoate /Dimate, Malathion, Supracide, Imidan				■
CHLORINATED HYDROCARBON	endosulfan	Thiodan/Thionex			■	
PYRETHROIDS	bifenthrin, cyfluthrin, deltamethrin, esfenvalerate, fenpropathrin, lambda-cyhalothrin, permethrin	Brigade, Baythroid, Decis, Asana, Danitol, Warrior, Ambush/Pounce				■
	pyrethrum/pyrethrin	PyGanic			■	
INSECT GROWTH REGULATORS (IGRS)	methoxyfenozide, tebufenozide	Intrepid, Confirm	■			
	buprofezin, pyriproxyfen	Applaud/Centaur, Esteem		■		
	novaluron	Rimon				■
DIAMIDES	chlorantraniliprole, flubendiamide	Altacor, Belt	■			
MACROCYCLIC LACTONES	abamectin/avermectin, emamectin benzoate, spinetoram, spinosad	Agri-Mek, Proclaim, Delegate, Entrust/Success				■
MITICIDES	acequinocyl, clofentezine, etoxazole, fenpyroximate, fenbutatin-oxide, hexythiazox	Kanemite, Apollo, Zeal/Secure, Fujimite/Portal, Vendex, Onager/Savey	■			
	spirodiclofen	Envidor		■		
	bifenazate	Acramite			■	
	pyridaben	Nexter/Pyramite				■
OTHER INSECTICIDES	formetanateHCl	Carzol				■
	azadirachtin, horticultural mineral oils, indoxacarb, spirotetramat	Aza-Direct/Neemix, Stylet Oil, Avaunt, Movento			■	
	flonicamid, kaolin clay, potassium salts of fatty acids/soap	Beleaf, Surround, M-Pede		■		
	Bacillus thuringiensis, *Cydia pomonella* granulosis virus	Bt/Dipel, Carpovirusine/Cyd-X	■			
FUNGICIDES	captan, mancozeb	Captan, Dithane/Manzate/Penncozeb		■		
	sterol inhibitors, strobilurins	Indar/Nova/Rally/Rubigan, Flint/Sovran	■			
	lime sulfur*, sulfur*			■		
PLANT GROWTH REGULATORS	ethephon, NAA/1-Naphthaleneacetic acid	Ethrel	■			

**Repellent for more than one day.*

Wild Pollinators of Eastern NY: http://www.danforthlab.entomology.cornell.edu/files/all/pollinators_guide_web.pdf

Insecticide Toxicity to Pollinators

Active ingredient	Trade name(s)	Chemical group	Mode of action*	LD_{50} (µg/ bee)	Risk ranking	Reference
acequinocyl	Kanemite	Electron transport inhibitor	20B	100	Very low	1
acetamiprid	Assail	Neonicotinoid	4A	8.1	Moderate	1
avermectin/abamectin	Agri-Mek, Avid	Avermectin	6	0.002	High	5
azadirachtin	Aza-Direct, Neemix	Unknown	UN	2.5	Moderate	1
Bacillus thuringiensis var. kurstaki	Dipel, Biobit, Javelin, Deliver	Biological	11A	NA	Very low	1
bifenazate	Acramite	Unknown	UN	7.8	Moderate	1
bifenthrin	Brigade, Capture	Pyrethroid	3A	0.0146	High	1
buprofezin	Centaur, Applaud, Courier	Chitin biosynthesis inhibitor	16	200	Very low	1
Burkholderia sp.	Venerate	Biological	UN	>100	Very low	3
carbaryl	Carbaryl, Sevin	Carbamate	1A	1.1	High	1

Minimizing Pesticide Risk to Bees in Fruit Crops; Extension Bulletin E3245
http://msue.anr.msu.edu/uploads/resources/pdfs/Minimizing_Pesticide_Risk_to_Bees_in_Fruit_Crops_%28E3245%29.pdf

Managing Pollinators & SWD in Small Fruit

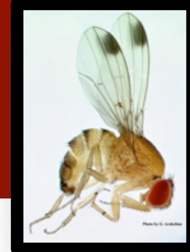
Reducing pesticide risk to bees

- Develop and implement a pollination contract with your beekeeper.

- Use integrated pest management (IPM) to reduce sprays.

- **Avoid insecticide and fungicide sprays during crop bloom.**

• **Captan** (Captan, Captec, Captevate)
• **Chlorothalinil** (Bravo)
• **Mancozeb** (Penncozeb, Dithane etc.)



Reducing pesticide risk to bees

- **Apply pesticides after sunset or before sunrise, or when air temperature is below 50°F.**
- Select the least toxic pesticides and formulations.
- **Reduce drift to areas outside orchards where bees forage.**
  - Use larger droplet size and use of air induction nozzles,
  - Reduce manifold air speed along the perimeter,
  - Reduce pump pressure that creates more fine droplets.

Managing Pollinators & SWD in Small Fruit

Reducing pesticide risk to bees

- **Remove flowering weeds from crops.**
  - Mow or use selective herbicides to control flowering weeds in the crop field before applications to reduce risk to bees.
  - Dandelions and broad leaf flowering plants (Mullin)

- **Establish bee-friendly habitat away from crops**
  - Planting wildflowers is the best way to support bee diversity and abundance

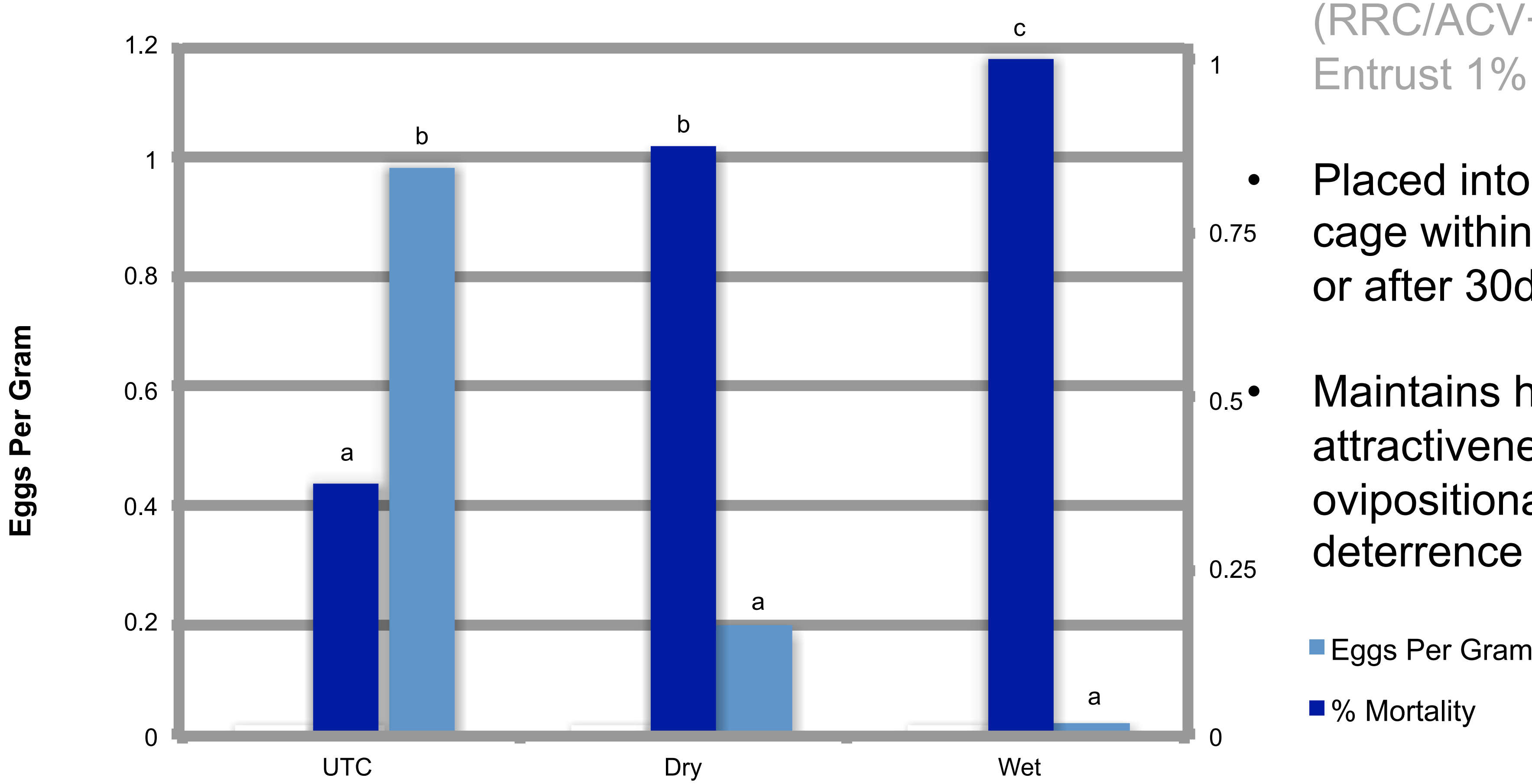
Attract and Kill for SWD in Small Fruit

- 3.5” substrate woven polypropylene netting
- Raspberry concentrate, cider vinegar, yeast, gelatin,

  Super Absorbent Polymer (SAP) liquid holding (60:1 V/V)
- 1% A.I. solution of insecticide active ingredient @ 2 mL/disk

- SWD Monitoring
- Weather Resistant & PYO

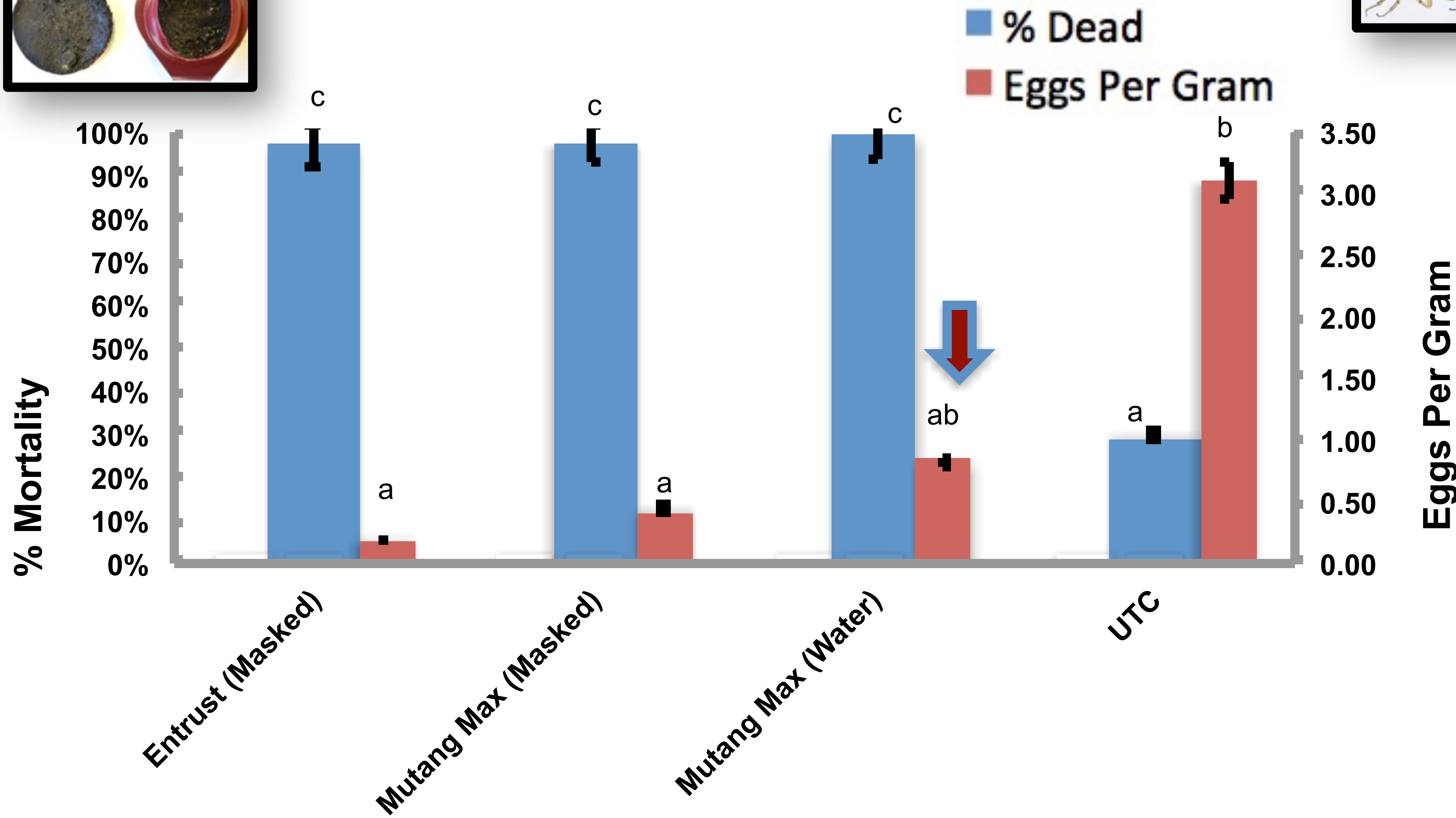
Attract and Kill for SWD in Small Fruit
ATK Screening Studies: Entrust



- ATK disc + solution (RRC/ACV+yeast); Entrust 1% AI
- Placed into SWD cage within 24h (wet) or after 30d (dry)
- Maintains high attractiveness and ovipositional deterrence

Attract and Kill for SWD in Small Fruit

ATK Screening Studies: Entrust

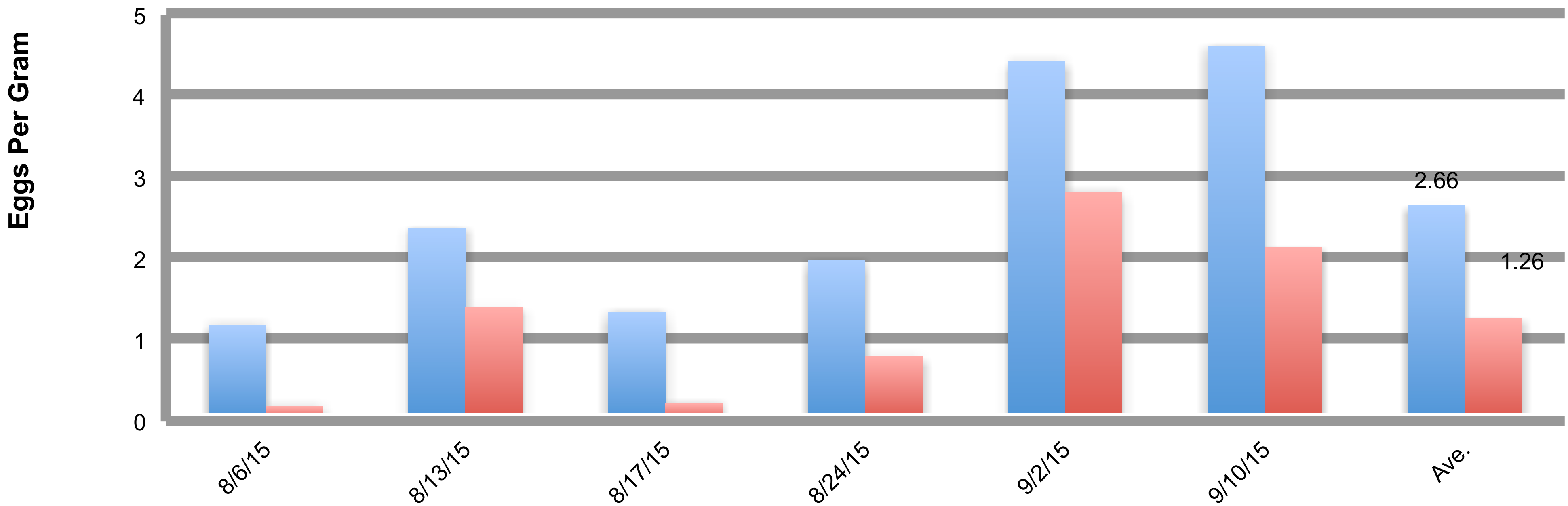


Attract and Kill for SWD in Small Fruit

Field Screening Studies: Entrust

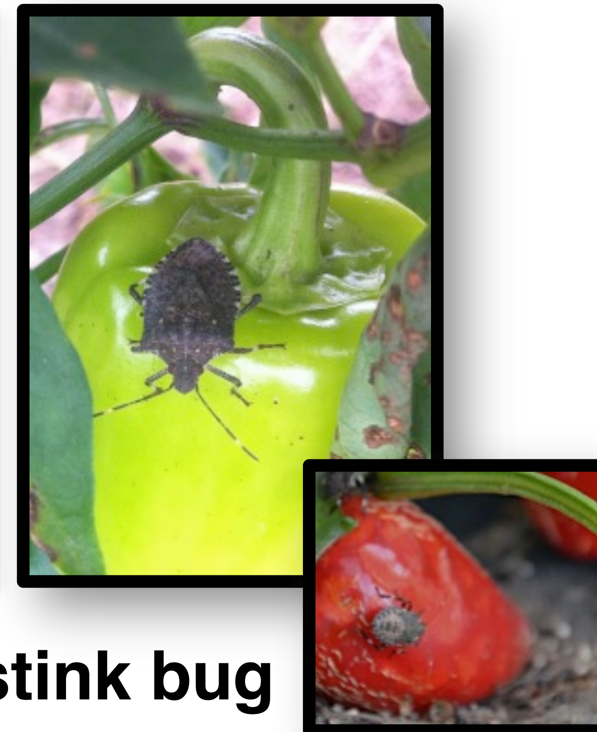
Raspberry, Milton, NY

ATK: Honeysuckle 6 July; Raspberry 28 July



ATK Placement: Early (SWD Adults)
52.6% reduction in eggs/gram fruit

Invasive Insects Vegetable Production

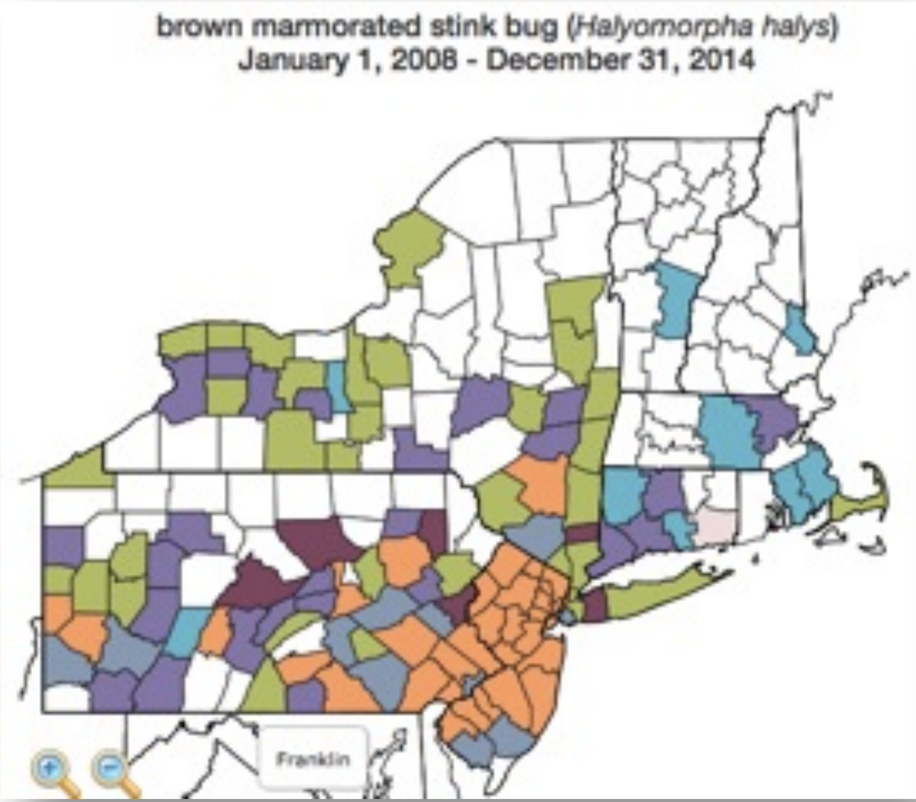


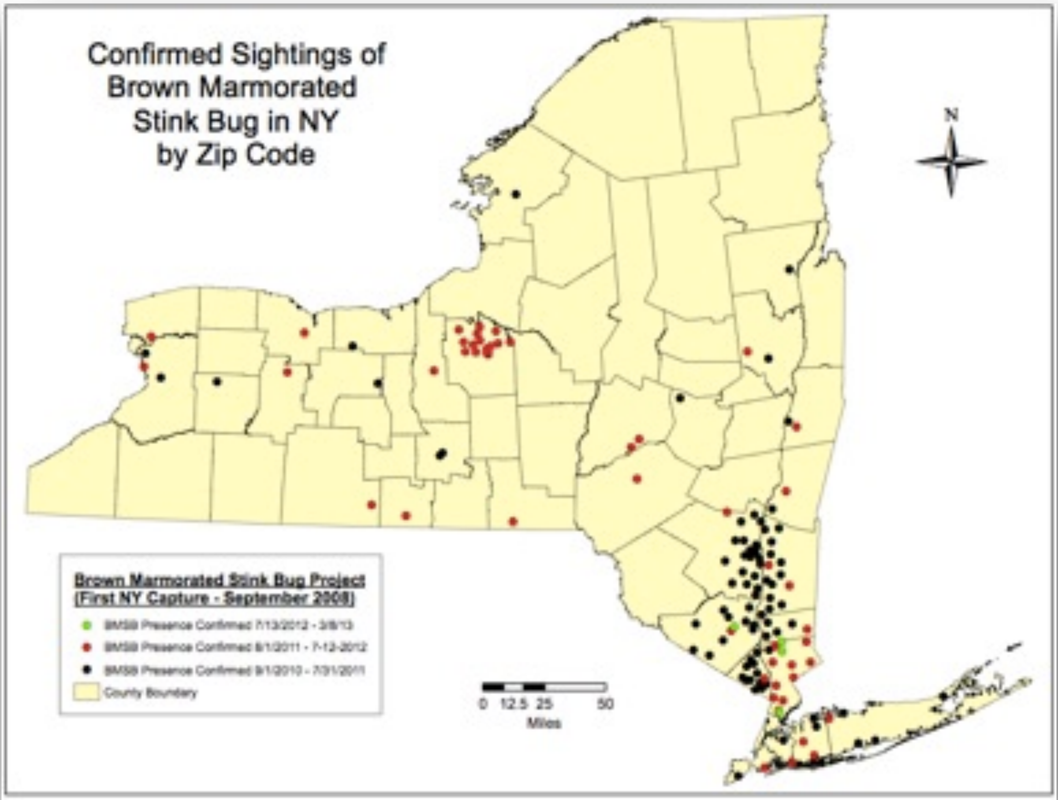
Brown marmorated stink bug

BMSB Injury to Organic Pepper Hudson Valley, NY

The species was first documented in NY in the Hudson Valley Region in 2008.

In 2012 the pest caused significant injury to pome fruit in three NY counties.





Golden Delicious Apple With BMSB Feeding Injury, Campbell Hall, NY October - 2012

5 bins: Range from 38 – 57% damage

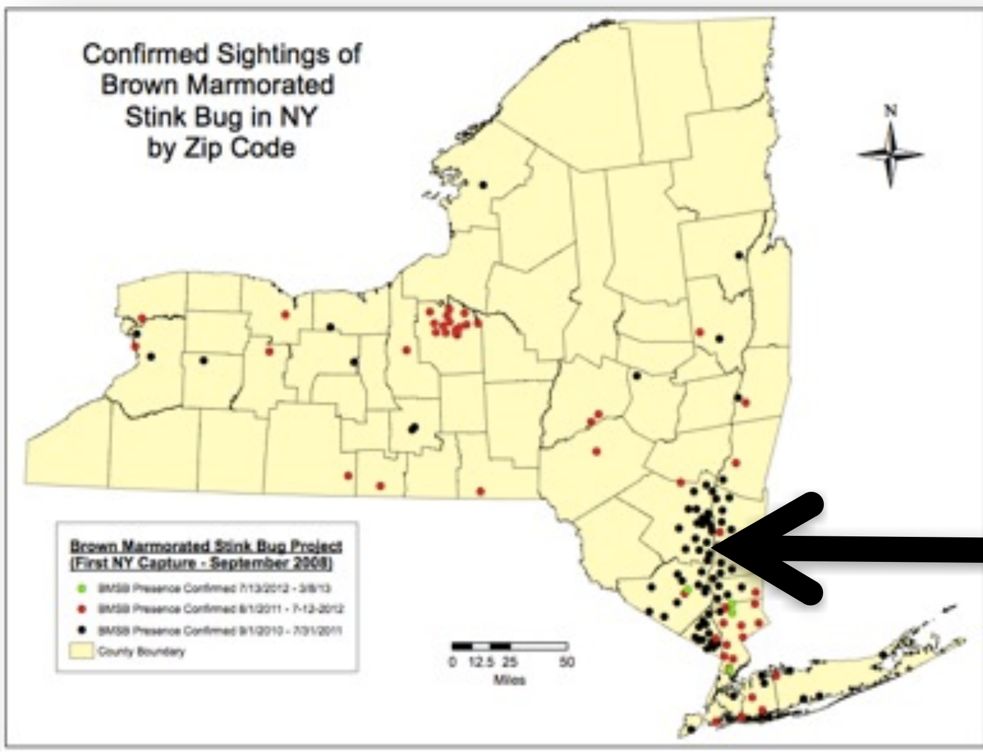
Pink Lady Apple With BMSB Feeding Injury, Campbell Hall, NY November - 2012

BMSB Feeding Injury Assessment, Hudson Valley Research Lab, NY 2012

BMSB Injury to Organic Pepper Hudson Valley, NY

- On August 12th, 15% injury was observed in a 1-acre organic planting of Jalapeno Pepper

- Nymph population averaged 4 per plant.



Marlboro, NY.


BMSB in Jalapeno Pepper
15% feeding injury

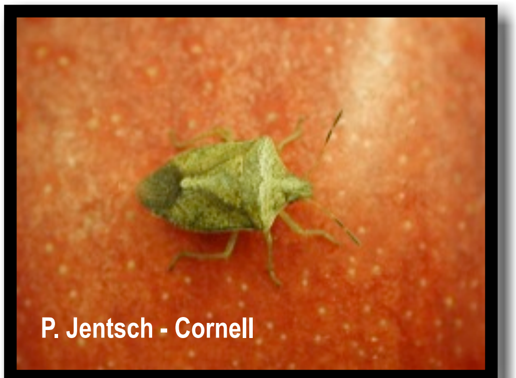
Hudson Valley Stink Bug Complex
species of economic importance

Brown Stink Bug, *Euschistus servus* (Say)

Adult Stink bug damage

GT TC P Bloom PF 1C 2C 3C 4C 5C 6C 7C 8C

21 March 21 April 27 April 1 May 14 May 28 May 10 June 25 June 5 July 15 July 1 Aug. 15 Aug. 1 Sept.



Green Stink Bug, *Acrosternum hilare* (Say).

Adult Stink bug damage

GT TC P Bloom PF 1C 2C 3C 4C 5C 6C 7C 8C

21 March 21 April 27 April 1 May 14 May 28 May 10 June 25 June 5 July 15 July 1 Aug. 15 Aug. 1 Sept.

Brown marmorated stink bug, *Halyomorpha halys* (Stål)

Adult SB Presence | Adult & Nymph Stink bug damage

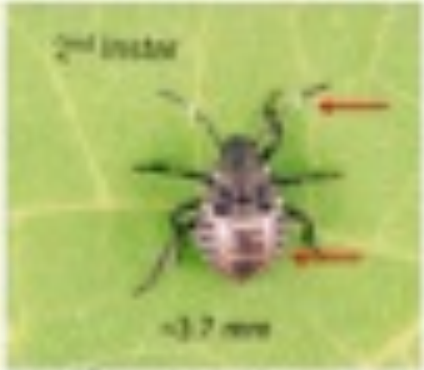
GT TC P Bloom PF 1C 2C 3C 4C 5C 6C 7C 8C

21 March 21 April 27 April 1 May 14 May 28 May 10 June 25 June 5 July 15 July 1 Aug. 15 Aug. 1 Sept.

BMSB: Insect Biology

Eggs: Average 28/cluster; light green to white

1st instar: black & red; cluster near eggs



2nd instar: striped antennae

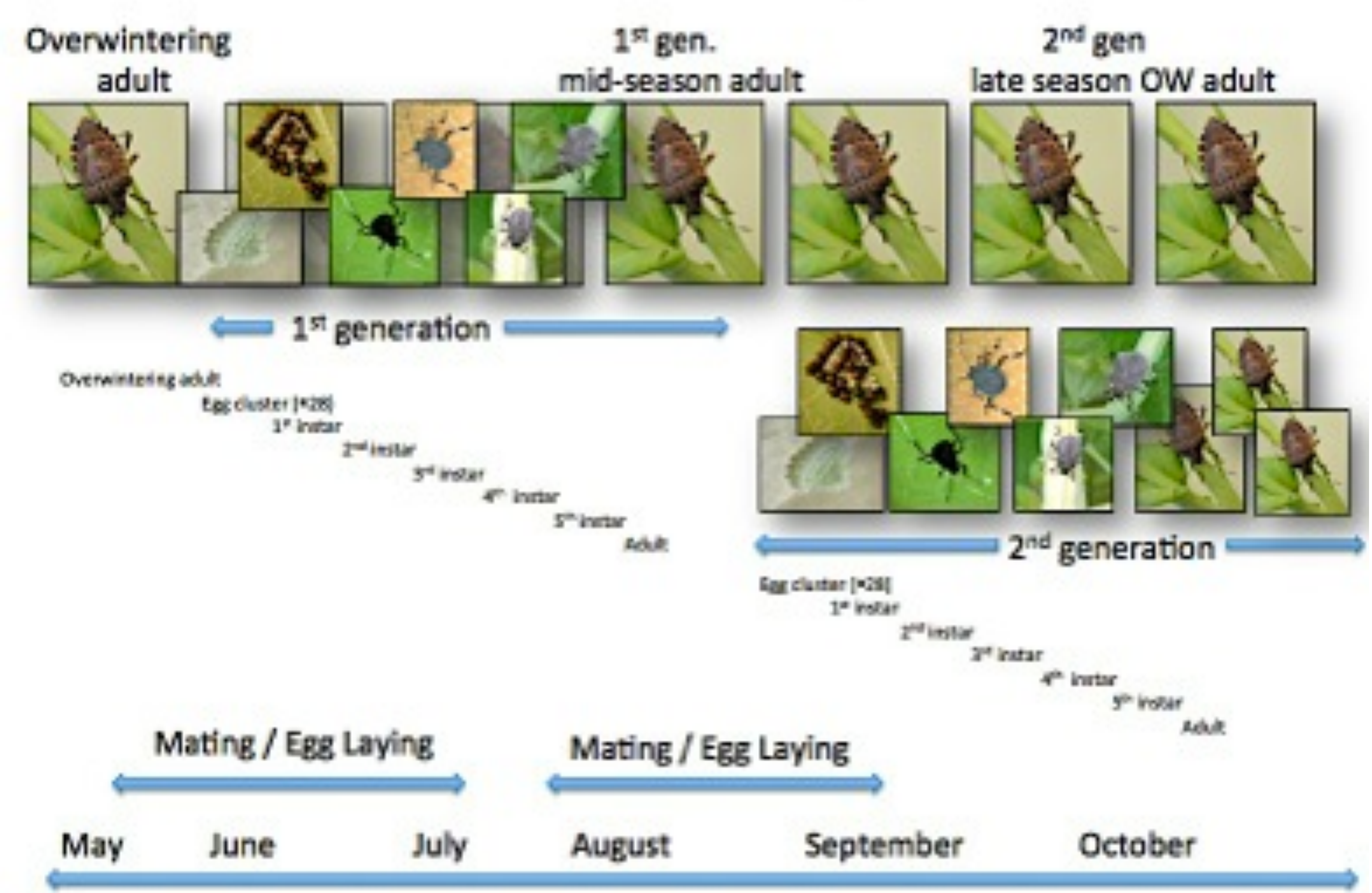
3rd instar: striped antennae and legs

4th instar: thoratic spur striped antennae & legs

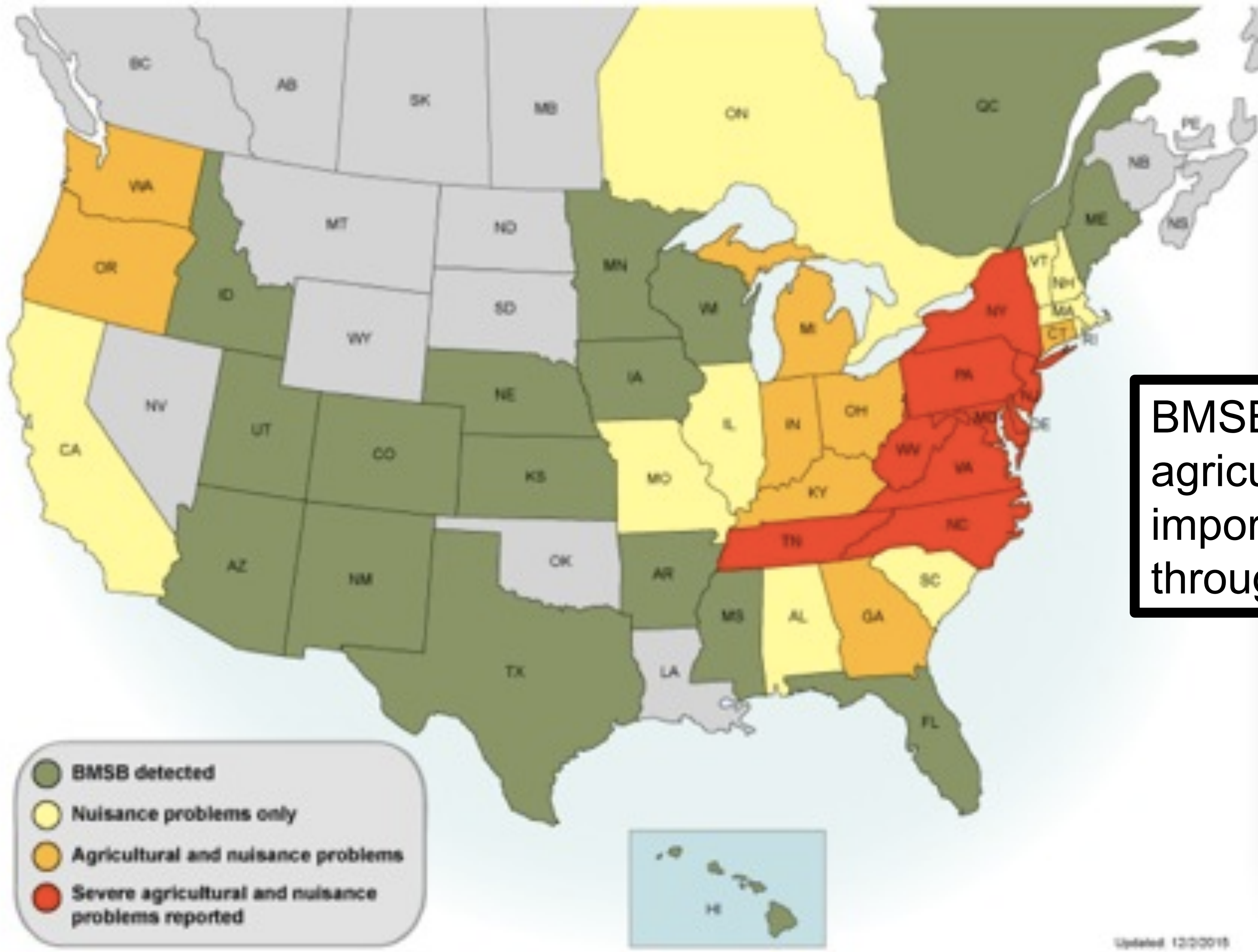
5th instar: wing pads striped antennae & legs

BMSB Adults: red eyes, 4 cream colored dots on shoulders; banding on legs and antenna, smooth blunt shoulders. Banded abdomen; 14 -17 mm in length.

BMSB Biology: 2 Generations in the HV in 2012

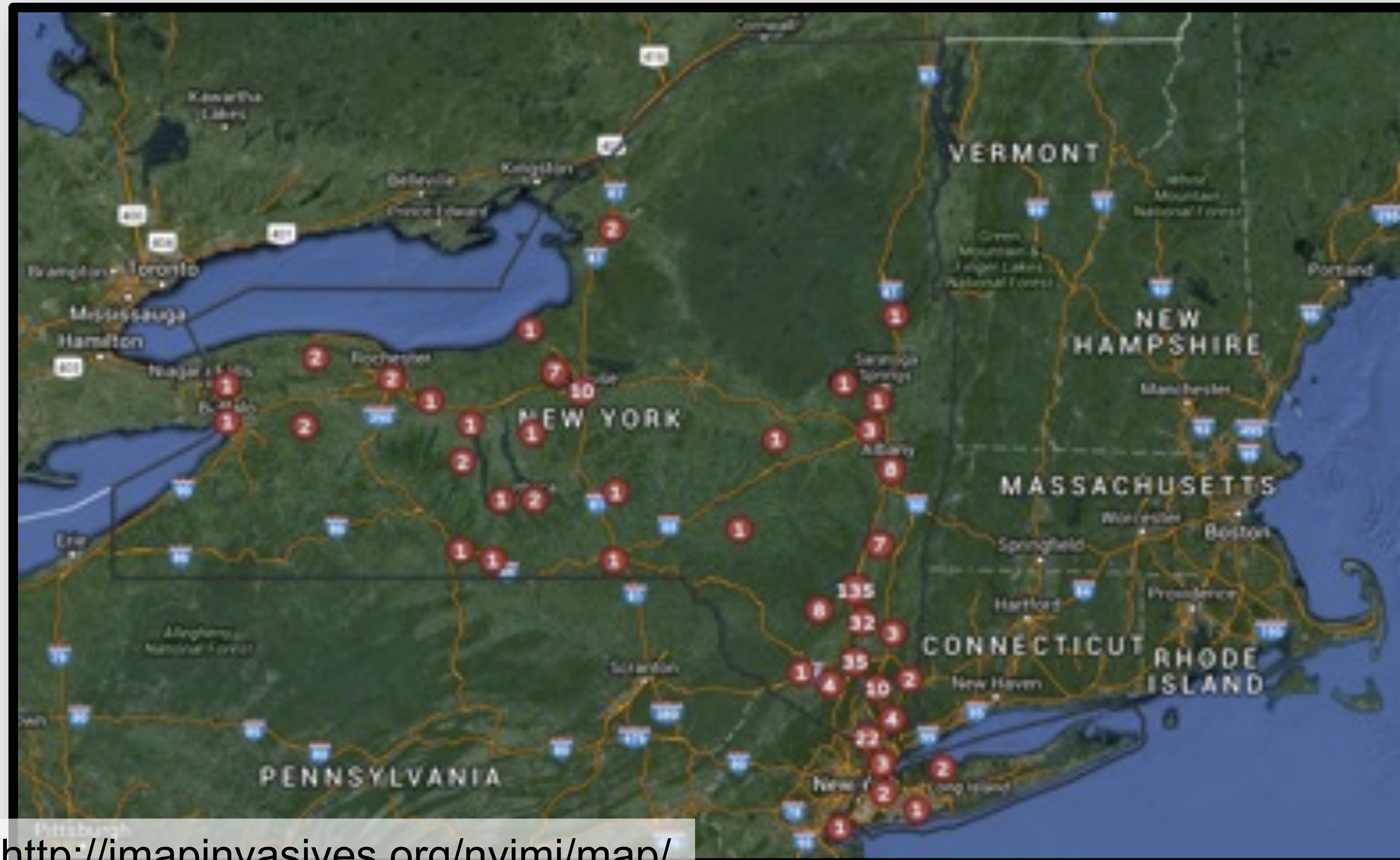


BMSB Establishment in the US



BMSB increasing in agricultural importance throughout the US

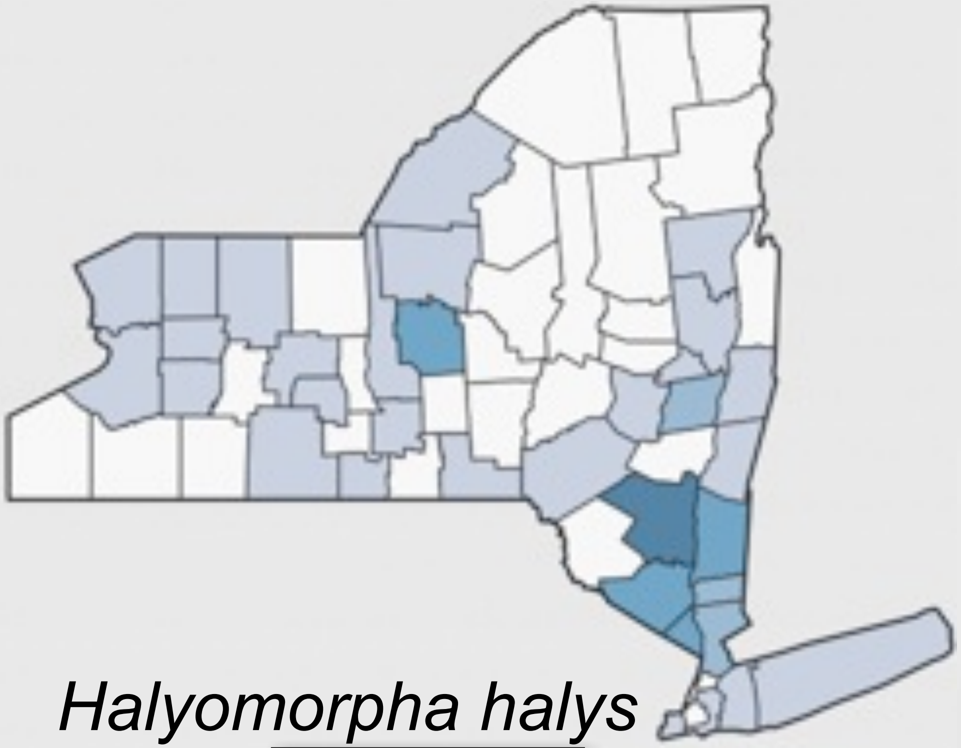
New York Invasive Species Public Map
BMSB Distribution in NYS



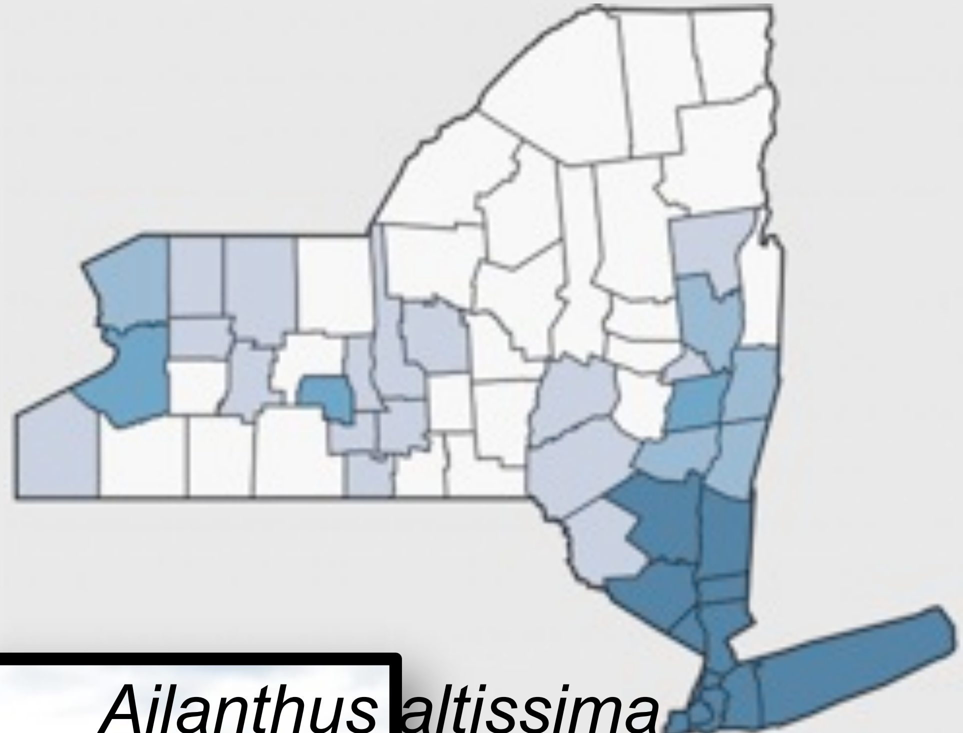
http://imapinvasives.org/nyimi/map/

New York Invasive Species Public Map
BMSB Distribution in NYS

New York Invasive Species Public Map
BMSB Distribution in NYS

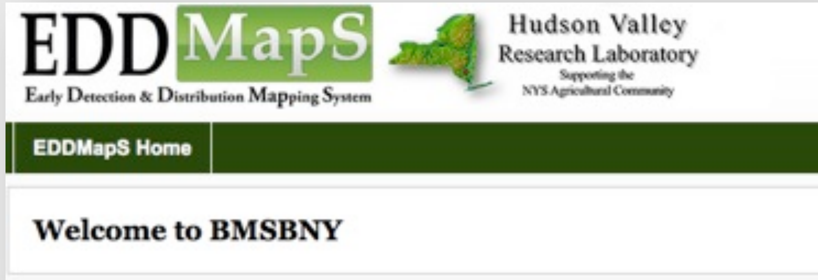


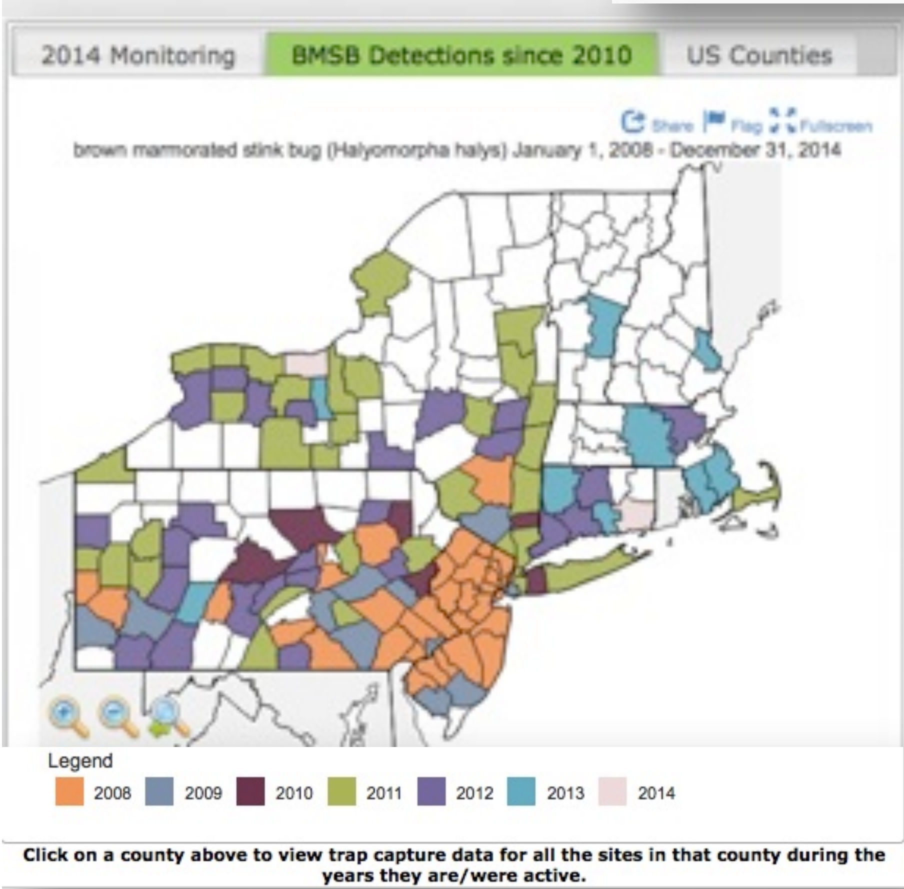
Halyomorpha halys

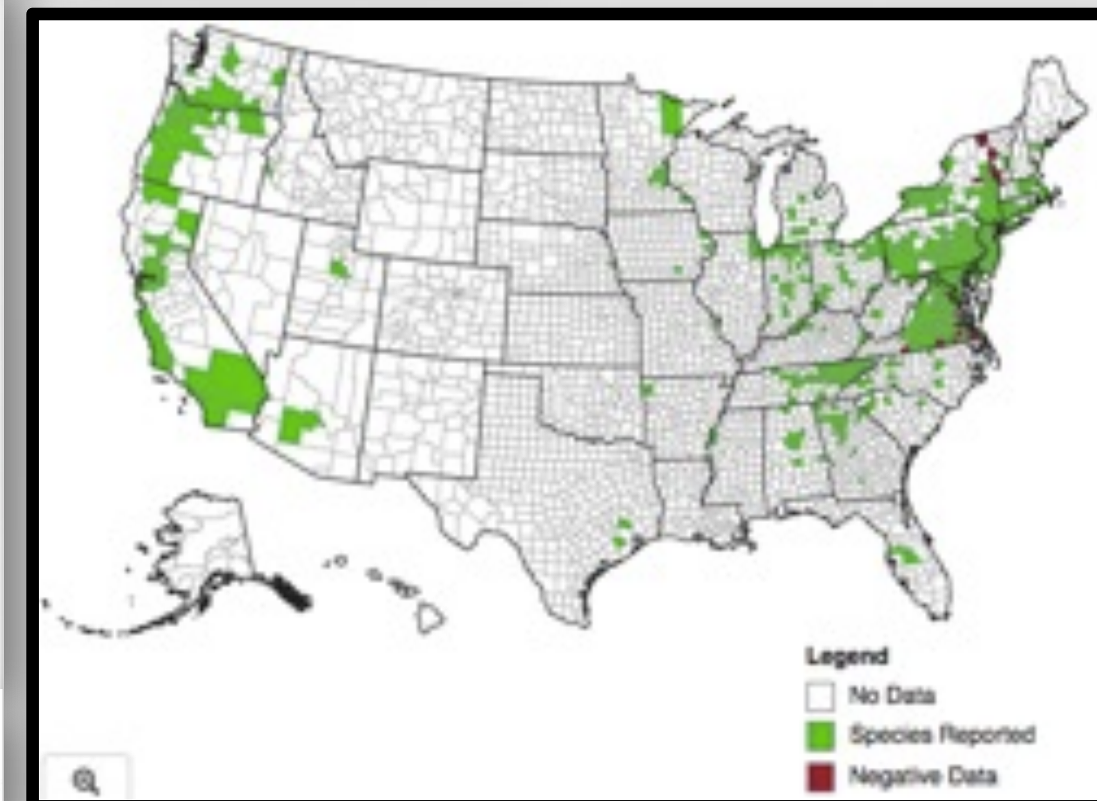


Ailanthus altissima

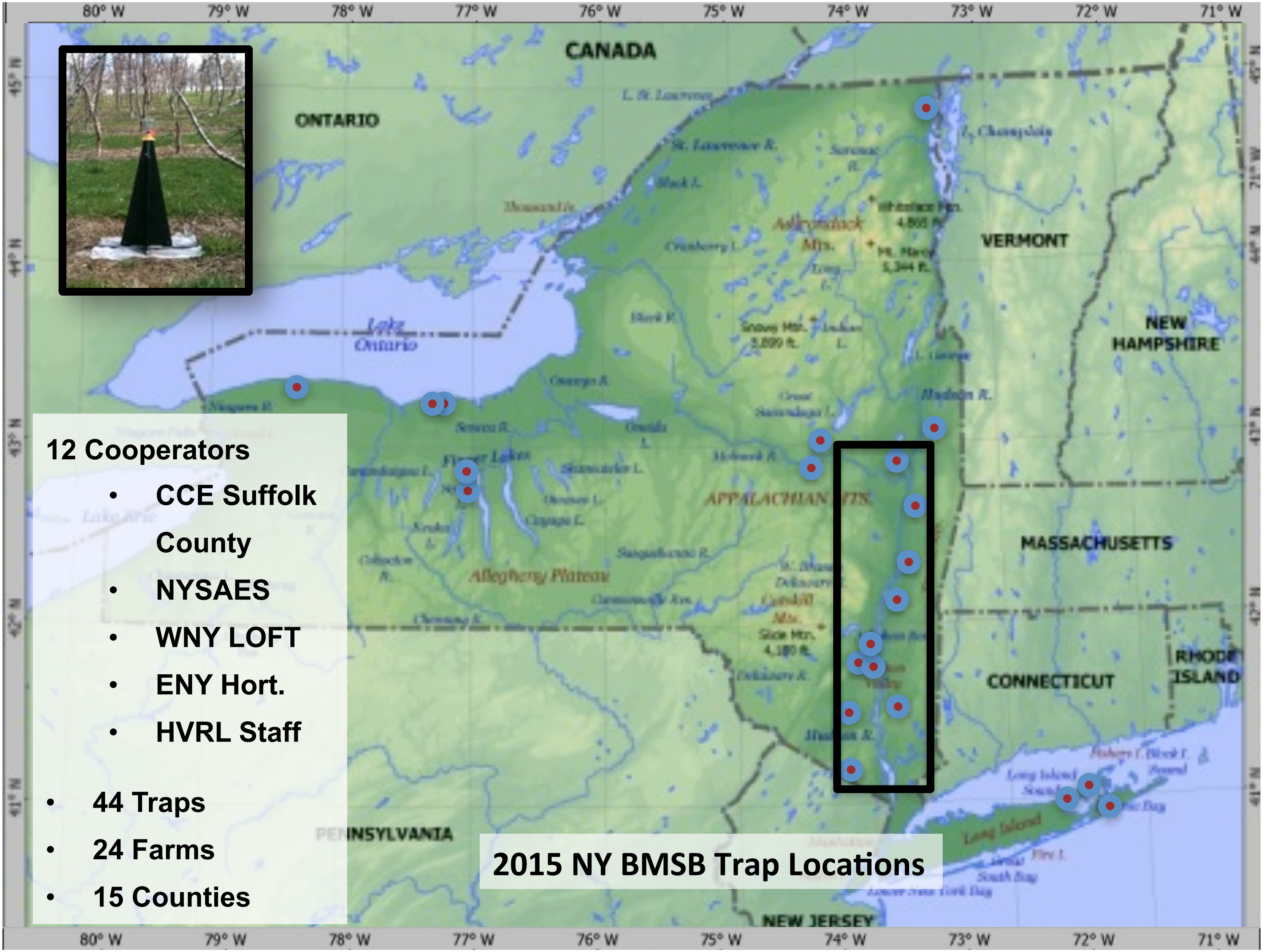
EDDMaps.org/bmsbny/
BMSB Distribution in NYS Tree Fruit Orchards







2015 NY BMSB Trap Locations

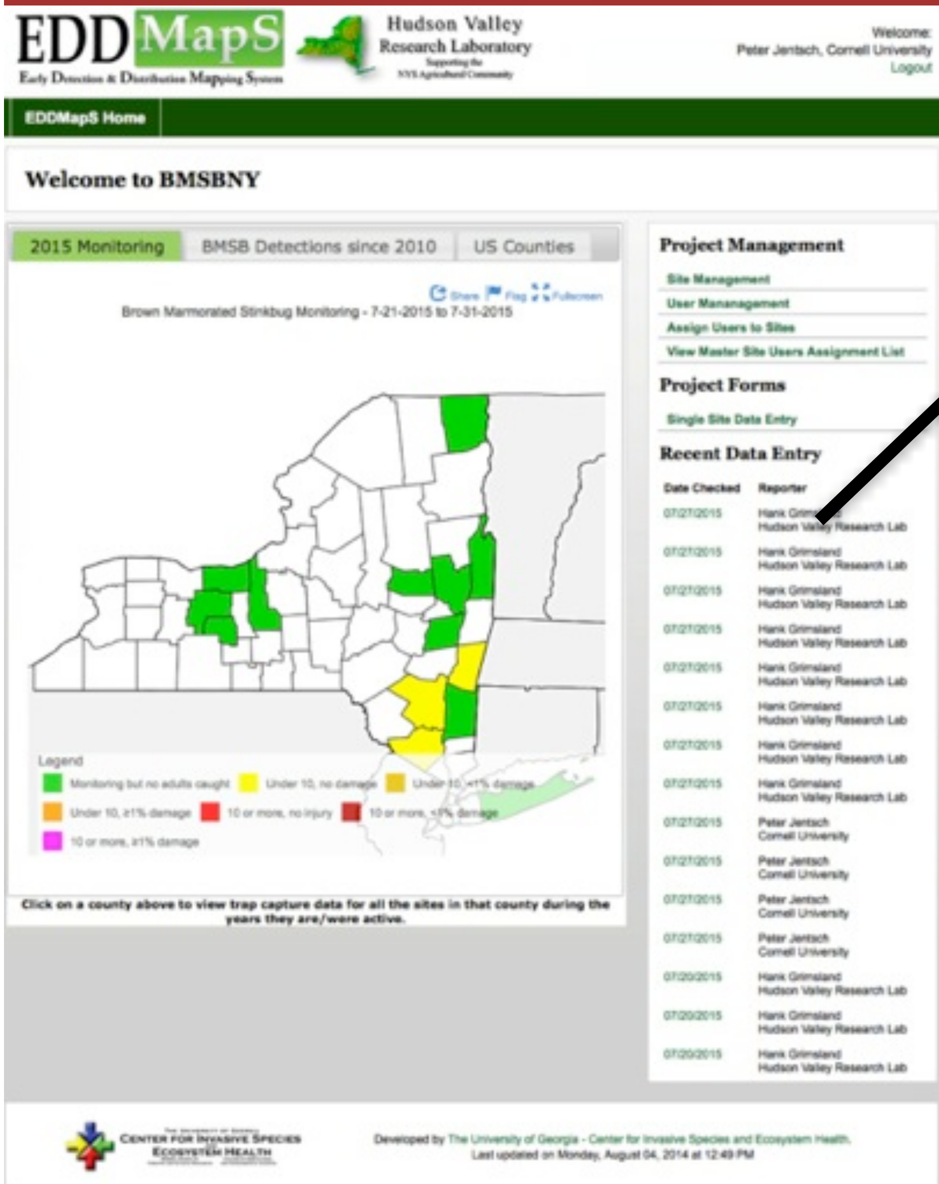


12 Cooperators

- CCE Suffolk County
- NYSAES
- WNY LOFT
- ENY Hort.
- HVRL Staff

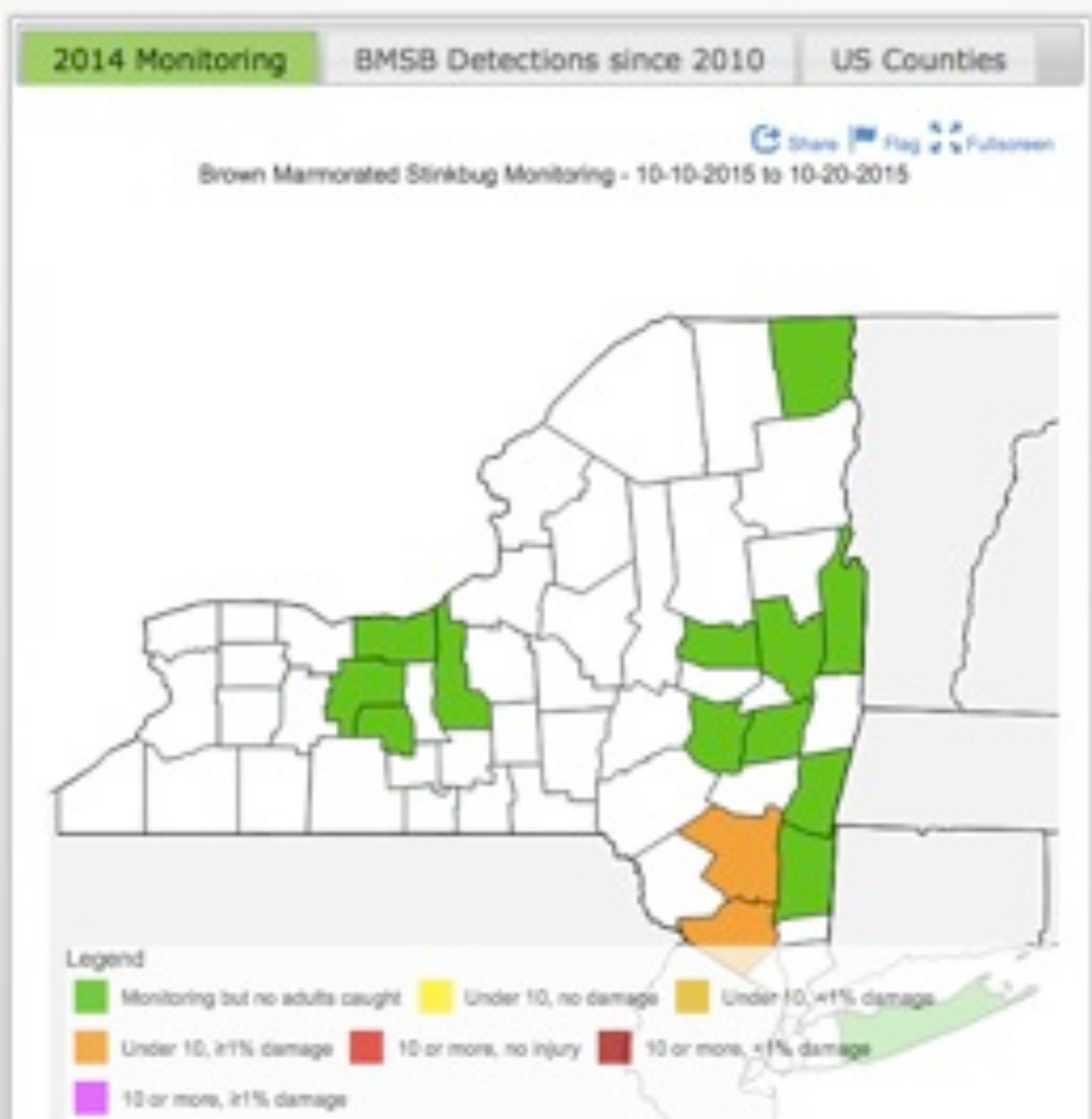
- 44 Traps
- 24 Farms
- 15 Counties

EDDMaps.org/bmsbny/
BMSB Distribution in NYS Tree Fruit Orchards

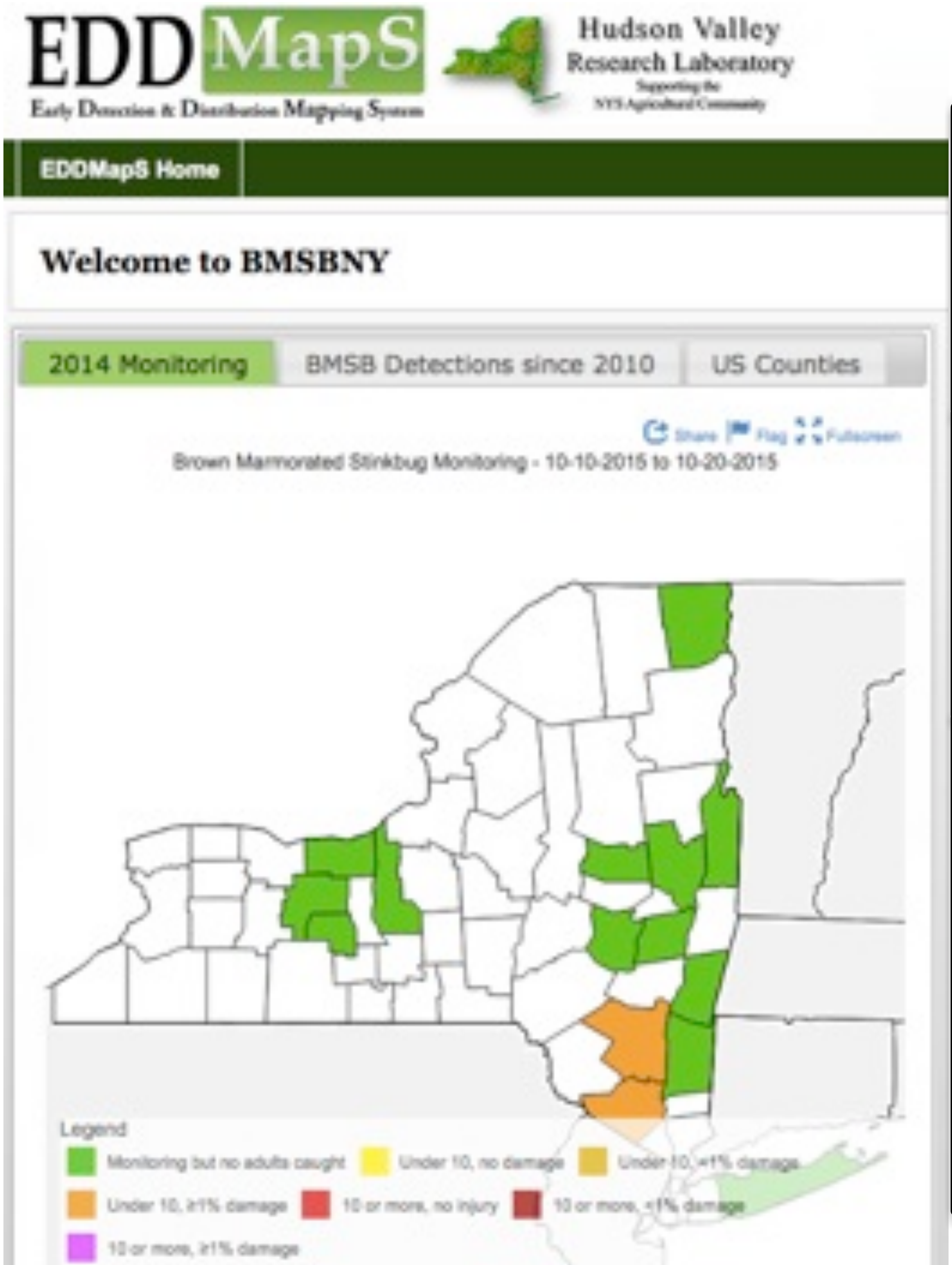


- Presence / absence data
  - Individual site access

EDDMaps.org/bmsbny/
BMSB Distribution in NYS Tree Fruit Orchards



- Presence / absence
- Population Threshold
  + Damage Levels
  by county



15 NYS counties / 44 Sites

- Absence (Green)
Monitoring but no adults caught

- Presence (Yellow)
Under 10, no damage

- Presence + Damage Levels
Under 10, <1% damage

- Presence + Damage Levels
Under 10, ≥1% damage

- BMSB Threshold + Damage Levels
10 or more, no injury

- BMSB Threshold + Damage Levels
10 or more, <1% damage

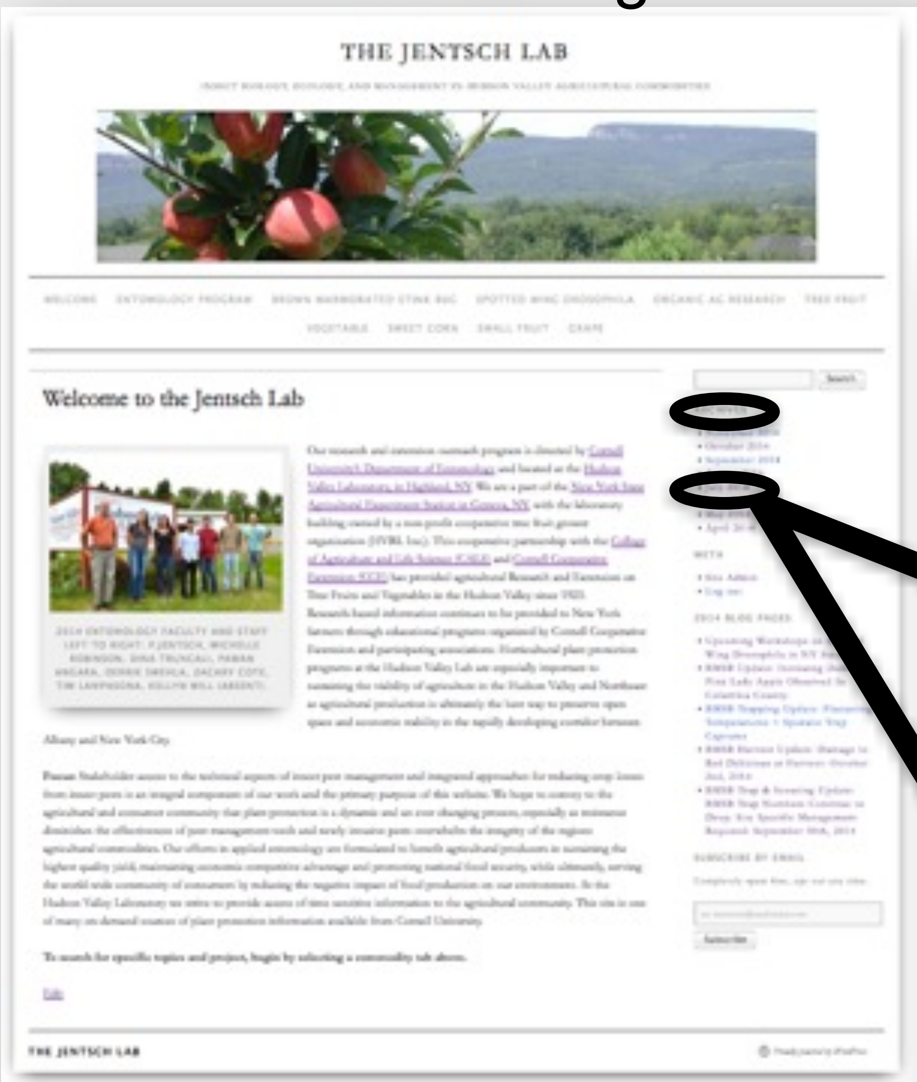
- BMSB Threshold + Damage Levels
10 or more, ≥1% damage

BMSB Management Threshold: Communication

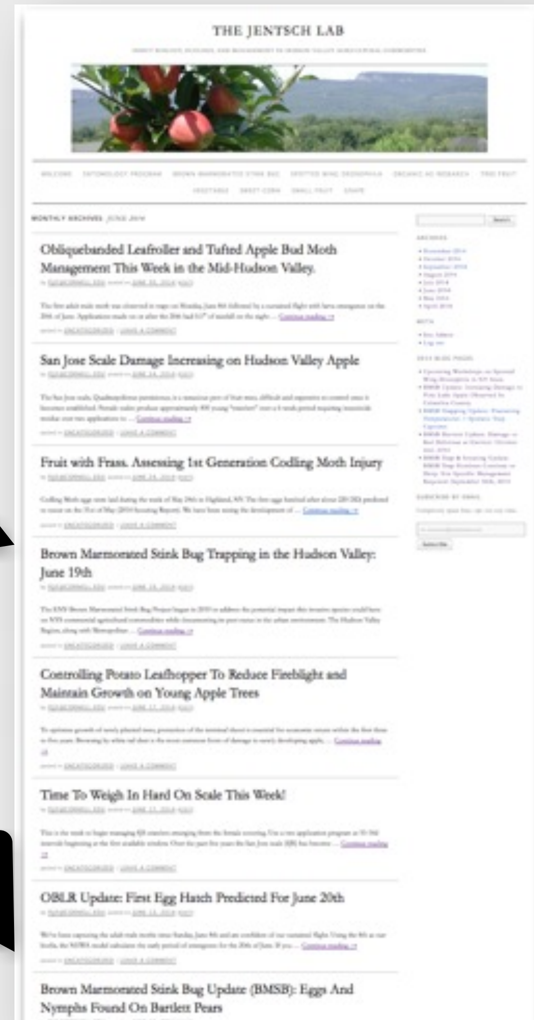
- **2015: Employed a 10 Adult / Trap Threshold**
- **Disseminate recommendations using ENY CCE Hort News; Scaffolds Newsletter; HVRL Lab Blog Site**
- **Growers suscribe to receive email Internet based link for BMSB mgt. recommendations as BMSB traps and damage levels are assessed**
- **Hudson Valley Research Lab: Blog site**
- **https://blogs.cornell.edu/jentsch/**

BMSB Management Threshold: Communication

Email link to BlogSite



Insect Alerts & Recommendations

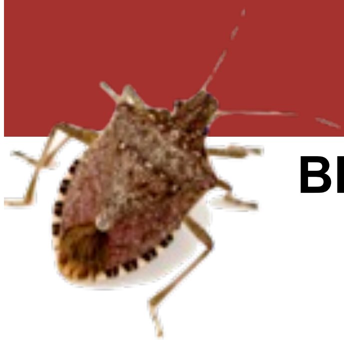


Management Options

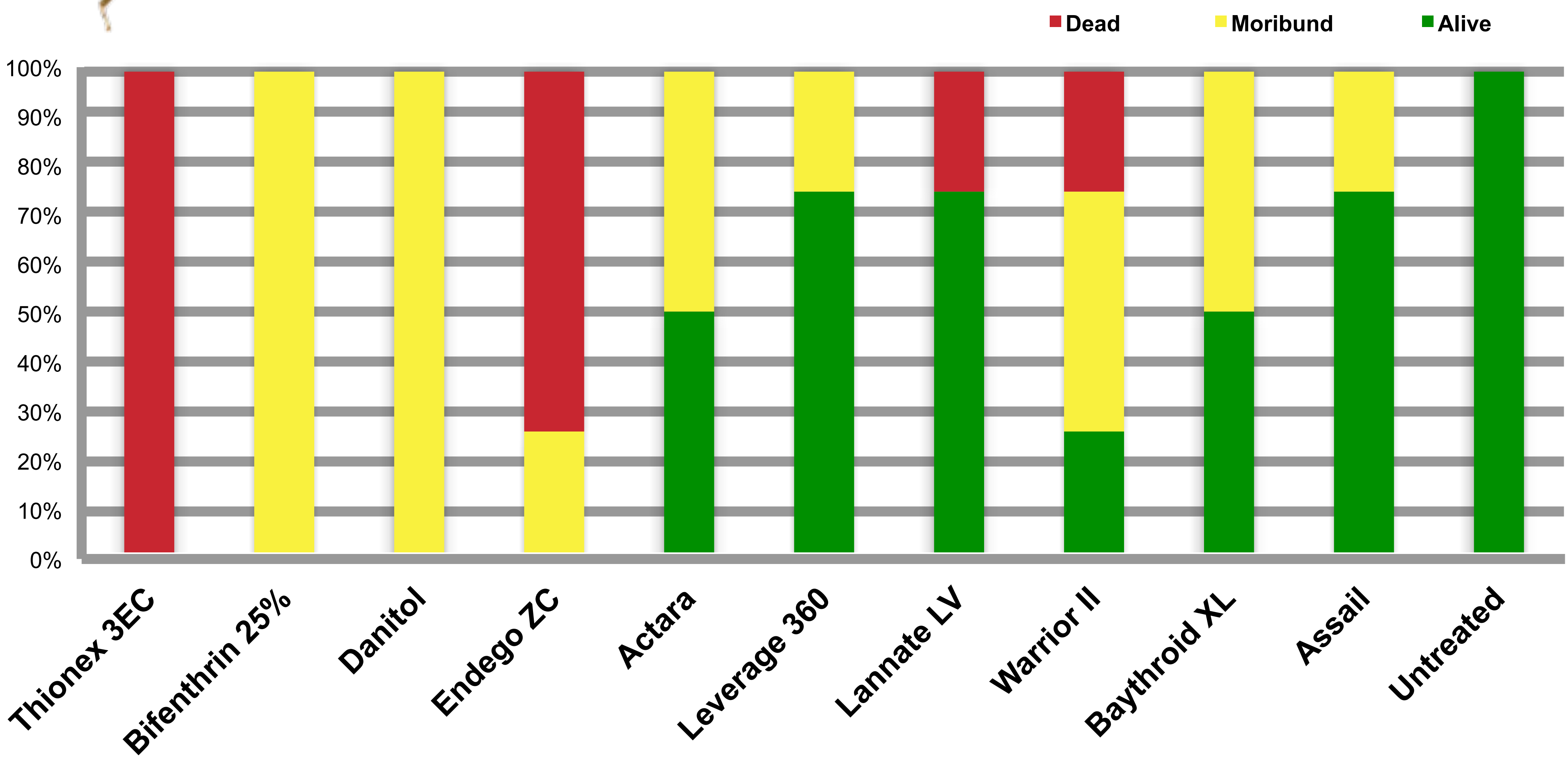
Insecticide Group	Product	Active Ingredient	% Adult BMSB Mortality[1]
Pyrethroid	Bifenture	bifenthrin	100
	Danitol	fenpropathrin	95
	Warrior II	lambda-cyhalothrin	73
Carbmate	Lannate	methomyl	92
	Vydate	oxymyl	68
Neonicotinoid	Actara	thiamethoxam	92
	Assail	acetamiprid	87
	Calypso	thiacloprid	58
Pre-mix	Leverage 360	imidacloprid and bifenthrin	95
	Endigo	lambda-cyhalothrin and thiamethoxam	98
	Voliam Flexi	chlorantraniliprole and thiamethoxam	98

1. Direct contact activity of insecticides against BMSB adults in a lab setting may be very high, yet the activity of field-aged residue may, over time, quickly becomes ineffective at preventing feeding injury.

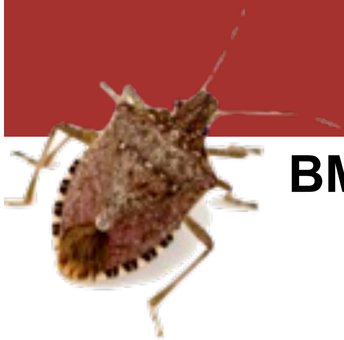
Management Options



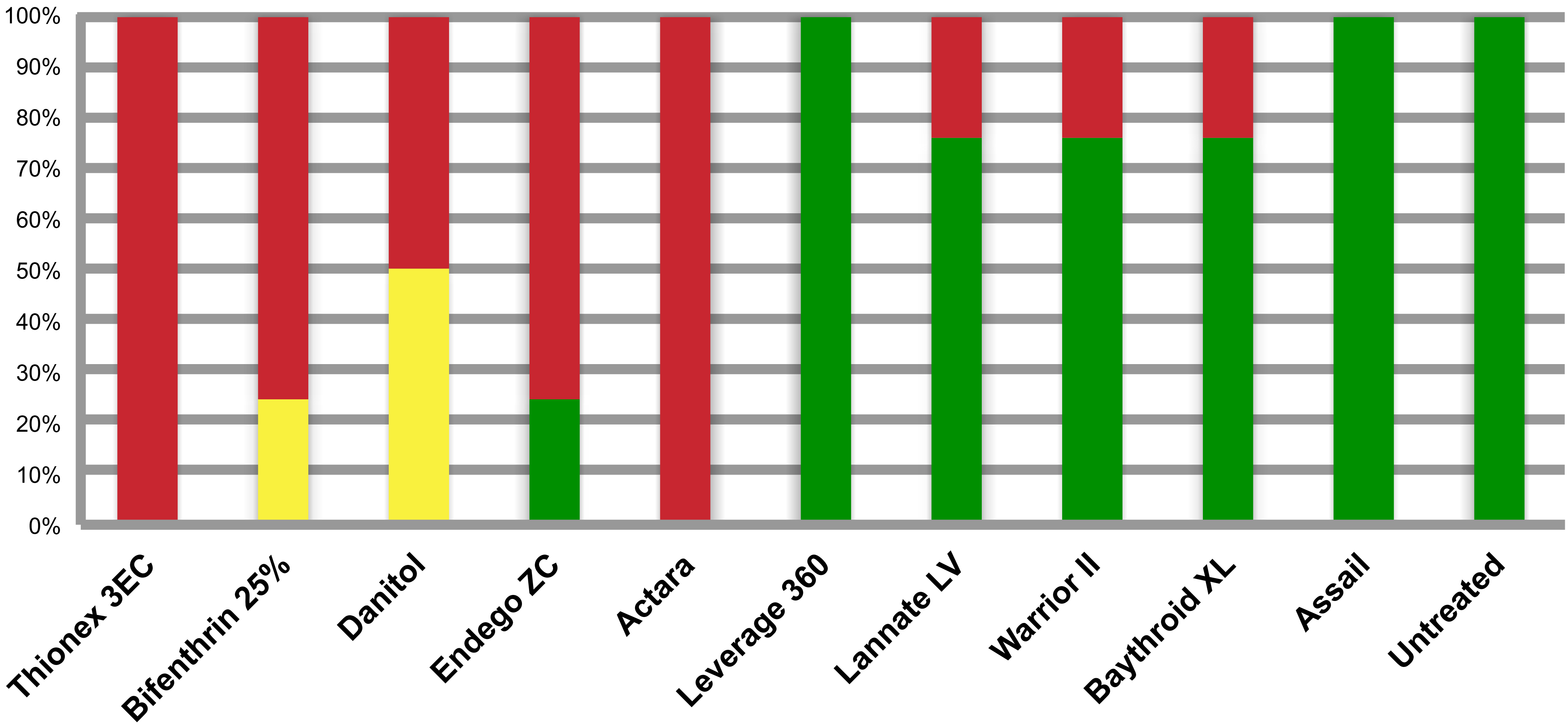
BMSB Adult Exposure to Insecticide Residue of Apple Foliage
24h Old Residue @ 1 d



Management Options



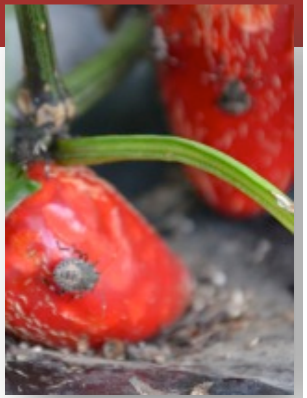
BMSB Adult Exposure to Insecticide Residue of Apple Foliage
24h Old Residue @ 3 d



Pollinator Conservation Study:
BMSB Management Using Attract & Kill

- Integrated pest management using 4 components employed to reduce BMSB field populations.
  - Netting - substrate to hold insecticide
  - Halogen lights - BMSB attractant
  - Pheromone blend - BMSB attractant
  - Biological control (*Beauveria bassiana*) on crop
  - Insecticide - treatment to net only

Pollinator Conservation Study: BMSB Management Using Attract & Kill



- 3 applications of Mycotrol-O @ 16 oz./A
  14 August, 1 & 14 September.
  Applications on 1 & 14 Sept. timed post rain events.

- 2 nets attached to 8' posts were positioned along the north eastern edge of the field, 30m apart

- 2 pheromone lure sets (USDA # 10 + MDT) placed along top edge of 7' x 14' netting, used to attract BMSB away from agricultural commodity as trap and kill stations.


MDT
USDA #10

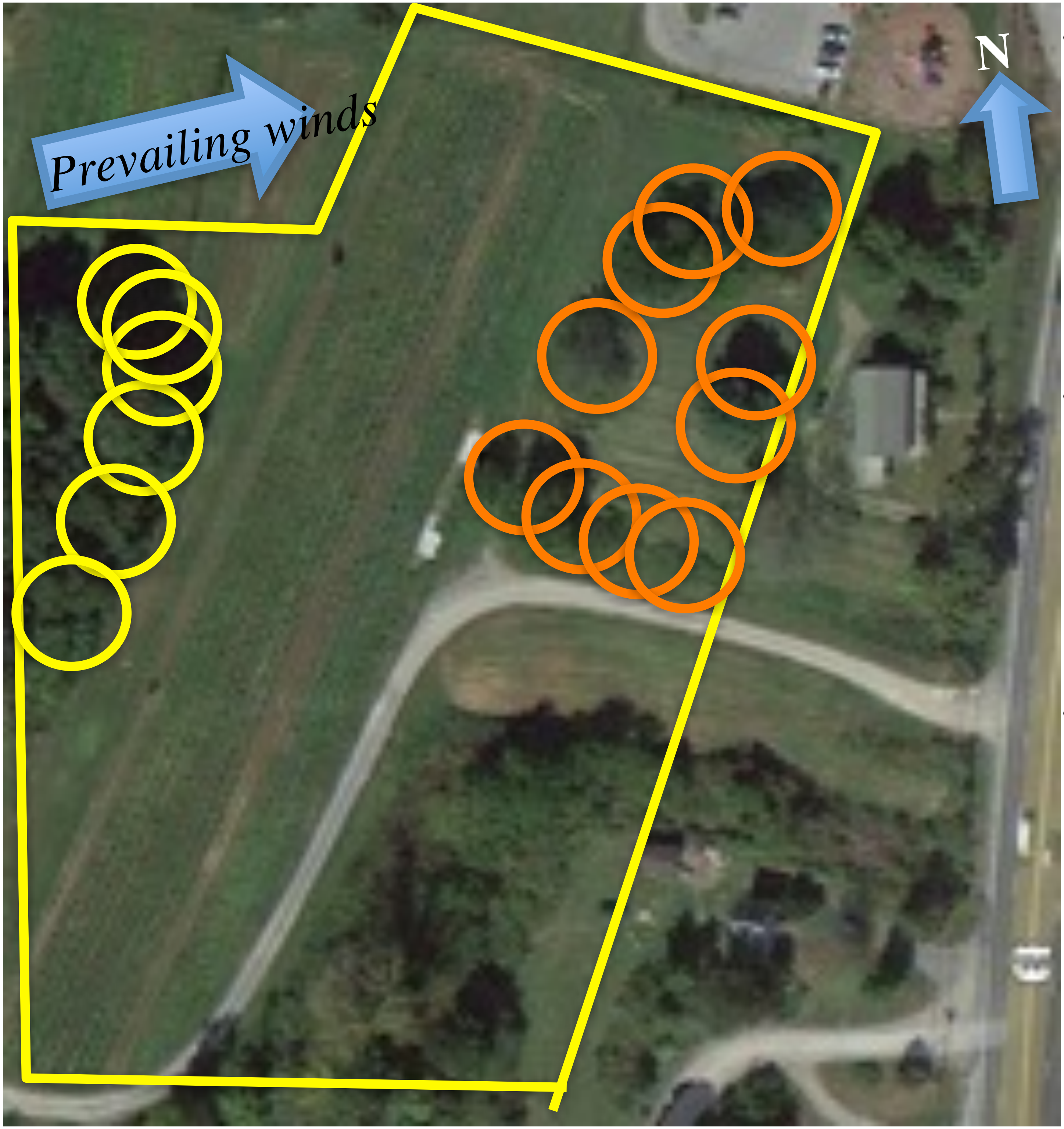
Proceedure:

- Nets were of Blockade™ Insect Screen 36 x 25 mils PAK Unlimited, INC.
- Single trap was added a 500W light.
- On day 0 (7 September), each net were sprayed with 0.75 gal. of Bifenthrin 10DF solution using 3.0 oz./gal.
- On days 0-1, nets were monitored with no captures of BMSB observed.
- On day 2 (9 September), lures and 500w Halogen light were added.
- Sampling of netted traps were made through October.

Proceedures Con’t

- Generator + 500W Halogen light directed toward the field population of BMSB.
- Plastic sheets to define location and number of BMSB trap and kill data.
- Study was designed to:
  1. Determine the attractiveness of lights with net relative to net alone
  2. Determine the number of BMSB observed coming from field versus forest sides of trap

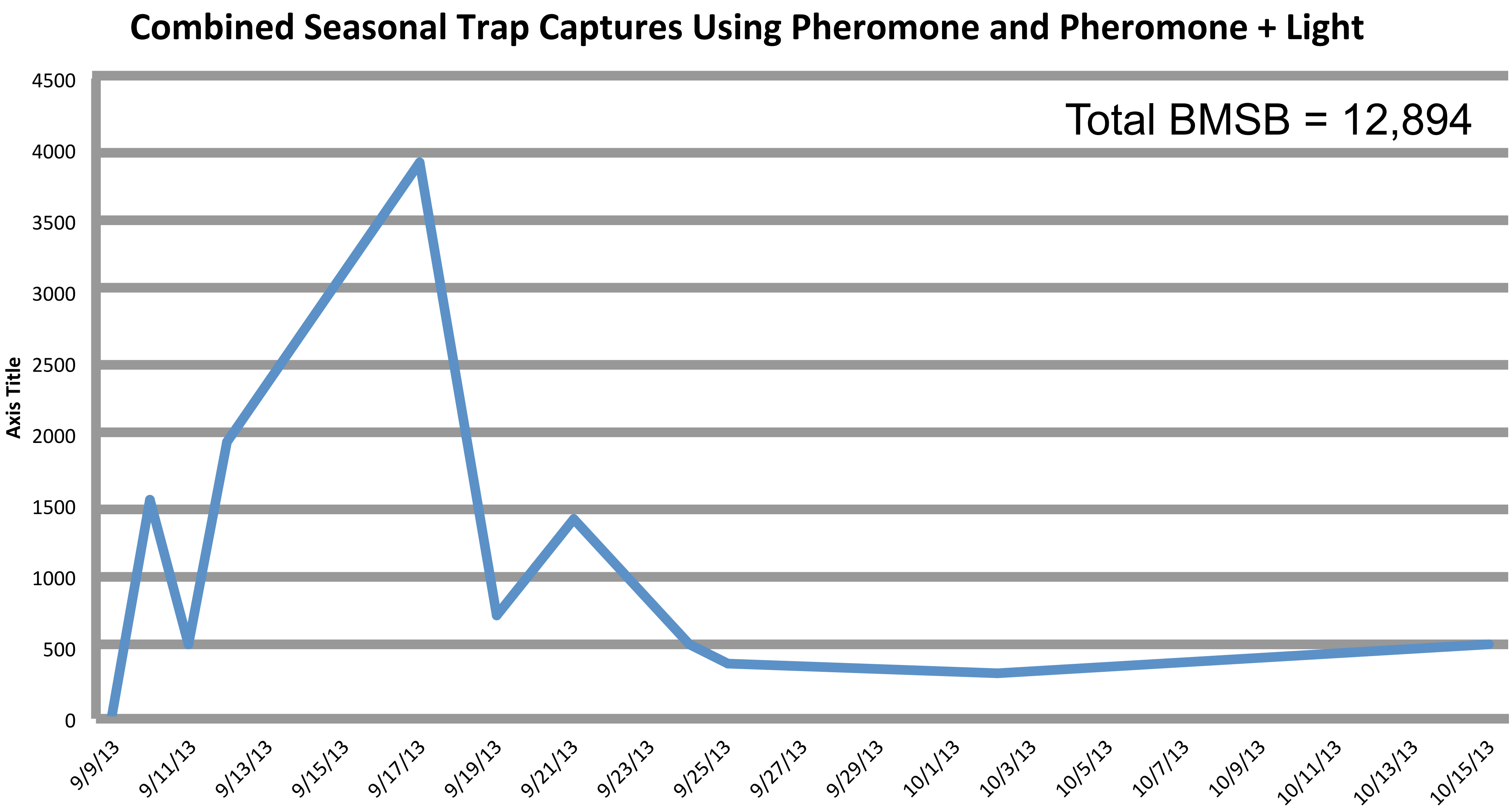
Hudson Valley Research Laboratory



- BMSB populations were observed on Black Walnut and Tree of Heaven, appearing to have acted as intermediate hosts, fostering migrations
- BMSB locations on netting traps with only pheromone were equally dispersed on the field and forested sides of net.
- Nights when lights were on, BMSB were heavily concentrated on the field side in front of the light with higher numbers observed.

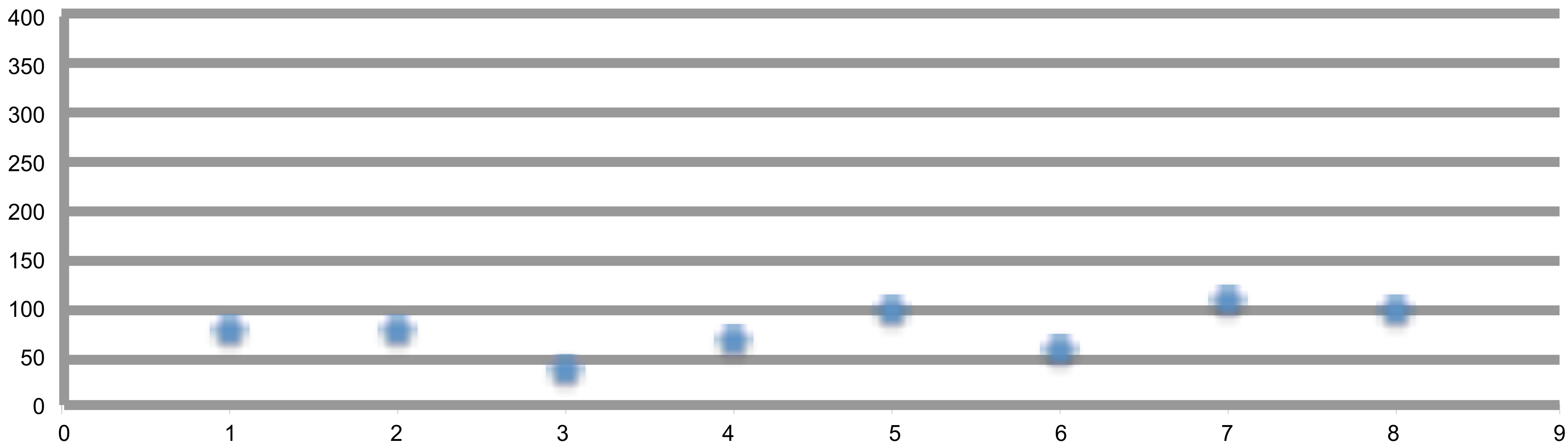
Ailanthus altissima (yellow circle)
Juglans nigra (orange circle)

Studies of the Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål), in New York State

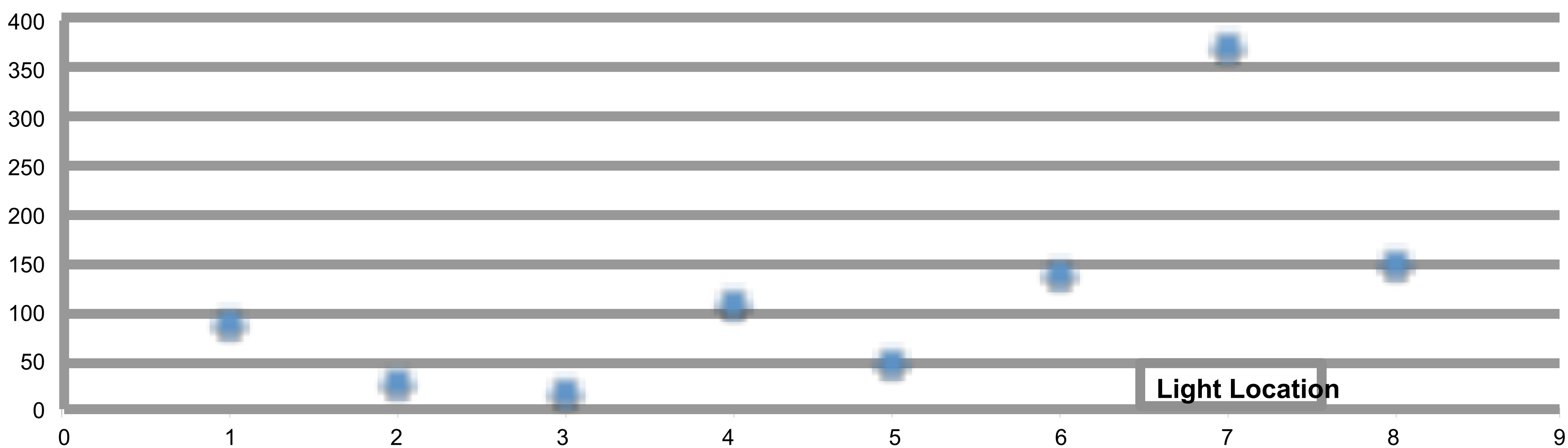


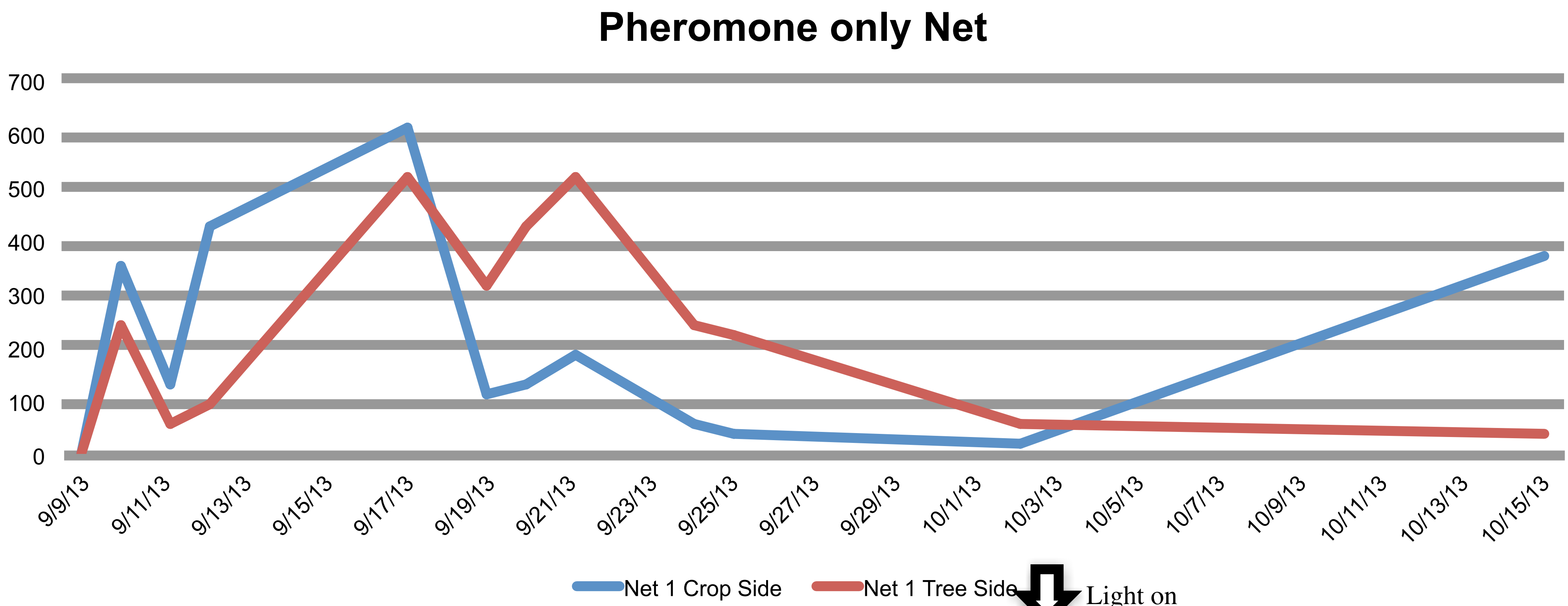
Adult BMSB Capture Locations Along the Base of Netting Of Two Trap Types on morning of 11 September, 2013

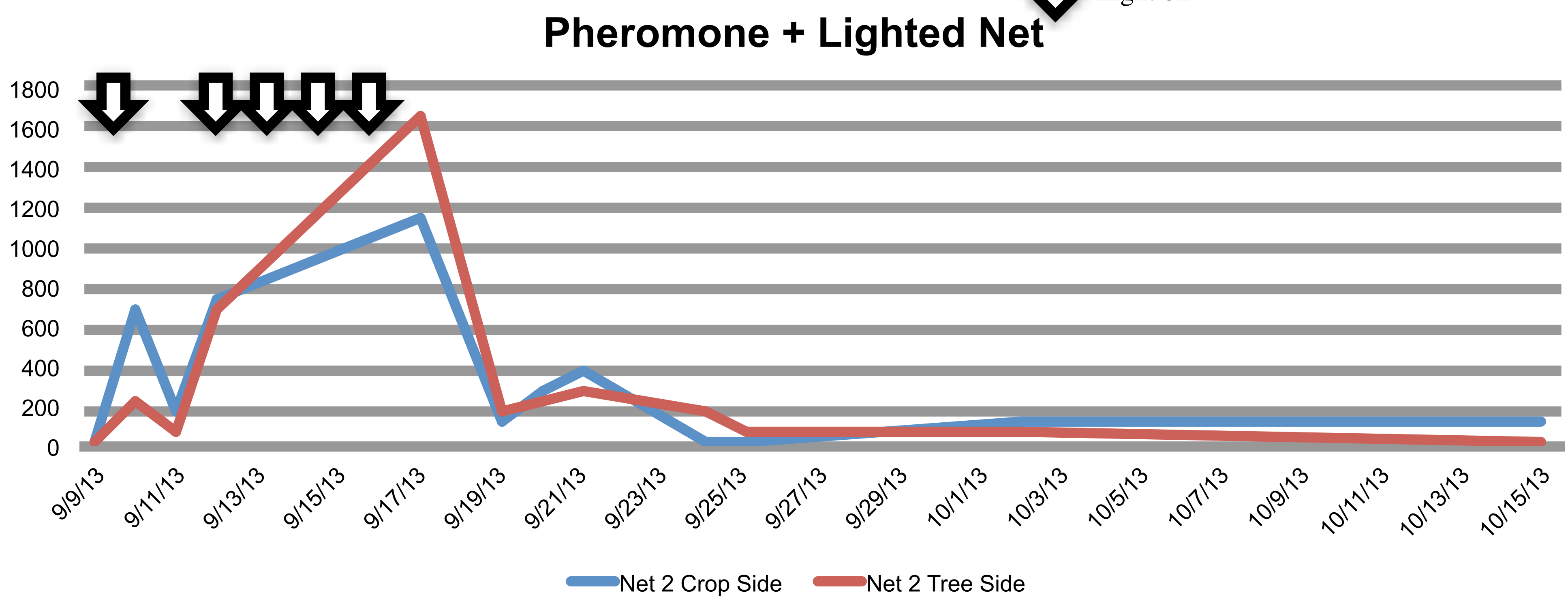
#10 + MDT Lure only



#10 + MDT Lure + 500W Halogen Lamp

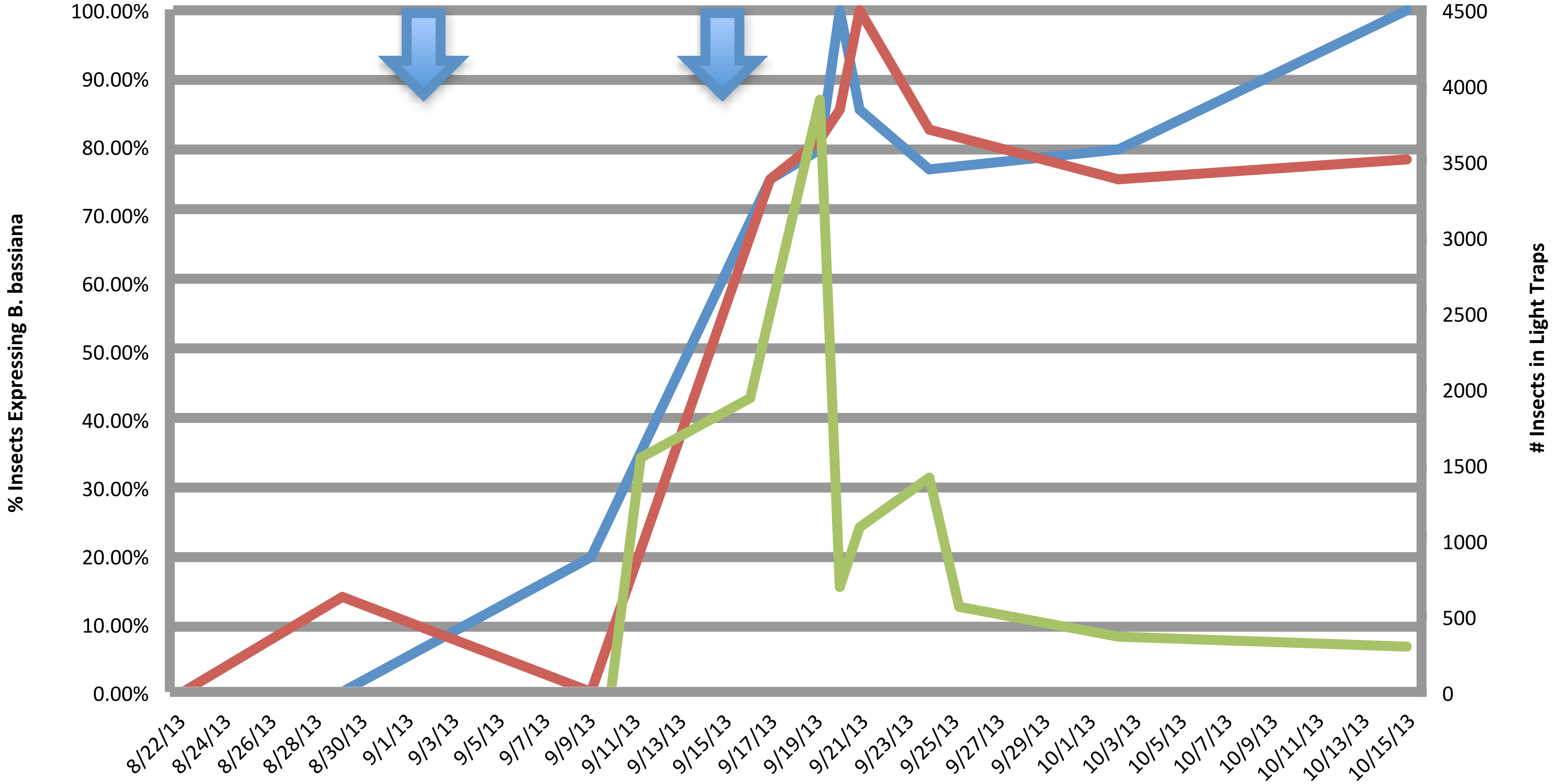



Pheromone only Net
700
600
500
400
300
200
100
0
9/9/13
9/11/13
9/13/13
9/15/13
9/17/13
9/19/13
9/21/13
9/23/13
9/25/13
9/27/13
9/29/13
10/1/13
10/3/13
10/5/13
10/7/13
10/9/13
10/11/13
10/13/13
10/15/13
Net 1 Crop Side
Net 1 Tree Side
Light on


Pheromone + Lighted Net
1800
1600
1400
1200
1000
800
600
400
200
0
9/9/13
9/11/13
9/13/13
9/15/13
9/17/13
9/19/13
9/21/13
9/23/13
9/25/13
9/27/13
9/29/13
10/1/13
10/3/13
10/5/13
10/7/13
10/9/13
10/11/13
10/13/13
10/15/13
Net 2 Crop Side
Net 2 Tree Side


BMSB Infested With
Beauveria bassiana strain GHA
(Mycotrol-O @ 16 oz./A)

B. bassiana expression over Time



	8/22/13	8/29/13	9/9/13	9/10/13	9/11/13	9/16/13	9/17/13	9/19/13	9/20/13	9/21/13	9/24/13	9/25/13	10/2/13	10/15/13	
Net 1 infection	0.00%	0.00%	20.00%			73.66%		75.00%	80.00%	100.00%	85.71%	76.92%		80.00%	100.00%
Net 2 infection	0.00%	14.29%	0.00%			82.95%		75.00%	80.95%	84.62%	100.00%	82.76%		75.00%	78.57%
Population	0			0	1556	521	1954		3935	708	1090	1392	545	375	287

Beauvaria bassiana strain GHA applications *(Mycotrol-O @ 16 oz./A)*

Discussion and Future Work

- Netting attracted and killed large numbers of BMSB, but enough to manage large infestations on it's own?
- In 2013, BMSB populations decreased after netting captures, and new crop was harvested with no further economic loss, after grower considered plot to be lost cause.
- Replicated study over several plantings needed to determine effect of presence of netting/biocontrol on damage and populations.

Thank You - Questions

Support from the Tree Fruit and Agrichemical Industry
NYSAES, CCE, Technical staff and field assistants