Invasive Insect Tsunami:
Managing Brown Marmorated Stink Bug in NYS Orchards

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Photograph: **Christopher Hedstrom** USDA-APHIS Quarantine Facility, Corvallis, Oregon

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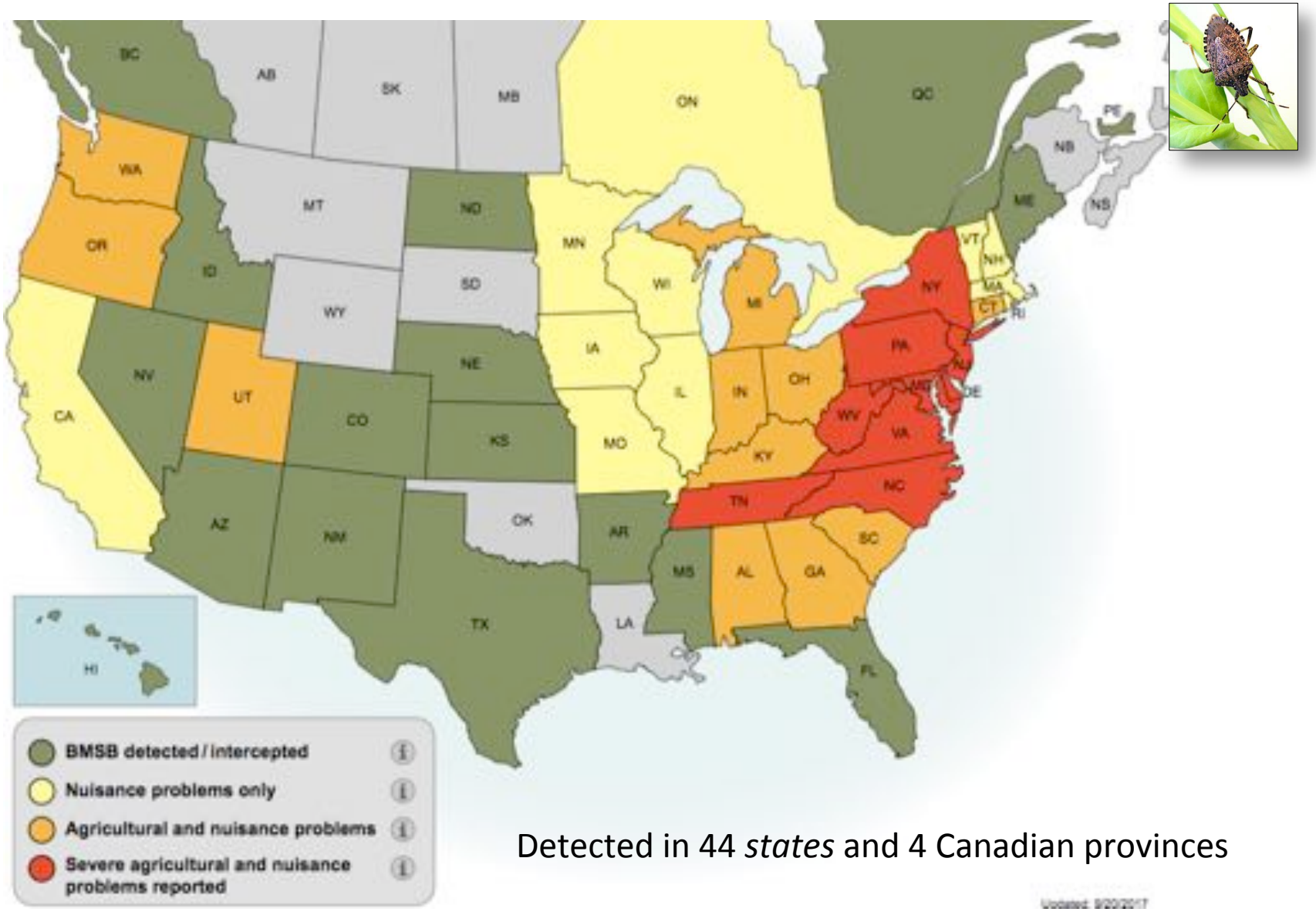
Red Tomato Annual Growers Meeting
March 1, 2019
Henry A. Wallace Center, Hyde Park, NY

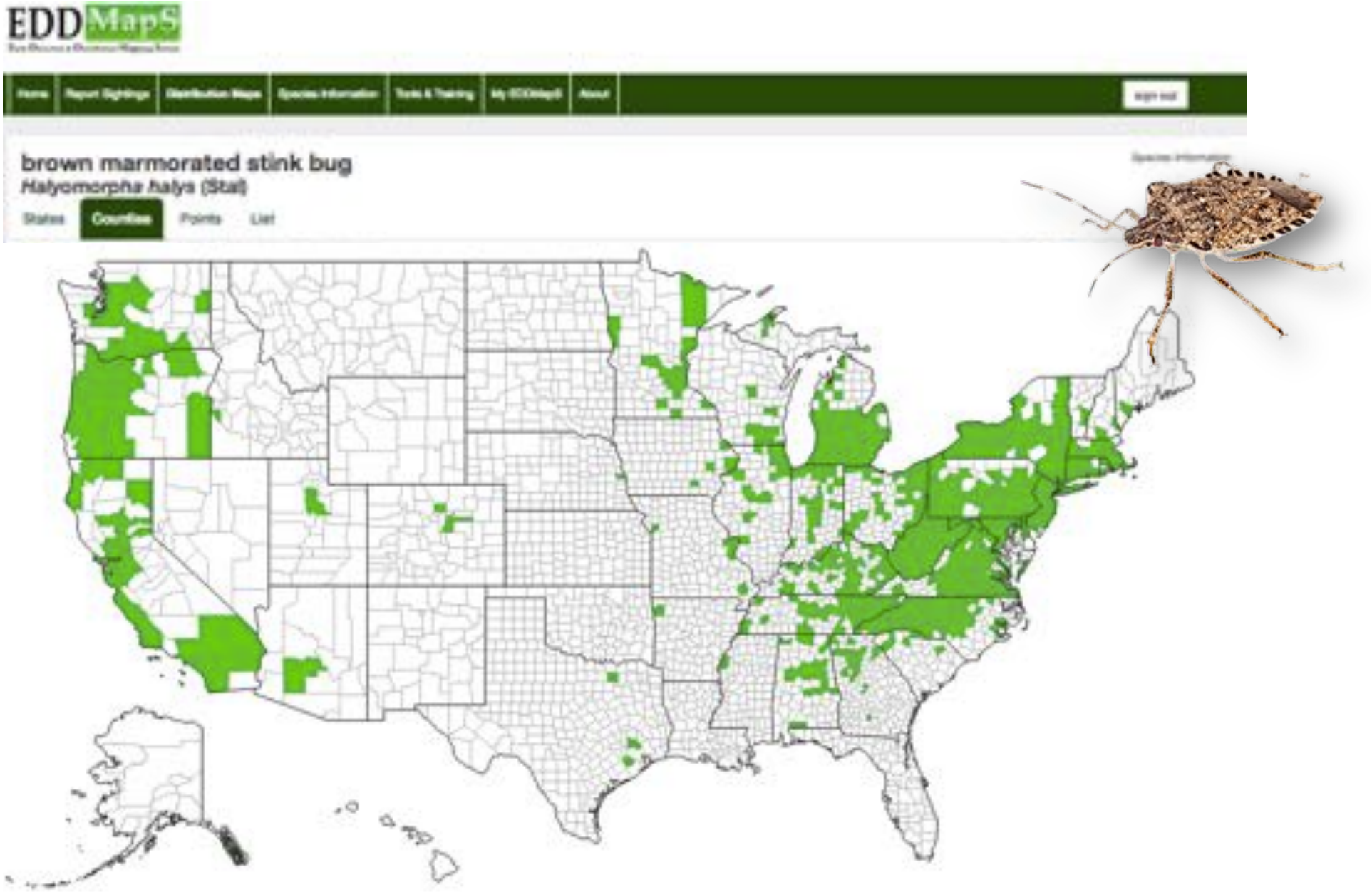
Brown Marmorated Stink Bug Management

- BMSB Ecology & Biology
- Monitoring / Scouting
- Stink Bug Injury Diagnostics
- Insecticide Efficacy Studies
- Biological Control
- Novel / Innovation Mgt. Research

The Brown Marmorated Stink Bug in the Ag. & Urban Environment



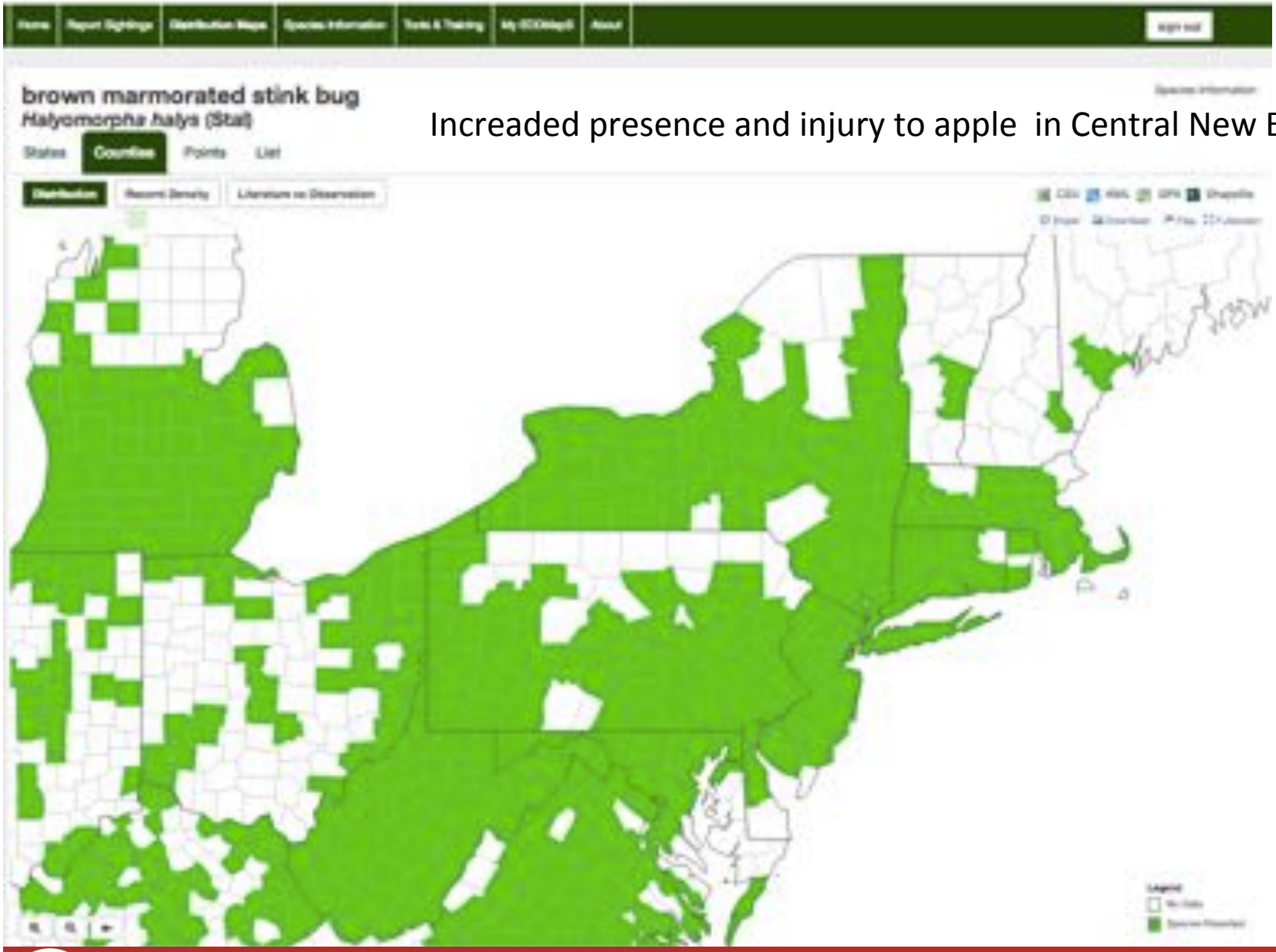
Detected in 44 *states* and 4 Canadian provinces



Citizen Science Project Participation (Homeowners)

BMSB has been detected in all but 6 of 62 counties in NYS

EDDMapS



Increaded presence and injury to apple in Central New England

Hudson Valley Stink Bug Complex (Pentatomidae)
Species Of Economic Importance

Stink Bug Biology

- Large 'Shield' bug body form (3.5 cm)
- Proboscis (moutparts) shielded prior to insertion into fruit
- Body held above the surface of foliage and fruit
- Tarsi hold insect on small segments onto smooth surfaces
- Limited exposure to residual insecticides

Hudson Valley Stink Bug Complex (Pentatomidae)
Species Of Economic Importance

Brown Stink Bug, *Euschistus servus* (Say)

- Native to North America
- Feeds on broad leaf plant & seed (Mullen, Dock, Plantain)
- Moves to apple borders during periods of drought
- Pyrethroids, Pre-mix Neonic + Pyrethroid

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

- Native to North America
- Arborial dwelling, feed on seed, stems and foliage
- Moves to apple borders during periods of drought

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

- Newly invasive in North America
- Arborial dwelling, feed on seed, stems and foliage
- Moves to apple borders during periods of high population, drought

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.

Factors for BMSB Success: Overwintering

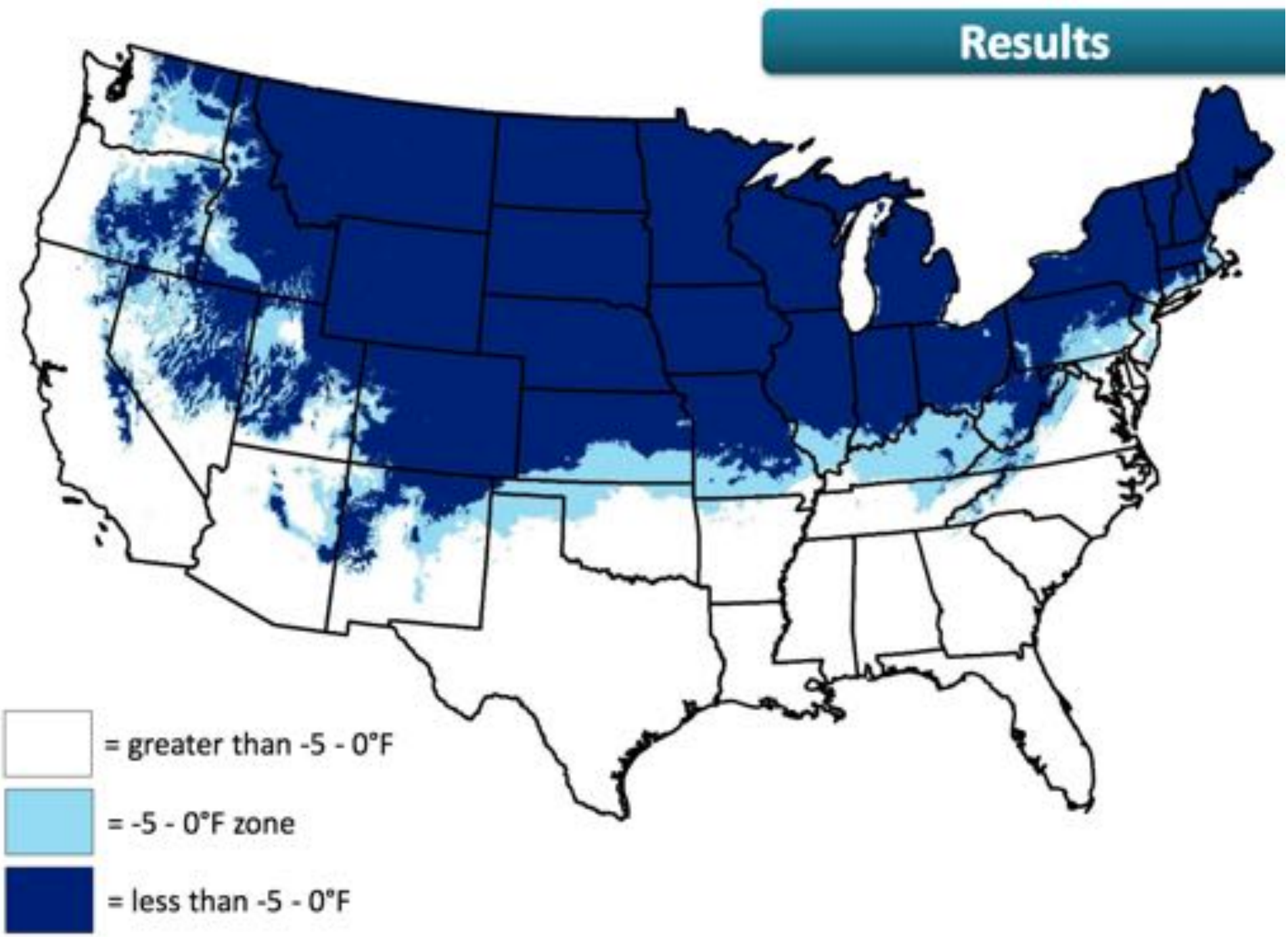
Overwintering habitat

- A small percent of the population will aggregate in buildings where temperature extremes allow for survival in northern climates, **potentially creating localized cluster points for Ag. infestations.**

- The majority of BMSB reside in the woodland habitat (Standing Dead Oak (*Quercus* spp.), Locust (*Robinia* spp.) Lee, Doo-Hyung et al. 2014)

- In woodland habitat, temperatures below -18°C or -0.4°F will kill 90% of the population (Kuhar, T. 2016)

Results

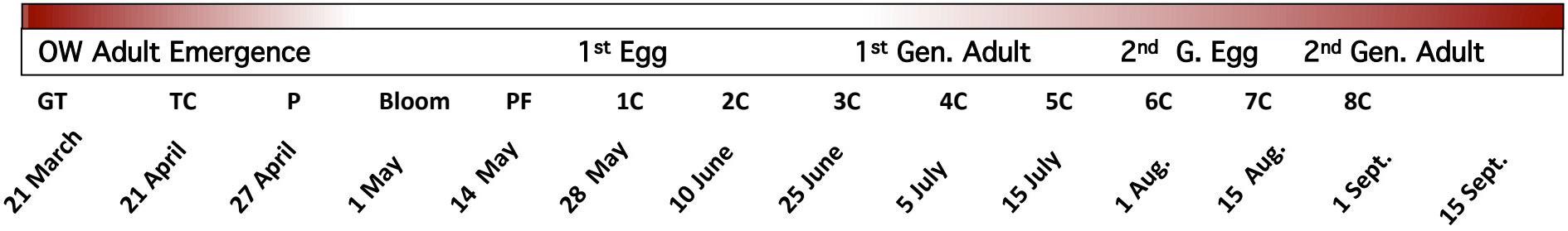


Factors for BMSB Success: # of Generations

- **Sunlight / Day length** (BMSB adult mating)
  - **13.5h day length** for mating and egg laying to begin
  - Geneva, NY April 29th – Aug 13th
  - HVRL Highland May 1st – Aug. 11th

Factors for BMSB Success: # of Generations

- **Degree Day Accumulations**
  - It requires **538 degree days** (DD – based 50ºF) to develop from egg to adult.
  - An additional **148 DD** are required for female maturation **at 77ºF.**
  - Total of **686 DD_{50}** for 1 generation;
  - **1224 DD_{50}** for a **2nd complete the adult OW population**



Brown Marmorated Stink Bug Management

- BMSB Ecology & Biology
- **Monitoring / Scouting**
- **Stink Bug Injury Diagnostics**
- **Insecticide Efficacy Studies**
- **Biological Control**
- **Novel / Innovation Mgt. Research**

State-wide Trap Monitoring of BMSB in NY

USDA #10 Lure & MDT Using Tedders Traps

Vented trap container holding duel lure

Killing strip of Vapona; bungi cord straps

Pyrimid black base to mimmic tree trunk

Screened base to **reduce weeds** and provide contrast for crawling SB

Placed along decidious woodland / orchard edge

AgBio-inc.com
Trap, lures, kill strip

Treatment Threshold: 10 adults / trap / week

Green & Brown Marmorated Stink Bug: Monitoring

Tedders Trap
*duel pheromone

Sticky Card Trap
*duel pheromone

AtK Trap (Vestegaard)
*duel pheromone
*deltamethrin-Incorporated net

Threshold: 10 adults / trap / week

Green & Brown Marmorated Stink Bug: Monitoring

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Brown Marmorated Stink Bug Management

- BMSB Ecology & Biology
- Monitoring / Scouting
- **Stink Bug Injury Diagnostics**
- Insecticide Efficacy Studies
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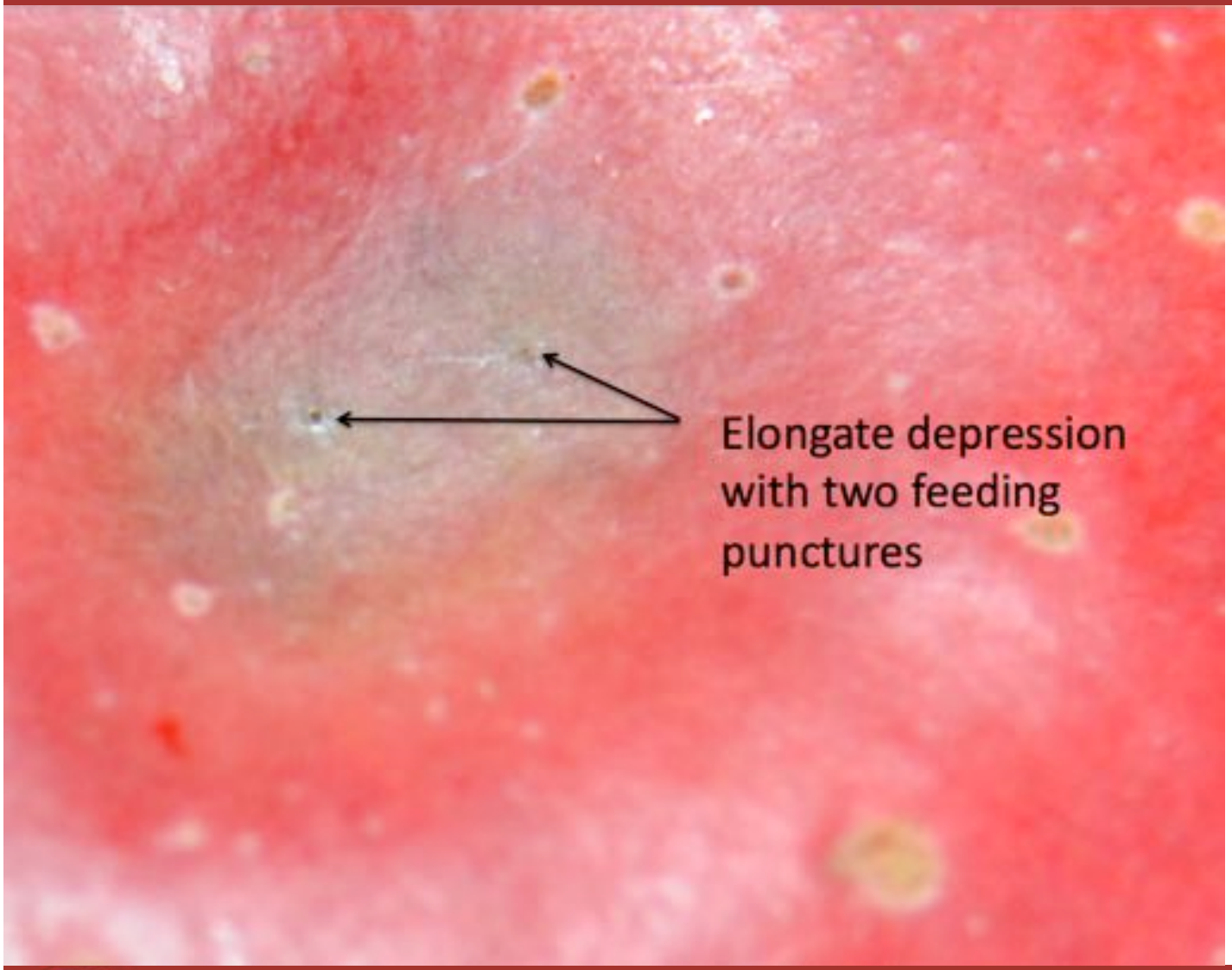
Stink Bug Injury to Apple

BMSB: Defining Injury
Stink Bug, Hail, Bitter Pit, Maggot



Stink Bug:

- Discolored shallow depression
- Corking to skin surface
- **Feeding puncture**

BMSB: Defining Injury
Stink Bug, Hail, Bitter Pit, Maggot

Hail injury:

- Discolored shallow depression
- Corking to skin surface
- **No feeding puncture**

BMSB: Defining Injury
Stink Bug, Hail, Bitter Pit, Maggot

Bitter Pit:

- Discolored shallow depression
- **Corking not to skin surface**
- **No feeding puncture**

BMSB: Defining Injury
Stink Bug, Hail, Bitter Pit, Maggot

Apple Maggot:

- Sting Depression
- **No skin Discoloration**
- **No corking**
- Oxidized tunneling or trails

Brown Marmorated Stink Bug Management

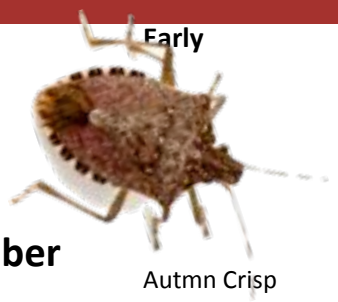
- BMSB Ecology & Biology
- Monitoring / Scouting
- Stink Bug Injury Diagnostics
- **Insecticide Efficacy** Biological Control
- Novel / Innovation Mgt. Research

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
Pre-mix	Leverage 360	imidacloprid and β-cyfluthrin	95
	Endigo	lambda-cyhaloth	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.

NY BMSB Management Options

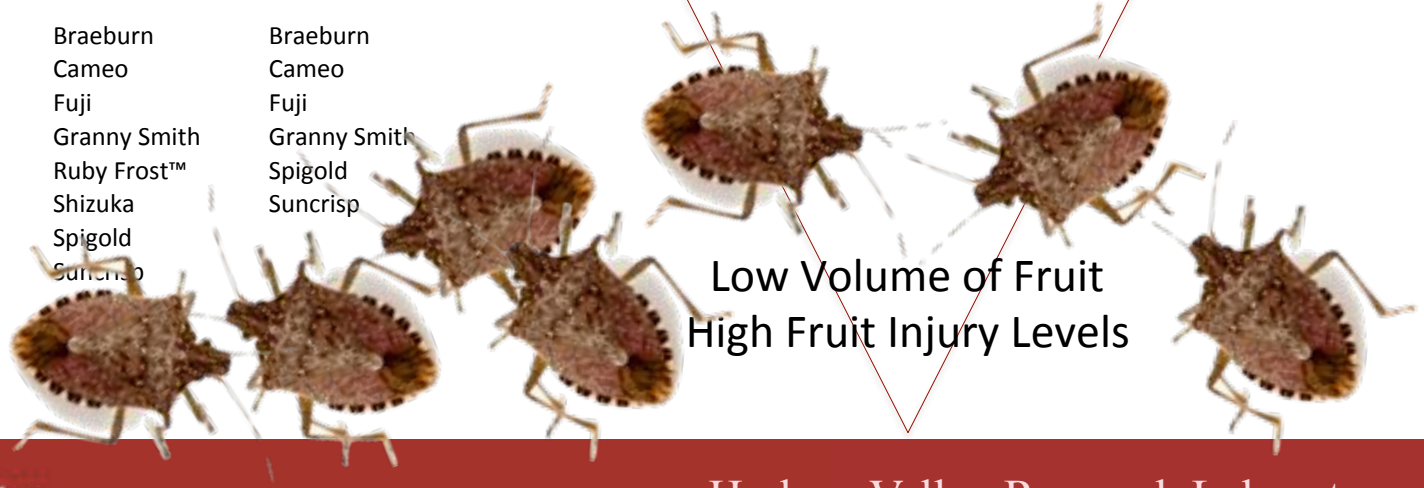


	Early	Mid	Late	
August		Blondee Sansa	Blondee Paulared Tydeman Zestar	**WHOLE ORCHARD** application early-mid August Trap Threshold + observation Egg laying in orchard possible 35-7d PHI
September	Autmn Crisp Blondee Gala Ginger Gold	Autmn Crisp Cortland Empire Honeycrisp	Ambrosia Autmn Crisp Braeburn Golden Delicious	**PERIMETER ROW APPLICATIONS** 2-4 applications by September
	Golden Supreme Greening Jonamac McIntosh Twenty Ounce Tydeman	Macoun Shamrock Snow Sweet Tydeman	Jonagold Mutsu/Crispin Pinova Red Delicious Ruby Frost™ Ruby Jon Snap Dragon™ Snow Sweet	
October	Braeburn Cameo Fortune Idared Northern Spy Rome Ruby Frost™ Shizuka Snap Dragon™ Snow Sweet	Braeburn Cameo Fuji Granny Smith Ruby Frost™ Shizuka Spigold Suncrisp	Braeburn Cameo Fuji Granny Smith Spigold Suncrisp	5-8 applications by October employing **Perimeter Row applications**
November	Pink Lady			>6 applications by November **Perimeter Row applications**

NY BMSB Management Options

	Early	Mid	Late
August		Blondee Sansa	Blondee Paulared Tydeman Zestar
September	Autmn Crisp Blondee Gala Ginger Gold Golden Supreme Greening Jonamac McIntosh Twenty Ounce Tydeman	Autmn Crisp Cortland Empire Honeycrisp Macoun Shamrock Snow Sweet Tydeman	Ambrosia Autmn Crisp Braeburn Golden Delicious Jonagold Mutsu/Crispin Pinova Red Delicious Ruby Frost™ Ruby Jon Snap Dragon™ Snow Sweet
October	Braeburn Cameo Fortune Idared Northern Spy Rome Ruby Frost™ Shizuka Snap Dragon™ Snow Sweet	Braeburn Cameo Fuji Granny Smith Ruby Frost™ Shizuka Spigold Suncrisp	Braeburn Cameo Fuji Granny Smith Spigold Suncrisp
November	Pink Lady		

High Volume of Fruit
Low Injury Level



Low Volume of Fruit
High Fruit Injury Levels

NY Management Options

Product	Active ingredient	Rate / A	REI Hrs.	PHI Days	Efficacy (USDA)	Max. per crop / season	App. Interval
Actara 25WDG	Thiamethoxam	4.5-5.5 oz/A	12	35	+++	16.5 oz./A (0.258 lb. a.i./A)	10d
Asana XL 0.66EC	Esfenvalerate	4.8-14.5 fl oz/A	12	21	++	101 fl oz/A (0.525 lb AI/A).	NA
Baythroid XL 1EC	Beta-Cyfluthrin	1.4-2.8 fl oz/A	12	7	++	2.8 fl oz/A (0.022 lb AI/A).	14d
Besiege	Chlorantraniliprole / Lambda-cyhalothrin	6-12 fl oz/A	24	21	+++	31.0 fl oz/A	10d
Bifenture EC	Bifenthrin	5.2-12.8 fl oz/A	12	14	++++	32 fl ozs (0.50 lbs ai)	30d
Bifenture 10DF	Bifenthrin	12.8-32.0 oz/A	12	14	++++	80 ozs (0.50 lbs ai)	30d
Brigade WSB	Bifenthrin	12.8-32.0 oz/A	12	14	++++	80 ozs (0.50 lbs ai)	30d
Danitol 2.4EC	Fenpropathrin	10.66-21.33 fl oz/A	24	14	+++	42.56 fl ozs (0.80 lbs ai)	10d
Endigo ZC	Thiamethoxam / Lambda-cyhalothrin	5-6 fl fl oz/A	24	35	++++	19 fl oz./A (0.172 lb ai) NY	10d
Gladiator EC	Zeta-Cyfluthrin / Avermectin B1	19.0 fl.oz./A	12	28	++	38.0 fl oz/A	21d
Lannate 2.4LV*	Methomyl	2.25 pt/A	72	14	++++	240 ozs (0.50 lbs ai)	7d
Lannate 90SP*	Methomyl	0.75 lb./A	72	14	++++	5.0 lbs	7d
Leverage 360	Beta-Cyfluthrin / Imidacloprid	2.4-2.8 fl oz/A	12	7	+++	2.8 fl oz/A	14d
Surround 95WP	Kaolin	25-50 lb/A	4	0	+	NA	0d
Voliam Flexi	Chlorantraniliprole/Thiamethoxam	6.0-7.0 oz/A	12	35	+++	11 fl oz./A (0.172 lb ai) NY	10d
Vydate 2L*	Oxamyl	1.5-3.0 pt/A	48	14	++	281 fl oz/A (128 oz AI/A).	7d
Warrior 1CS	Lambda-cyhalothrin	2.56-5.12 fl oz/A	24	21	++	20.48 fl. oz. (0.28 lb. a.i.)**	5d

* Although these materials have excellent topical ratings in lab bioassay studies, field efficacy studies have shown economic fruit injury from BMSB feeding, suggesting low residual levels.

** Post bloom applications

(+) low to (++++) high efficacy

- Single Application (Thiamethoxam)
- NYS total 11.0 oz./A of Actara WDG
- 35 DTH

NY Management Options

Product	Active ingredient	Rate / A	REI Hrs.	PHI Days	Efficacy (USDA)	Max. per crop / season	App. Interval
Actara 25WDG	Thiamethoxam	4.5-5.5 oz/A	12	35	+++	16.5 oz./A (0.258 lb. a.i./A)	10d
Asana XL 0.66EC	Esfenvalerate	4.8-14.5 fl oz/A	12	21	++	101 fl oz/A (0.525 lb AI/A).	NA
Baythroid XL 1EC	Beta-Cyfluthrin	1.4-2.8 fl oz/A	12	7	++	2.8 fl oz/A (0.022 lb AI/A).	14d
Besiege	Chlorantraniliprole / Lambda-cyhalothrin	6-12 fl oz/A	24	21	+++	31.0 fl oz/A	10d
Bifenture EC	Bifenthrin	5.2-12.8 fl oz/A	12	14	++++	32 fl ozs (0.50 lbs ai)	30d
Bifenture 10DF	Bifenthrin	12.8-32.0 oz/A	12	14	++++	80 ozs (0.50 lbs ai)	30d
Brigade WSB	Bifenthrin	12.8-32.0 oz/A	12	14	++++	80 ozs (0.50 lbs ai)	30d
Danitol 2.4EC	Fenpropathrin	10.66-21.33 fl oz/A	24	14	+++	42.56 fl ozs (0.80 lbs ai)	10d
Endigo ZC	Thiamethoxam / Lambda-cyhalothrin	5-6 fl fl oz/A	24	35	++++	19 fl oz./A (0.172 lb ai) NY	10d
Gladiator EC	Zeta-Cyfluthrin / Avermectin B1	19.0 fl.oz./A	12	28	++	38.0 fl oz/A	21d
Lannate 2.4LV*	Methomyl	2.25 pt/A	72	14	++++	240 ozs (0.50 lbs ai)	7d
Lannate 90SP*	Methomyl	0.75 lb./A	72	14	++++	5.0 lbs	7d
Leverage 360	Beta-Cyfluthrin / Imidacloprid	2.4-2.8 fl oz/A	12	7	+++	2.8 fl oz/A	14d
Surround 95WP	Kaolin	25-50 lb/A	4	0	+	NA	0d
Voliam Flexi	Chlorantraniliprole/Thiamethoxam	6.0-7.0 oz/A	12	35	+++	11 fl oz./A (0.172 lb ai) NY	10d
Vydate 2L*	Oxamyl	1.5-3.0 pt/A	48	14	++	281 fl oz/A (128 oz AI/A).	7d
Warrior 1CS	Lambda-cyhalothrin	2.56-5.12 fl oz/A	24	21	++	20.48 fl. oz. (0.28 lb. a.i.)**	5d

* Although these materials have excellent topical ratings in lab bioassay studies, field efficacy studies have shown economic fruit injury from BMSB feeding, suggesting low residual levels.

** Post bloom applications

(+) low to (++++) high efficacy

- 5-10 d application schedule
- 21 DTH

NY Management Options

Product	Active ingredient	Rate / A	REI Hrs.	PHI Days	Efficacy (USDA)	Max. per crop / season	App. Interval
Actara 25WDG	Thiamethoxam	4.5-5.5 oz/A	12	35	+++	16.5 oz./A (0.258 lb. a.i./A)	10d
Asana XL 0.66EC	Esfenvalerate	4.8-14.5 fl oz/A	12	21	++	101 fl oz/A (0.525 lb AI/A).	NA
Baythroid XL 1EC	Beta-Cyfluthrin	1.4-2.8 fl oz/A	12	7	++	2.8 fl oz/A (0.022 lb AI/A).	14d
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Leverage 360	Beta-Cyfluthrin / Imidacloprid	2.4-2.8 fl oz/A	12	7	+++	2.8 fl oz/A	14d
Surround 95WP	Kaolin	25-50 lb/A	4	0	+	NA	0d
Voliam Flexi	Chlorantraniliprole/Thiamethoxam	6.0-7.0 oz/A	12	35	+++	11 fl oz./A (0.172 lb ai) NY	10d
Vydate 2L*	Oxamyl	1.5-3.0 pt/A	48	14	++	281 fl oz/A (128 oz AI/A).	7d
Warrior 1CS	Lambda-cyhalothrin	2.56-5.12 fl oz/A	24	21	++	20.48 fl. oz. (0.28 lb. a.i.)**	5d

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** Post bloom applications

(+) low to (++++) high efficacy

- 5-10 d application schedule
- Bifenthrin (30d Re-application)
- 14 DTH

NY Management Options

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Baythroid XL 1EC	Beta-Cyfluthrin	1.4-2.8 fl oz/A	12	7	++	2.8 fl oz/A (0.022 lb AI/A).	14d
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Voliam Flexi	Chlorantraniliprole/Thiamethoxam	6.0-7.0 oz/A	12	35	+++	11 fl oz./A (0.172 lb ai) NY	10d
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** Post bloom applications

(+) low to (++++) high efficacy

- 5-10 d application schedule
- 7 DTH
- Leverage; Closer
- 0 DTH Venerate

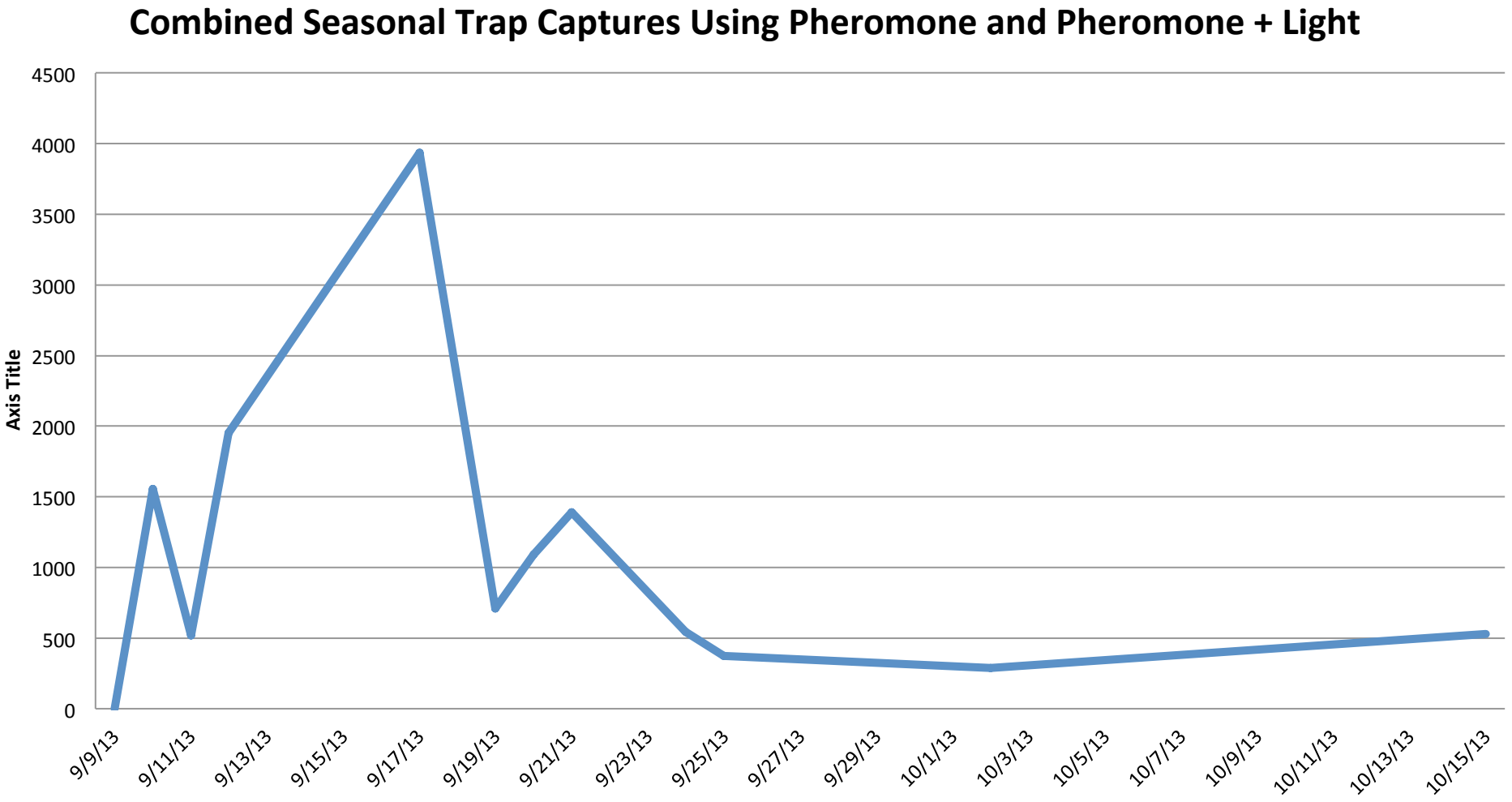
Brown Marmorated Stink Bug Management

- Aspects of BMSB Ecology & Biology
- Agricultural Monitoring / Scouting
- Defining Stink Bug Injury
- Directed Applications & Efficacy
- **Novel / Innovation (Research)**

Attract and Kill Netting in Orchard
Duel Pheromone + Insecticide

Attract and Kill Netting in Orchard
Duel Pheromone + Insecticide

Studies of the Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål), in New York State 2016



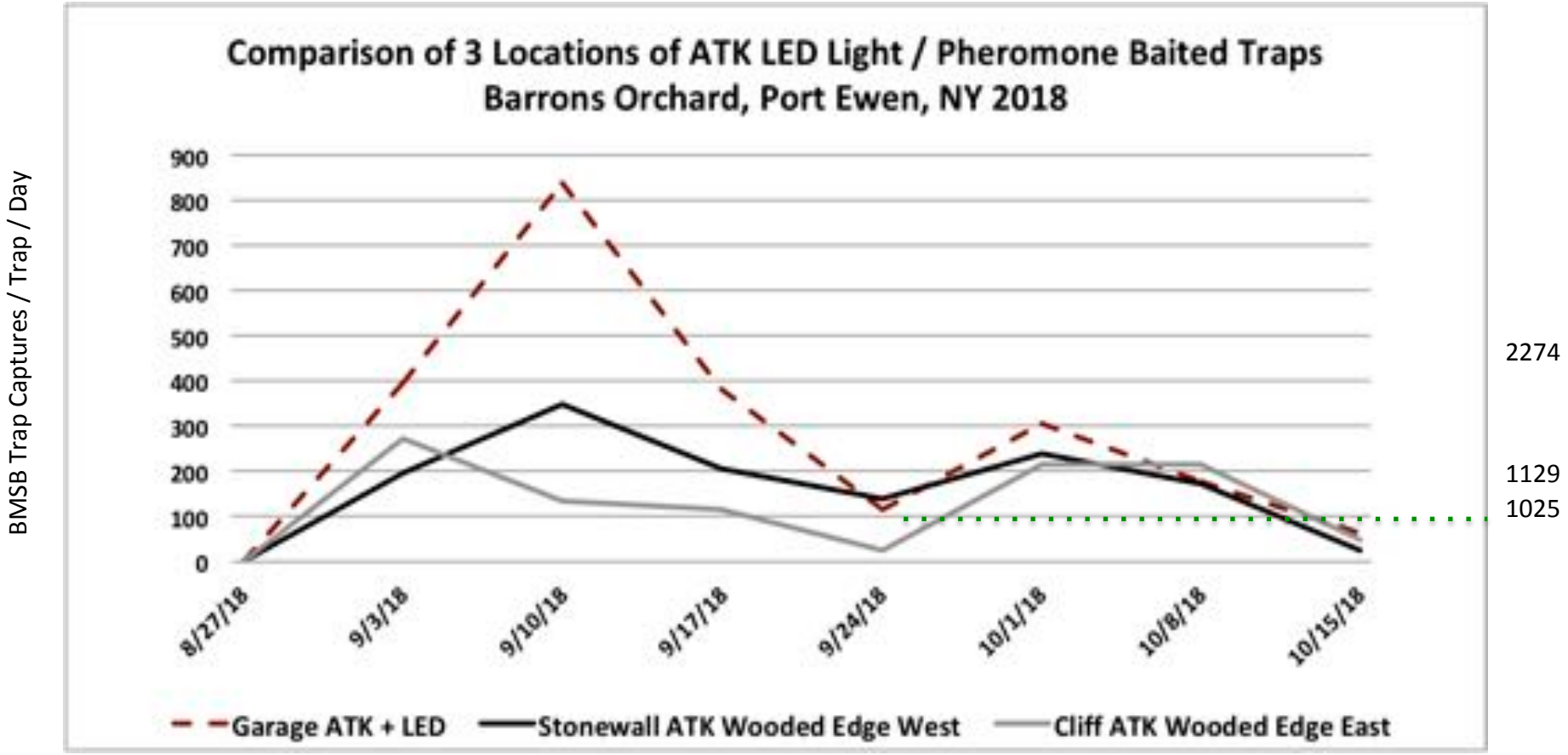
(September – 15 October: Total BMSB = 12,894

Monitoring *the* Stink Bug Complex
Using Free Standing Solar LED ATK + Phermone

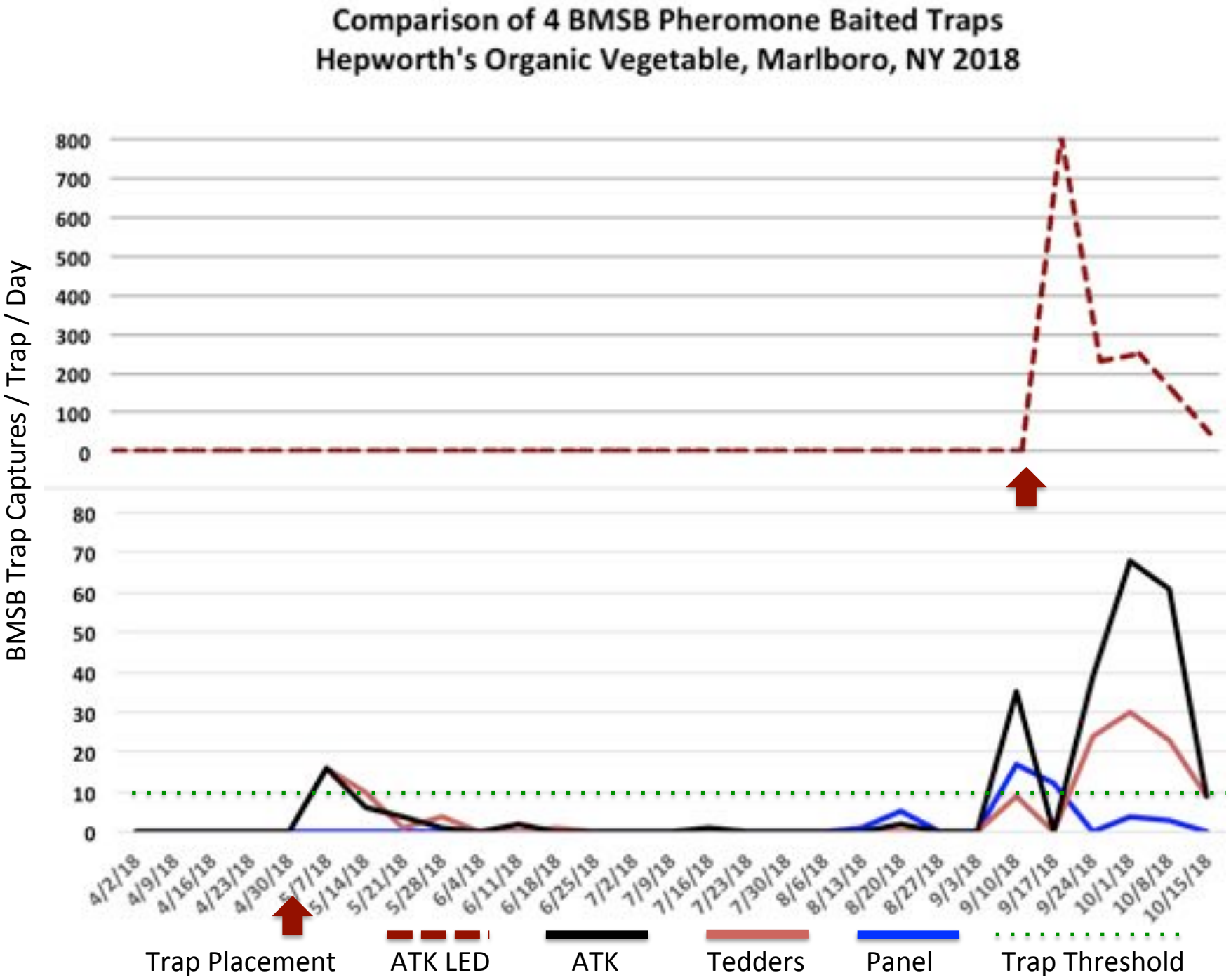
Cornell University

Hudson Valley Research Laboratory

Attract & Kill of the Stink Bug Complex
To Reduce BMSB Populations Along the Orchard Edge



Including Solar LED auto-on with ATK / pher. increases BMSB captures


Comparison of 4 BMSB Pheromone Baited Traps
Hepworth's Organic Vegetable, Marlboro, NY 2018
BMSB Trap Captures / Trap / Day
800
700
600
500
400
300
200
100
0
80
70
60
50
40
30
20
10
0
4/2/18
4/9/18
4/16/18
4/23/18
4/30/18
5/7/18
5/14/18
5/21/18
5/28/18
6/4/18
6/11/18
6/18/18
6/25/18
7/2/18
7/9/18
7/16/18
7/23/18
7/30/18
8/6/18
8/13/18
8/20/18
8/27/18
9/3/18
9/10/18
9/17/18
9/24/18
10/1/18
10/8/18
10/15/18
Trap Placement
ATK LED
ATK
Tedders
Panel
Trap Threshold

Redistribution of Samurai Wasp, Trissolcus japonicus (Ashmead) In NYS

- Samurai wasp, *Trissolcus japonicus*, is an egg parasitoid of the BMSB
- Lays 1 egg into each BMSB egg
- Wasp larva feed on BMSB nymph
- Adult wasp emerges from BMSB eggs
- Can have 5 generations / year

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Live along the wooded edge of Ag.

Resides in BMSB deciduous tree hosts

Limited exposiure to insecticides

Introduction to *Trissolcus japonicus* (Samurai Wasp) For BMSB Management ?

2 mm

Trissolcus japonicus

Trissolcus japonicus
Field Recovery Sites in the US

- In 2014 **adventive** populations (wild) of *T. japonicus* were found in Beltsville, MD using sentinel BMSB eggs

(Talamas EJ, Herlihy MV, Dieckhoff C, Hoelmer KA, Buffington ML, Bon M-C, Weber DC (2015) *Trissolcus japonicus* (Ashmead) emerges in North America. Journal of Hymenoptera Research 43: 119-128. https://doi.org/10.3897/JHR.43.4661)

- In 2015 *T. japonicus* were found in Vancouver, WA, Washington DC and Winchester, VA,.

- In 2016, *T. japonicus was also found* in WV, MD, NJ and NY in the East, and OR in the West.


2017
Sentinel Egg Placement
11 NYS Sites
Kingston
Toronto
Lake Ontario
Orleans Co.
Monroe Co.
Wayne Co.
Ontario Co.
New York
Columbia Co.
Ulster Co.
Dutchess Co.
Orange Co.
Connecticut
Pennsylvania

NYS DEC Liberation of Wildlife Permit (July 2017)

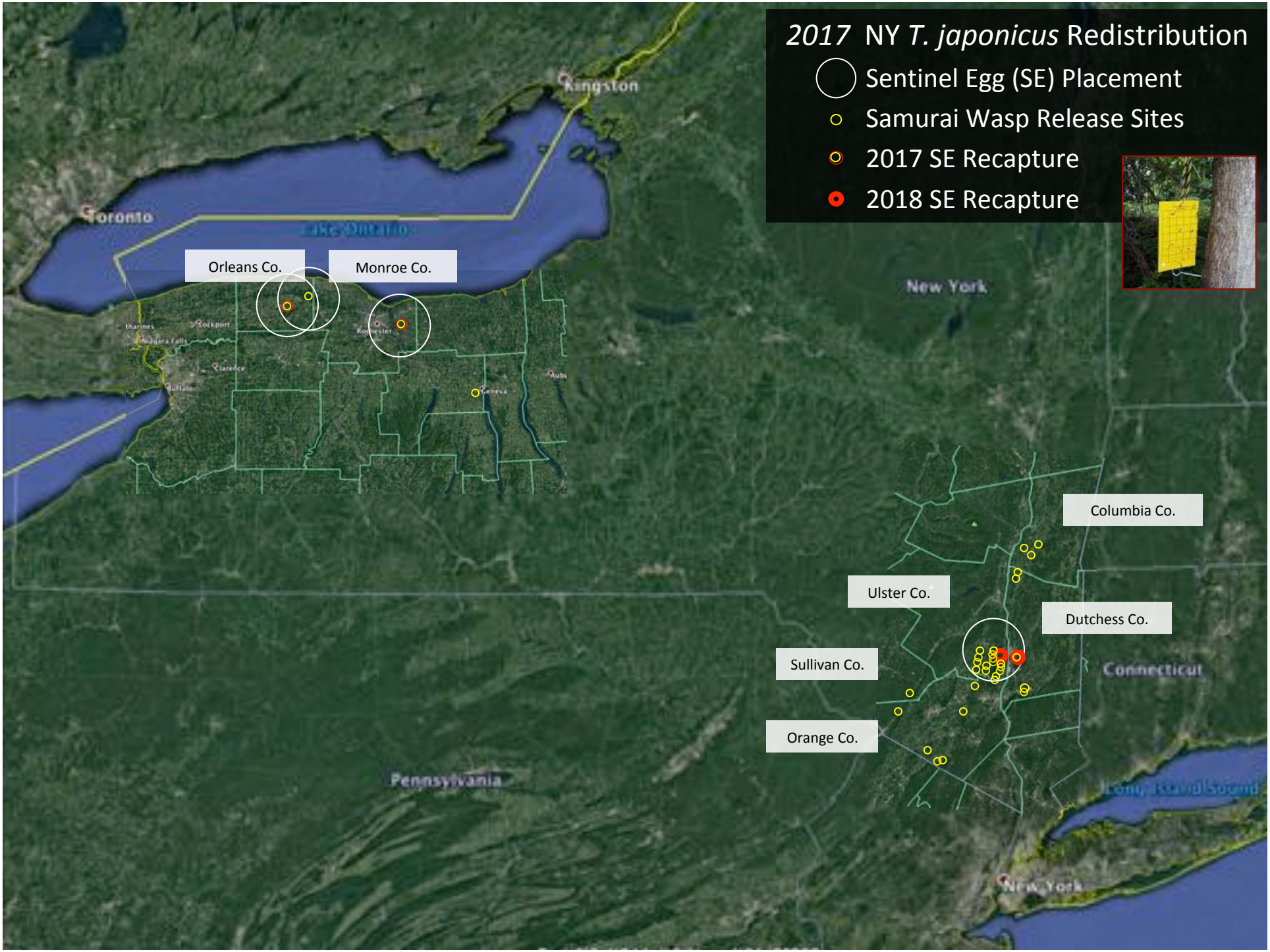
After in-depth review of applicable provisions of the Environmental Conservation Law (ECL) and Codes, Rules and Regulations of the State of New York (NYCRR), **DEC has concluded that its regulatory authority extends to the issuance of permits for the release of specifically defined species of wildlife and listed endangered, threatened, and/or invasive species.** Wildlife is defined in ECL S 1 1-0103. Endangered and threated species are identified in 6 NYCRR Part 182, and listed **invasive species are identified in 6 NYCRR Part 575.**

DEC has recently concluded that their statutory and regulatory framework around the Liberation of Wildlife Permit regulating release of biologicals such as insects does not generally apply to releasing insects into the wild, so long as the proposed release is not of an insect that is listed on either the endangered or invasive species listings.

Upon review by the DEC, the adventive *T. japonicus population does not require a* license or permit from DEC to undertake the movement and release of the Samurai wasp, as it is not listed within 6 NYCRR 575.

2017 Parasitized Egg Parasitoid Release 'Redistribution'

- Marlboro *T. japonicus* used to develop colony and parasitize -80°C BMSB eggs.
- Fixed parasitized eggs to petri dish lid added zip tie for RT mailing and emergence.
- Parasitized eggs sent to cooperators on **15th September.**
- Parasitized eggs placed on 32 sites of 25 farms in 5 NY counties.


2017 NY T. japonicus Redistribution
Sentinel Egg (SE) Placement
Samurai Wasp Release Sites
2017 SE Recapture
2018 SE Recapture
Orleans Co.
Monroe Co.
Columbia Co.
Ulster Co.
Dutchess Co.
Sullivan Co.
Orange Co.
Kingston
Toronto
Lake Ontario
New York
Pennsylvania
Connecticut
Long Island Sound
New York

Samurai Wasp Redistribution Sites 2017-2018
Citizen Science (N=29), Agricultural (N=34)

Photograph: **Christopher Hedstrom**
USDA-APHIS Quarantine Facility,
Corvallis, Oregon

Drape Net Insect Exclusion Study
Stink Bug Exclusion

Drape Net Insect Exclusion Study
Stink Bug Exclusion

Hudson Valley Research Lab

- Scab Resistant Block
- 11 Varieties on G.11
- 2018 Drape Net Study
  - Insect Exclusion

Drape Net Insect Exclusion Study
Samurai Wasp Conservation

Results of 2018 Insecticide and Acaricide Studies in Eastern New York. Jentsch et. al.

Table 1 **Management of the Apple Insect Complex Using 'Drape Net' IPM / Organic Split and Season Long IPM Management . Hudson Valley Research Laboratory, Highland, NY - 2018**

Net Type / Treatment / Rate	Incidence (%) of insect damaged cluster fruit											
	PC	EAS	TPB	Lf.Rlr	Int. Lep	Ext.Lep	CM	AM.P	AM.T	SJS	SB	Clean
1. Black Drape Early Season IPM	3.0 a	0.6 a	4.4 a	10.9 bc	2.2 b	18.8 b	11.3b	0.6 b	0.6 b	96.3 a	0.3 b	1.3 c
2. White Drape Early Season IPM	4.7 a	0.0 a	4.4 a	11.9 b	3.1 b	20.3 b	12.5 b	0.9 b	0.9 b	95.6 a	0.9 b	0.6 c
3. No Drape Early Season IPM	**10.8 a**	**0.8 a**	**4.6 a**	**22.9 a**	**6.7 a**	**37.1 a**	**23.8 a**	**7.5 a**	**4.2a**	**83.8 b**	**3.8 a**	**1.3 c**
4. Black Drape Season Long IPM	5.6 a	1.3 a	7.8 a	0.3 d	0.0 c	1.6 c	0.3 c	0.0 bc	0.0 b	6.6 d	0.0 b	82.5 a
5. White Drape Season Long IPM	7.8 a	0.9 a	7.8 a	0.3 d	0.0 c	0.6 c	0.0 c	0.3 b c	0.3 b	20.0 c	0.0 b	65.9 b
6. No Drape Season Long IPM	**5.6 a**	**0.9 a**	**5.0 a**	**0.6 cd**	**0.3 c**	**1.3 c**	**0.0 c**	**0.6 b c**	**0.3 b**	**6.3 d**	**0.9 b**	**81.3 a**
P value	0.2062	0.6565	0.5998	0.0001	0.0001	0.0001	0.0001	0.0001	0.0135	0.0001	0.0154	0.0001

* Evaluation made on 'Crimson Crisp, Honey Crisp & Gold Rush cultivars harvested on 29 September. Data were transformed using arcsine(sqrt(x)) prior to ANOVA (P ≤0.05). Means separation by Fisher Protected (P ≤0.05); treatment means followed by the same letter are not significantly different. Arithmetic means reported.