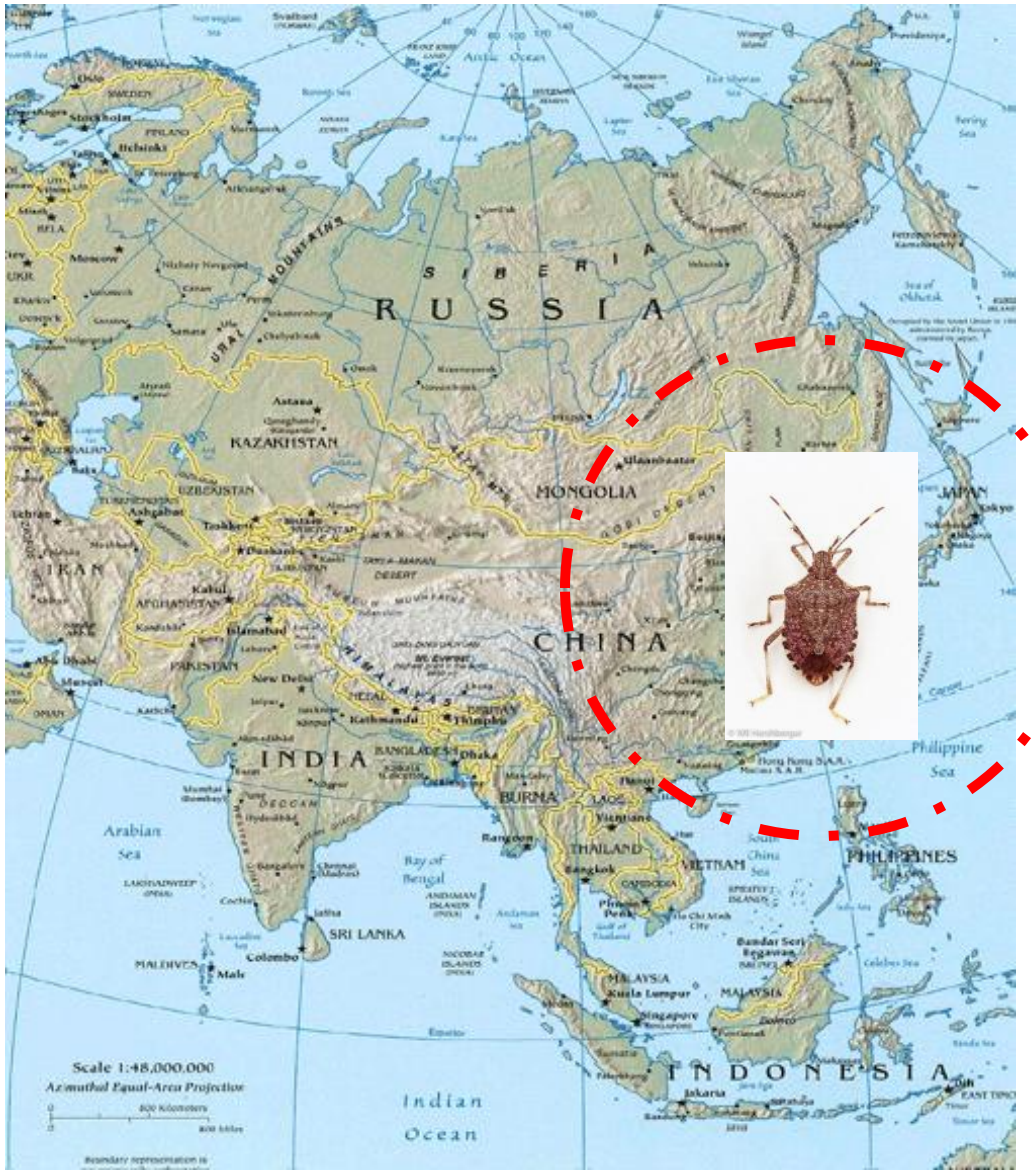
Emergence of Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål), as a Serious Pest of Agriculture

Tracy C. Leskey
USDA-ARS
Appalachian Fruit Research Station
Kearneysville, WV 25430 USA

Brown Marmorated Stink Bug is an Invasive Species



Native to China, Japan, Korea, and Taiwan.

Brown Marmorated Stink Bug Life History

Egg Mass

1st

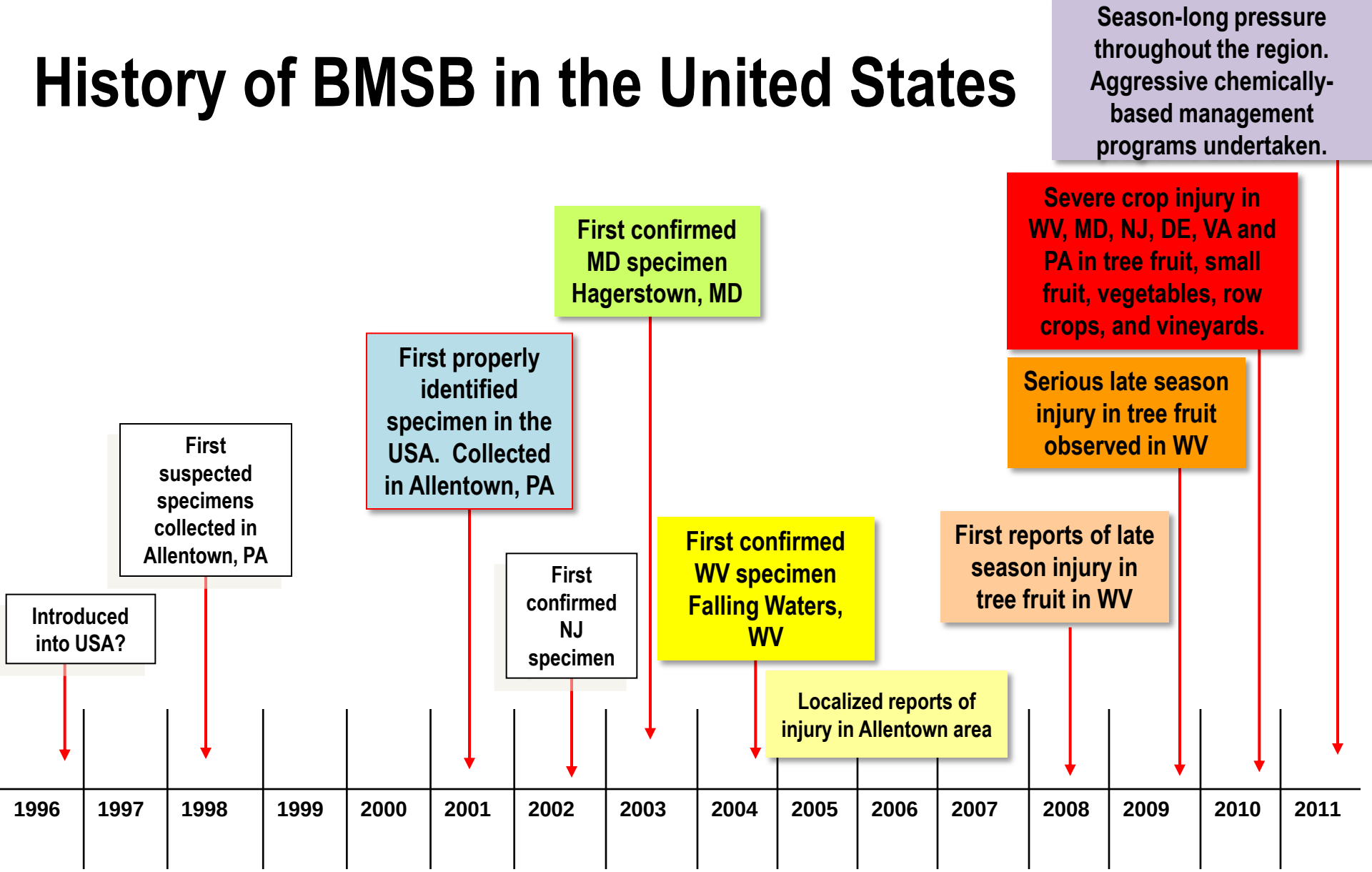
- Deposit eggs on undersides of leaves. Five nymphal stages. Two generations per year in much of the mid-Atlantic. Developmental period lasts ~50d from egg to adult.
- 300+ host plants including tree fruit, small fruit, grapes, vegetables, legumes, and ornamentals.

2nd 3rd 4th 5th

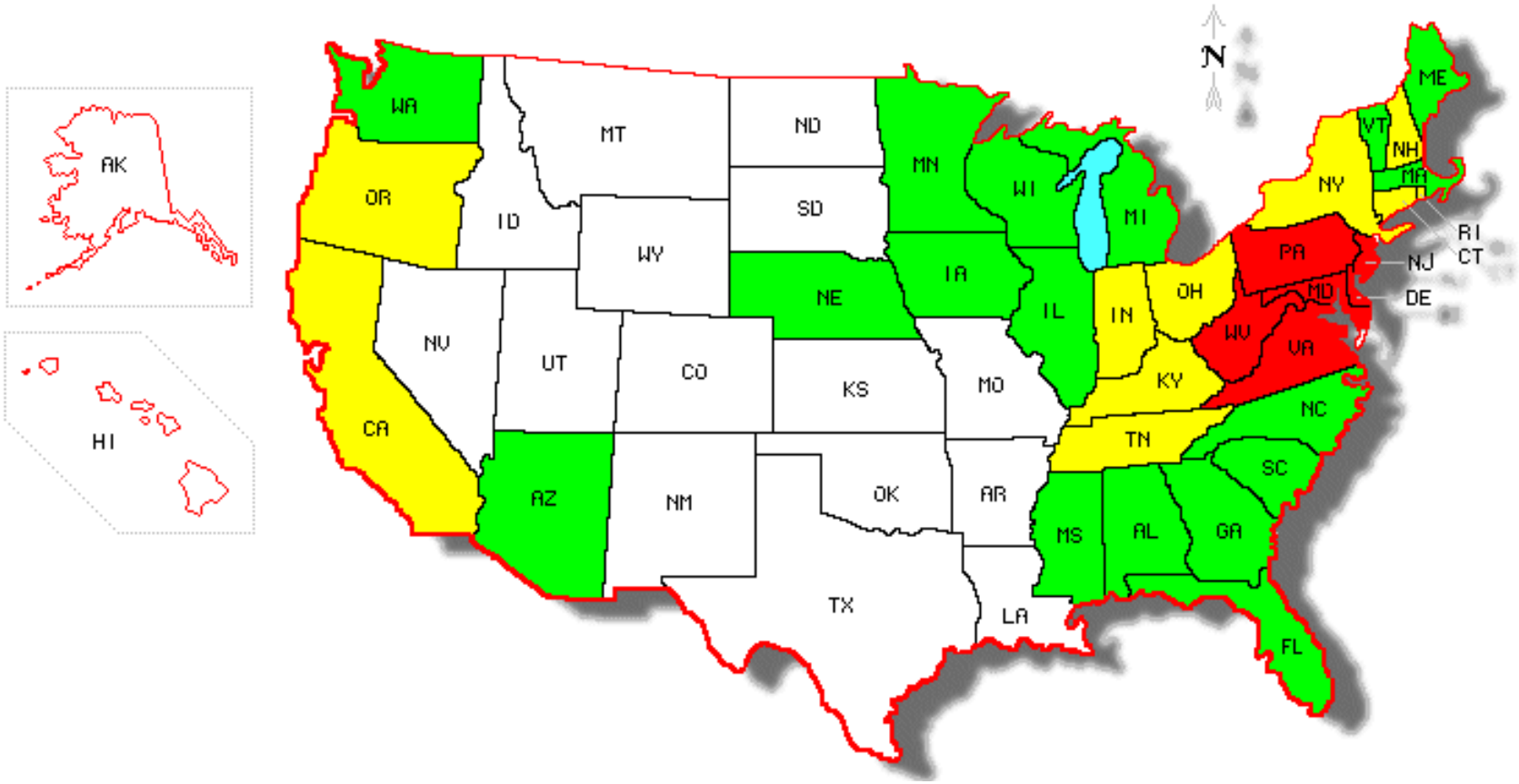
Adult Male

Adult Female

History of BMSB in the United States



Current Distribution of BMSB in the United States



- Severe Agricultural and Nuisance Problems Reported
- Nuisance Problems Only
- Detected

First Maryland BMSB Specimen

Service Information Research

SEL

Systematic Entomology Laboratory

Collected October 8, 2003

Shell Service Station and Snax Store, Hagerstown, MD

Increasing Populations of BMSB 2007-2010

2008-2009 Late Season Problems

- **1,100 acre commercial fruit orchard that produces 500,000 bushels of fruit annually.**
- **In 2009, nearly 10% of all fruit harvested redirected from fresh market to processing due to BMSB injury.**
- **Loss in value can reach 80-90%.**

Large Overwintering Population, Eastern Panhandle, WV. Fall 2009

Winter 2010


MAJOR WINTER STORM
IMPACT FRI NIGHT-SAT
•WHITEOUT CONDITIONS •ROAD CLOSURES
•FLIGHT CANCELATIONS
DISRUPTIVE SNOWFALL
HEAVIEST
STRONG
WINDS
L
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BMSB Early Season Activity
April – June 2010

- BMSB spotted in our experimental orchards by late April.

- Began photographing BMSB during the early season to document the presence of adult activity.

Montmorency Cherry
May 5, 2010

Loring Peach (20 mm Fruit)
May 10, 2010

Seckel Pear
June 10, 2010

Appearance of BMSB Injury in Stone Fruit Late June – Mid July 2010

Adult and Nymphal Feeding on Peach
July 21, 2010

July 29, 2010

July 29, 2010

Total loss of blocks of early-season stone fruit emerging throughout the region.

Adult and Nymphal Feeding on Corn
August 3, 2010

Adult and Nymphal Feeding on Tomato Early-Mid August 2010

Photos courtesy of Clarissa Mathews, Shepherd Univ. and Ames Herbert, VA Tech.

Adult and Nymphal Feeding on Pepper

Early-Mid August 2010

Photos courtesy of Ames Herbert, VA Tech.

Raspberries Mid August 2010 Photos Courtesy of Bryan Butler and Doug Pfeiffer

- Fruit feeding by nymphs and adults.
- Severe feeding leads to shriveled fruit that does not come free from the receptacle.
- Those with less severe injury to druplets left unmarketable.

Adult and Nymphal Feeding on Soybean Mid August 2010

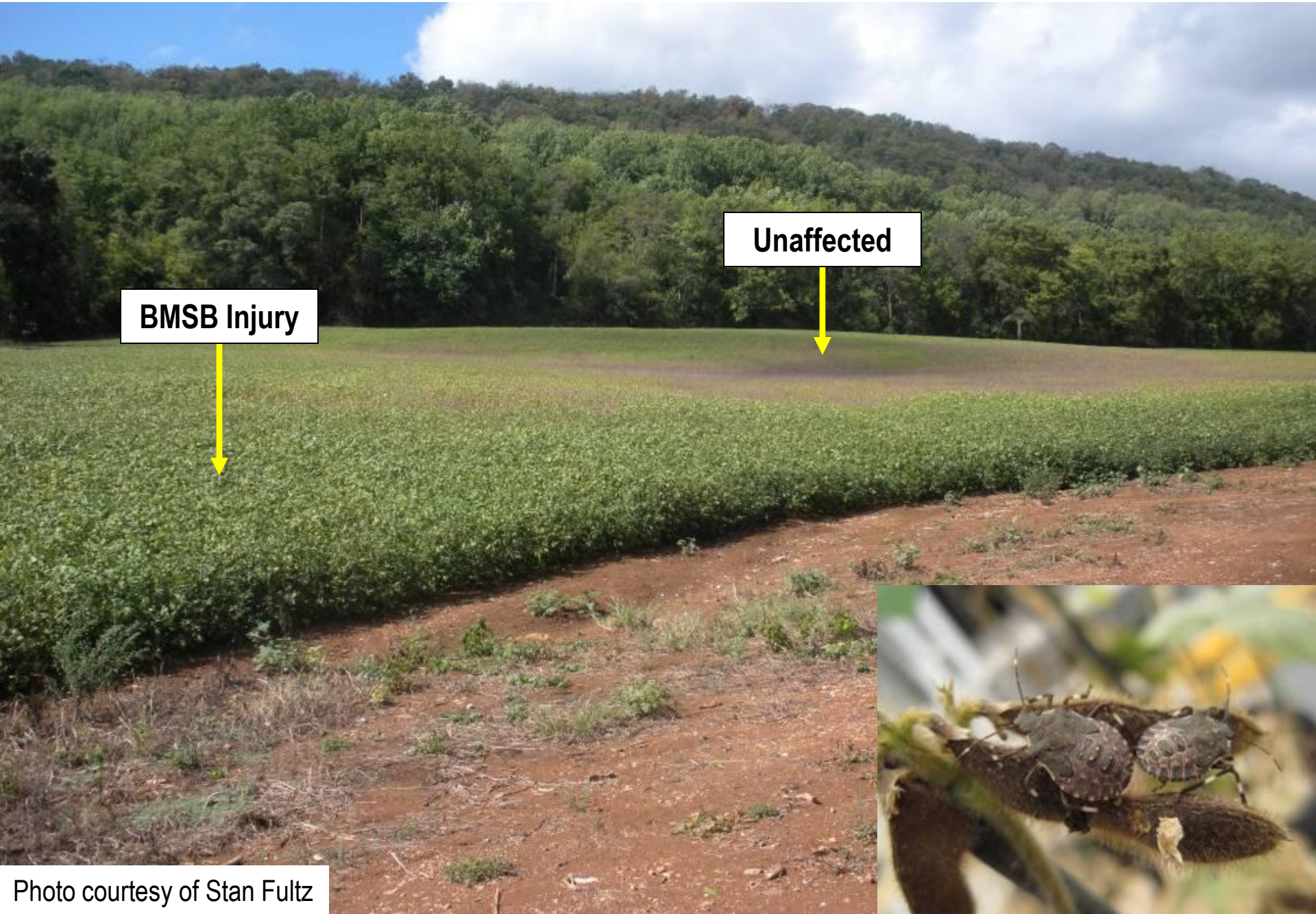


Photo courtesy of Stan Fultz

August 26, 2010 Late-Season Injury on Apple

Ornamentals, Nursery Crops, and Non-Bearing Fruit Trees

Photo courtesy of Kim Hoelmer

BMSB in Grape

Early September 2010

Photos courtesy of Doug Pfeiffer

Photo courtesy of Dean Polk

Hazelnuts

Photo courtesy of Peter Shearer

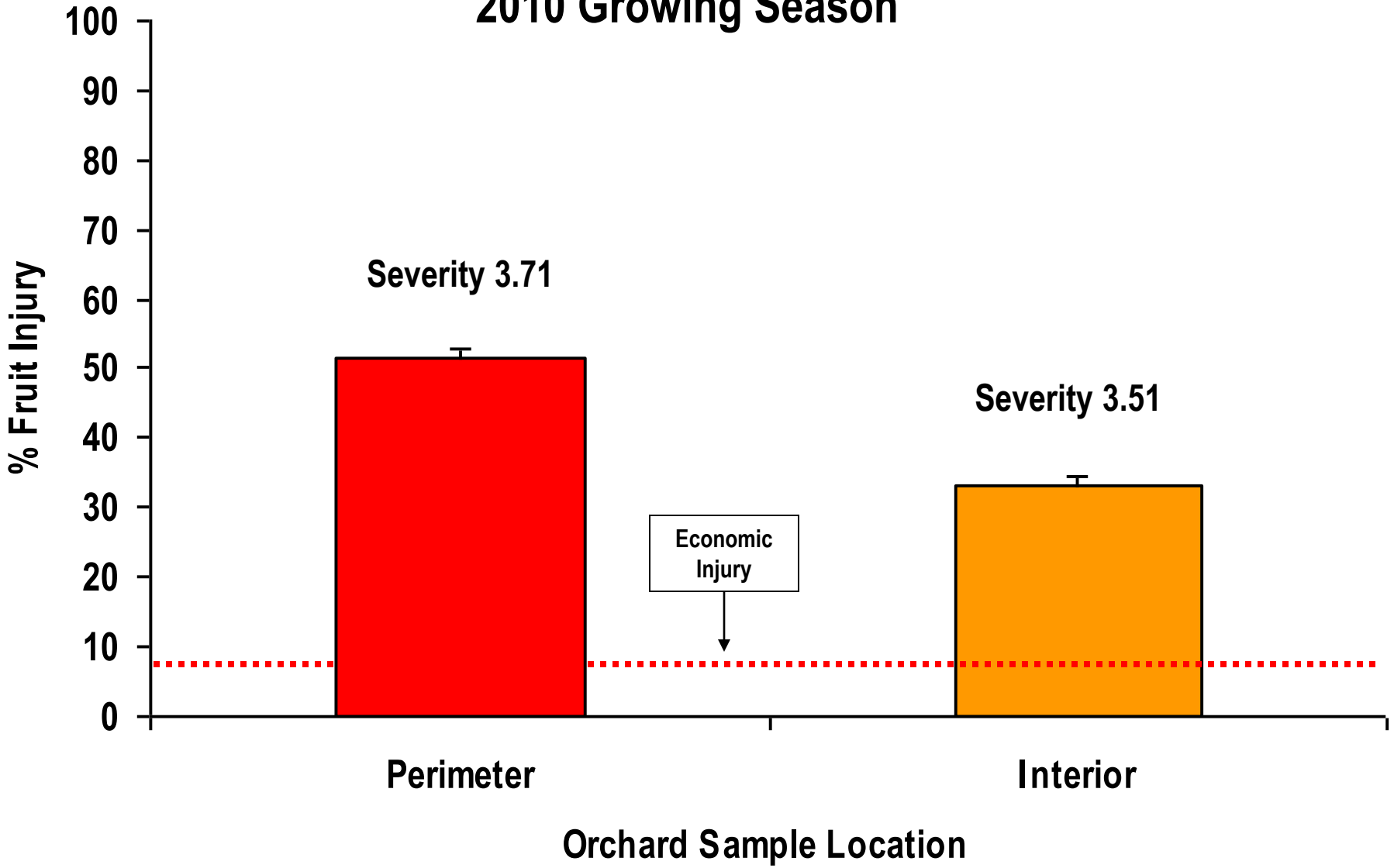
Post-Harvest Issues

No sign of injury when put into cold storage, but ~4-5 weeks later BMSB injury apparent.

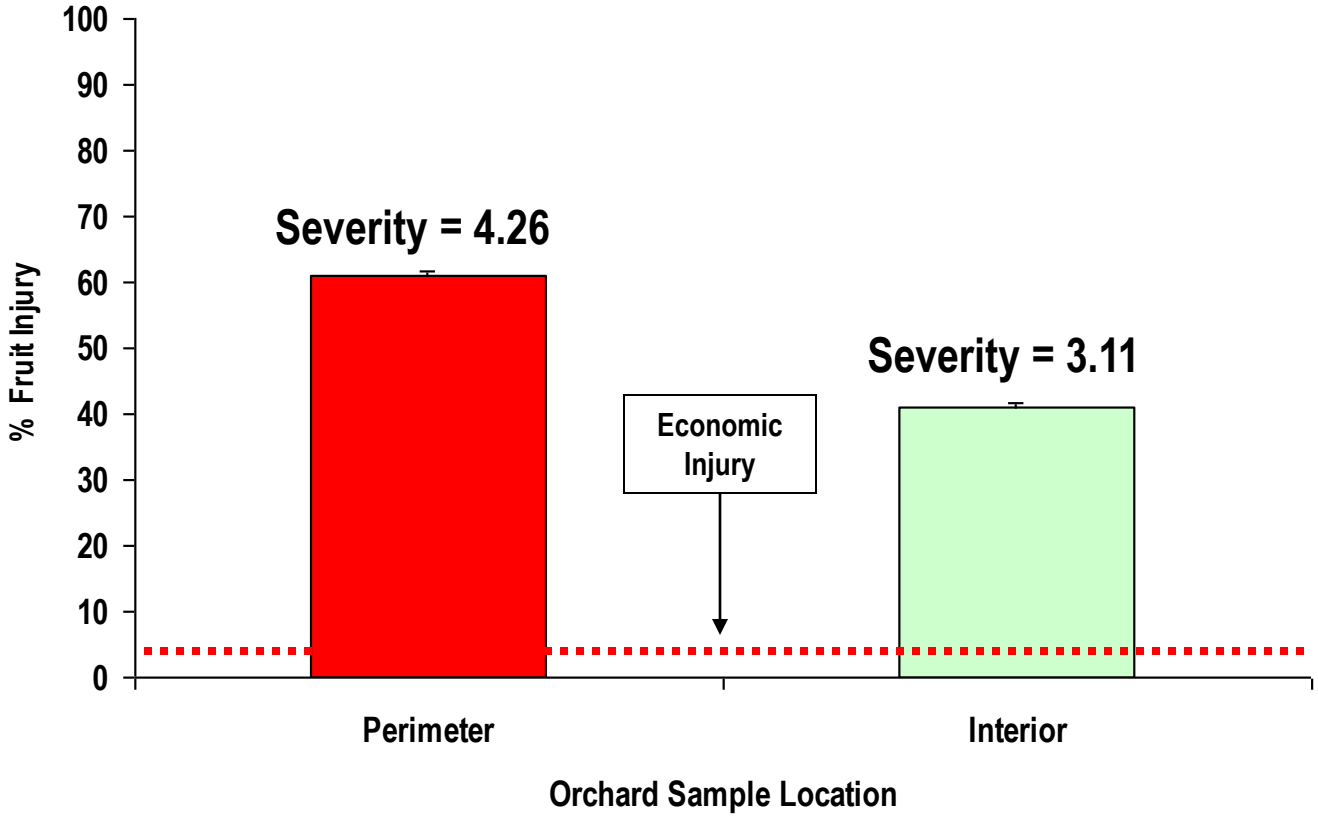
Documenting the Scale of the Threat Posed by BMSB to Tree Fruit

- Conducted a damage survey in commercial apple and peach orchards in WV and MD.
- Develop a repeatable method for assessing total amount and severity of injury to stone and pome fruit.
- Survey from mid-July to harvest.

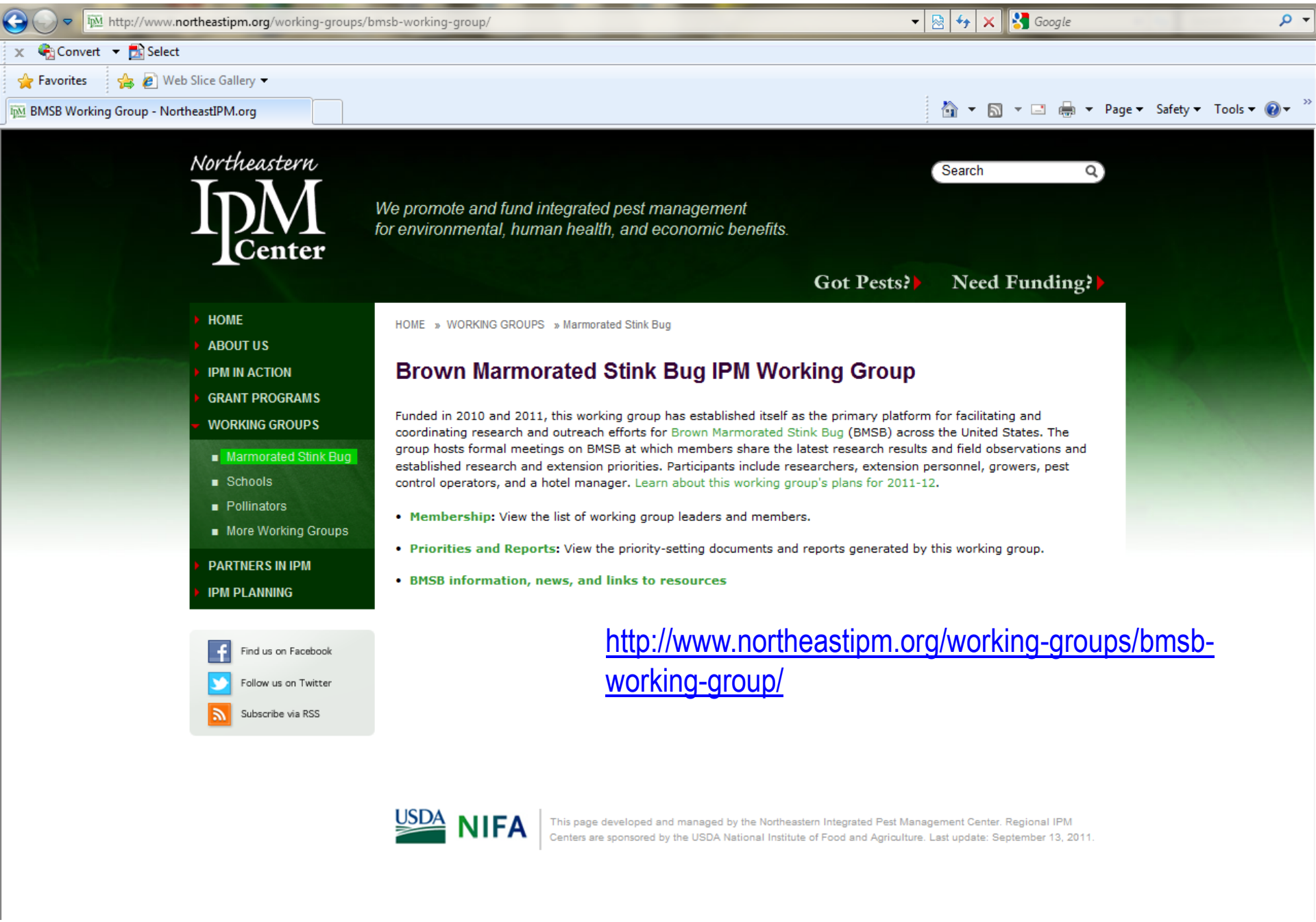
Damage Survey


BMSB Feeding Injury—Rate and Severity
Regional Commercial Peach Orchards
2010 Growing Season
% Fruit Injury
100
90
80
70
60
50
40
30
20
10
0
Severity 3.71
Severity 3.51
Economic Injury
Perimeter
Interior
Orchard Sample Location

BMSB Feeding Injury—Rate and Severity
Regional Commercial Apple Orchards
2010 Growing Season



2010 economic loss in mid-Atlantic apples due to BMSB feeding estimated at 37 million dollars (US Apple Association)


http://www.northeastipm.org/working-groups/bmsb-working-group/
Convert
Select
Favorites
Web Slice Gallery
BMSB Working Group - NortheastIPM.org
Page
Safety
Tools
Northeastern IPM Center
We promote and fund integrated pest management for environmental, human health, and economic benefits.
Search
Got Pests?
Need Funding?
HOME
ABOUT US
IPM IN ACTION
GRANT PROGRAMS
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Marmorated Stink Bug
Schools
Pollinators
More Working Groups
PARTNERS IN IPM
IPM PLANNING
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HOME » WORKING GROUPS » Marmorated Stink Bug
Brown Marmorated Stink Bug IPM Working Group
Funded in 2010 and 2011, this working group has established itself as the primary platform for facilitating and coordinating research and outreach efforts for Brown Marmorated Stink Bug (BMSB) across the United States. The group hosts formal meetings on BMSB at which members share the latest research results and field observations and established research and extension priorities. Participants include researchers, extension personnel, growers, pest control operators, and a hotel manager. Learn about this working group's plans for 2011-12.
Membership: View the list of working group leaders and members.
Priorities and Reports: View the priority-setting documents and reports generated by this working group.
BMSB information, news, and links to resources
http://www.northeastipm.org/working-groups/bmsb-working-group/
USDA NIFA
This page developed and managed by the Northeastern Integrated Pest Management Center. Regional IPM Centers are sponsored by the USDA National Institute of Food and Agriculture. Last update: September 13, 2011.

The New York Times

The Washington Post

TIME

CNNMoney

CBS NEWS

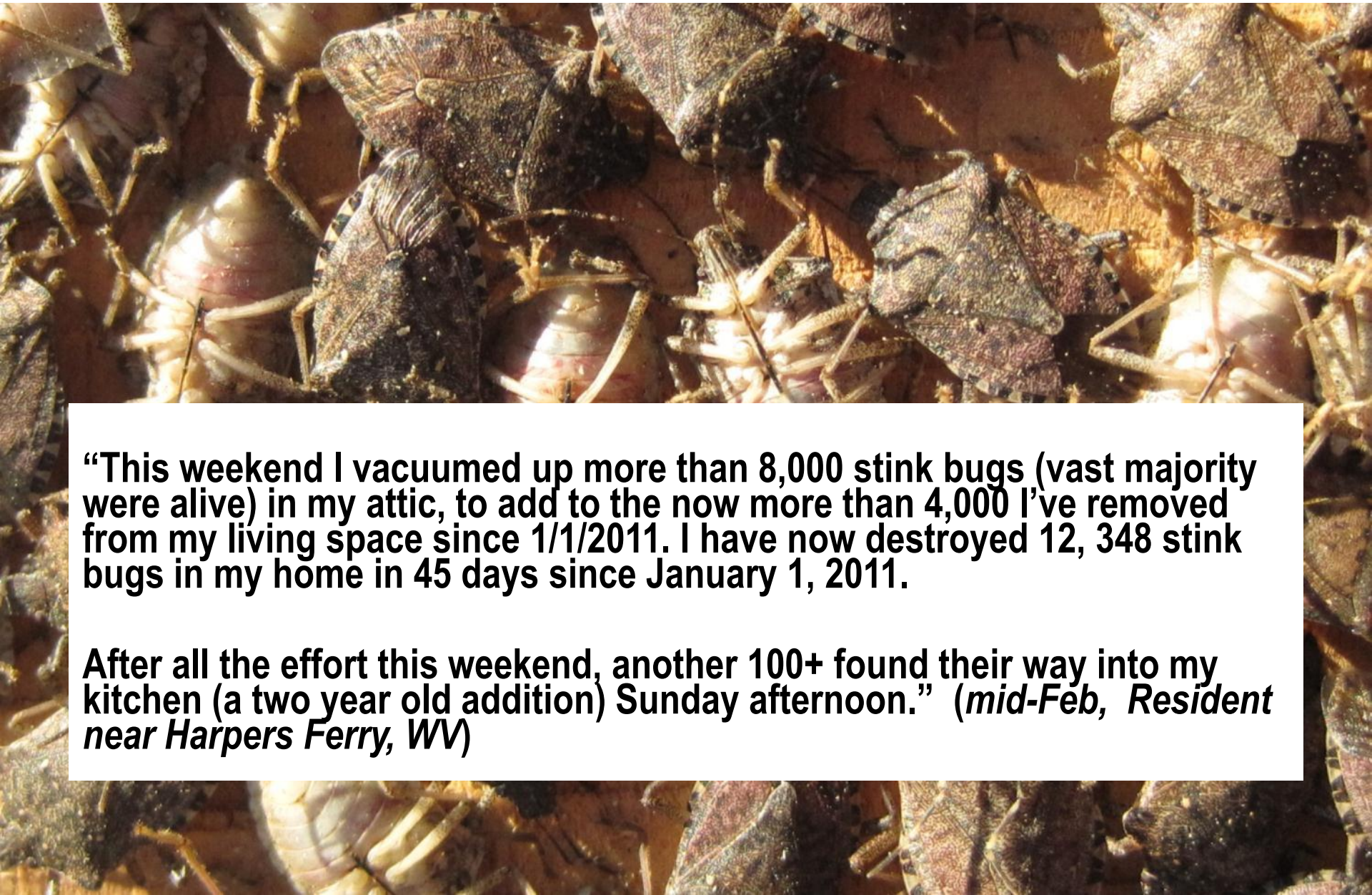
The Philadelphia Inquirer

Move Over, Bedbugs: Stink Bugs Have Landed

Steve Ruark for The New York Times

Kelli Wilson and her father, Richard Lee Pry, cleared stink bugs from her porch Friday in Burkittsville, Md. The shield-shaped invaders have damaged fruit and vegetable crops.

One Homeowner's Plight



"This weekend I vacuumed up more than 8,000 stink bugs (vast majority were alive) in my attic, to add to the now more than 4,000 I've removed from my living space since 1/1/2011. I have now destroyed 12, 348 stink bugs in my home in 45 days since January 1, 2011.

After all the effort this weekend, another 100+ found their way into my kitchen (a two year old addition) Sunday afternoon." (*mid-Feb, Resident near Harpers Ferry, WV*)

Challenges in Managing BMSB in Commercial Plantings

- Tremendous season-long pressure from populations moving from wild and other cultivated hosts into cropped areas leading to constant re-infestation of plots.
- Greatest efficacy observed when adults have direct contact with finished wet spray material. Only a small portion of damaging population likely exposed to this material.
- Avoidance behaviors allow them to potentially escape treatments.
- Insecticides labeled as excellent against native SBs not showing same field efficacy against BMSB. Knock down and recovery observed in grower orchards. Other materials completely ineffective.
- Section 18 Working Group. Fall-Winter laboratory-based insecticide trials by many cooperating institutions.

Laboratory-Based BMSB Insecticide Evaluations

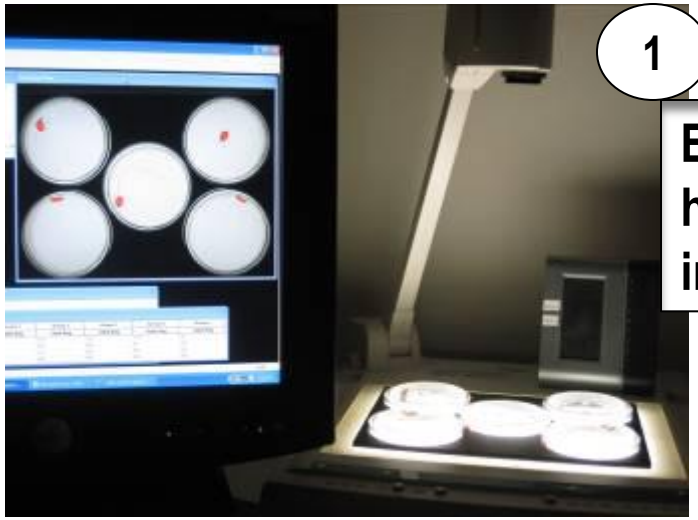
- Because of the constant (season-long) pressure from BMSB populations located outside orchards and other cropped areas, BMSB continuously re-infests plots.

- Thus, immigrating BMSB are unlikely to encounter direct contact with finished (wet) spray material.

- This population poses *the primary threat* to crops. Control depends on residual effectiveness and likelihood of uptake.

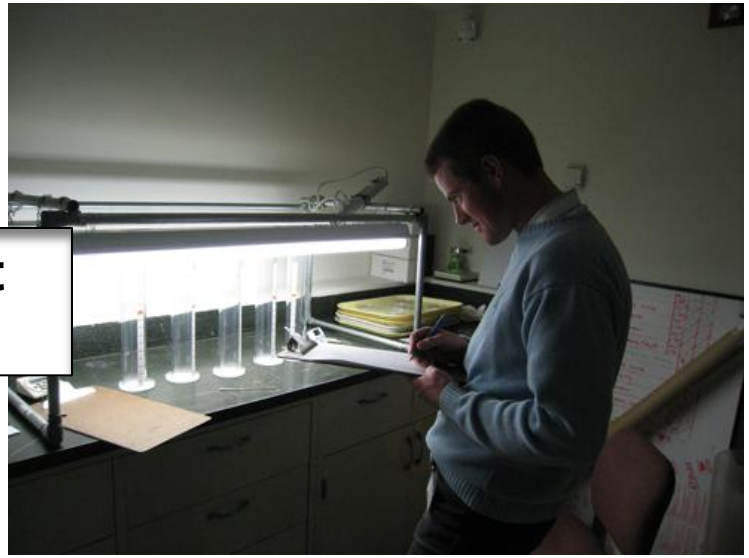
- Laboratory insecticide trials designed to be biologically relevant and based on control of this primary threat.

Experimental Trials



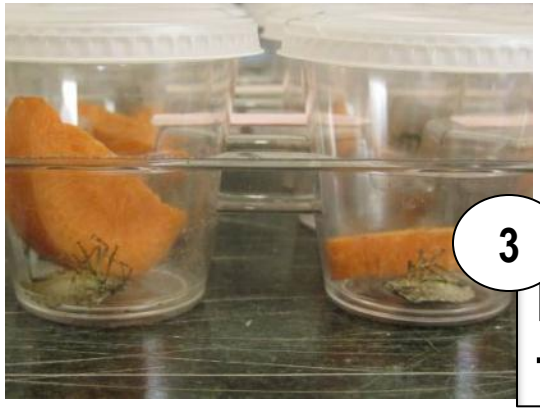
1

EthoVision trials for measuring horizontal mobility in no-choice insecticide-treated surfaces for 4.5h.



2

Direct observations of vertical movement capacity following insecticide exposure.



3

Mortality tracked for 7-d followed by final vertical movement trial.

BMSB Insecticide Evaluations
Sample Tracks

Water (Control) 505 microliters per arena

0 Hours Exposure
Track 00006
94.11 cm
145.31 sec

1 Hour Exposure
Track 00029
121.00 cm
125.13 sec

2 Hours Exposure
Track 00064
53.68 cm
105.11 sec

Warrior (Pyrethroid) 1.0 fl. oz. per 100 gallons

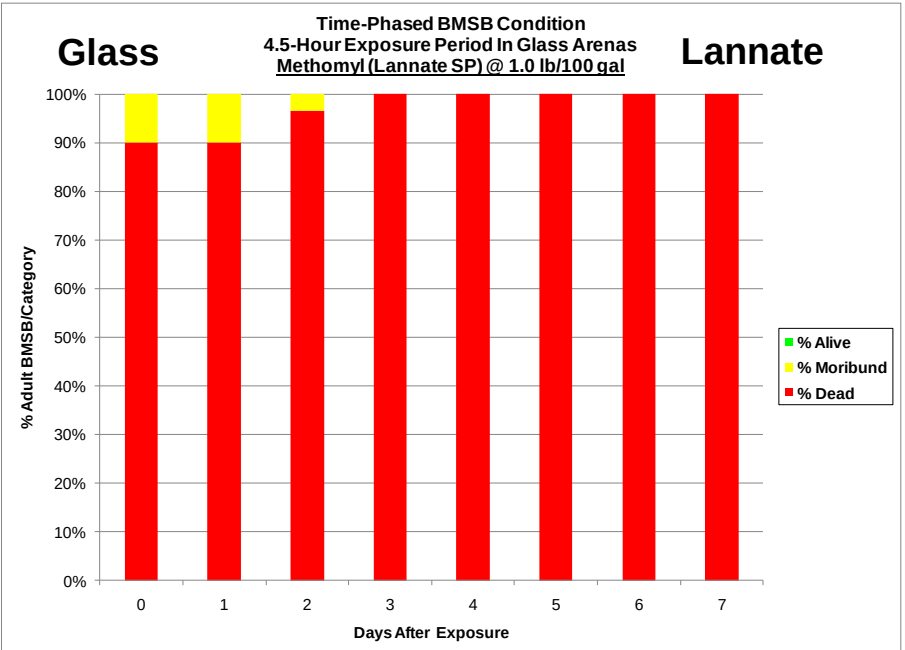
0 Hours Exposure
Track 00073
147.78 cm
343.34 sec

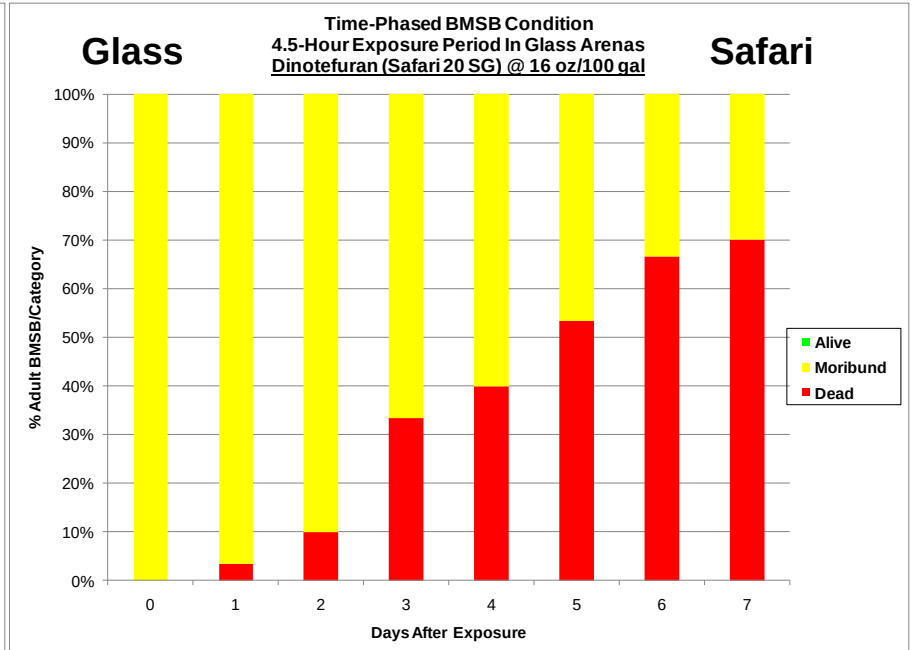
1 Hour Exposure
Track 00098
42.34 cm
79.41 sec

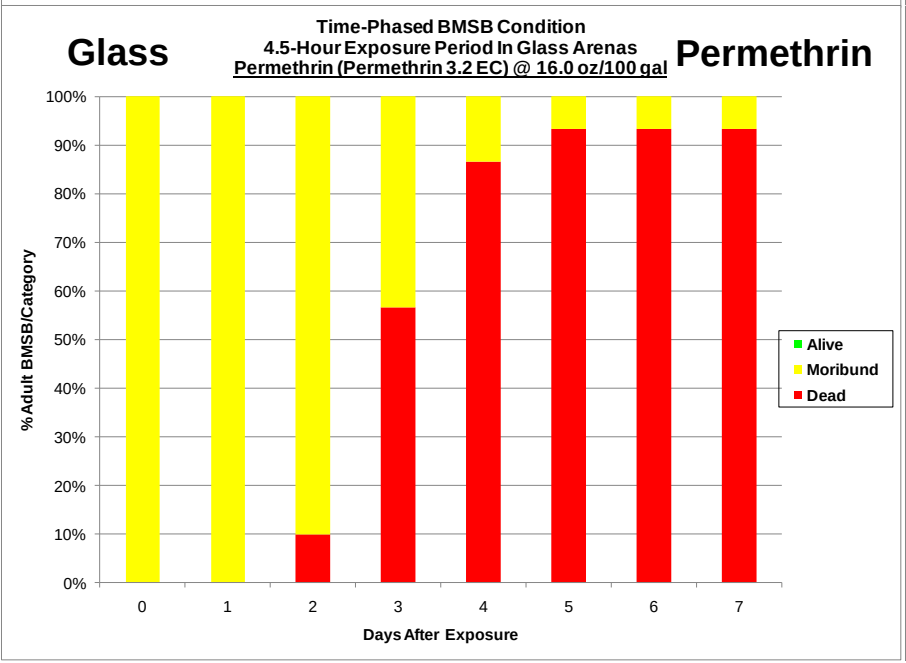
2 Hours Exposure
Track 00117
0.54 cm
0.83 sec

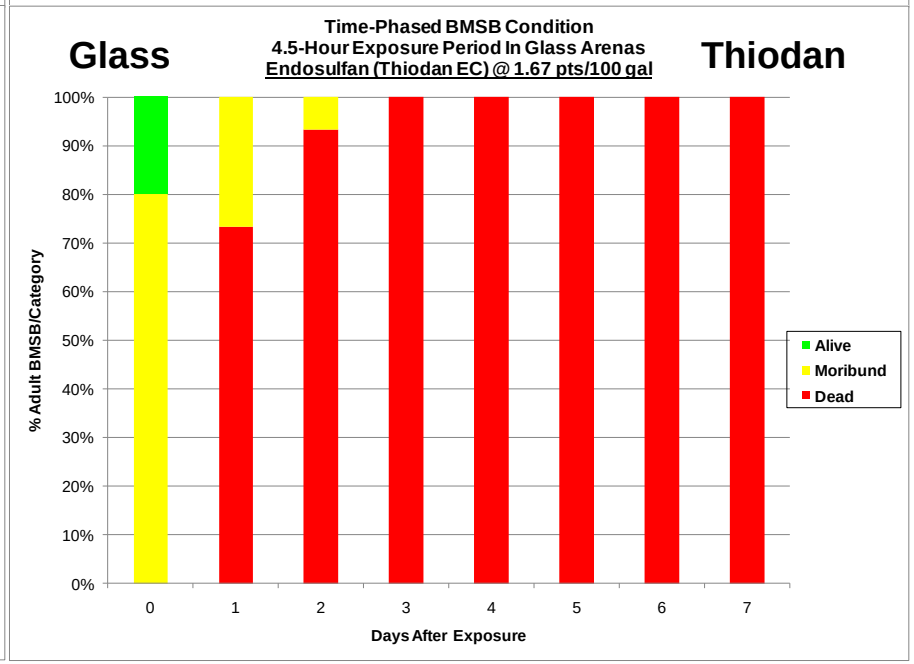
BMSB Insecticide Evaluations
7-Day Survivorship

Promising Compounds

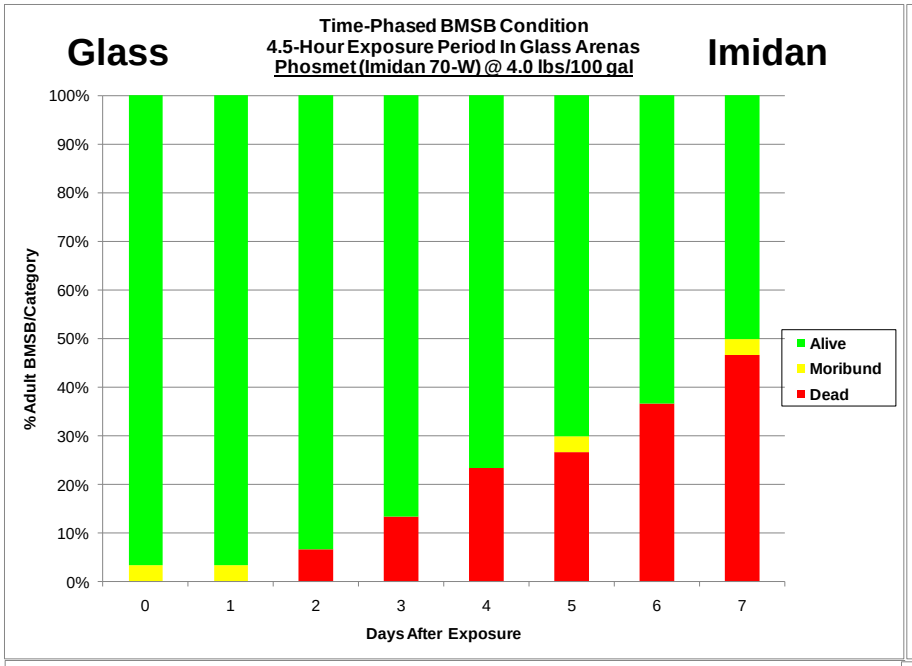


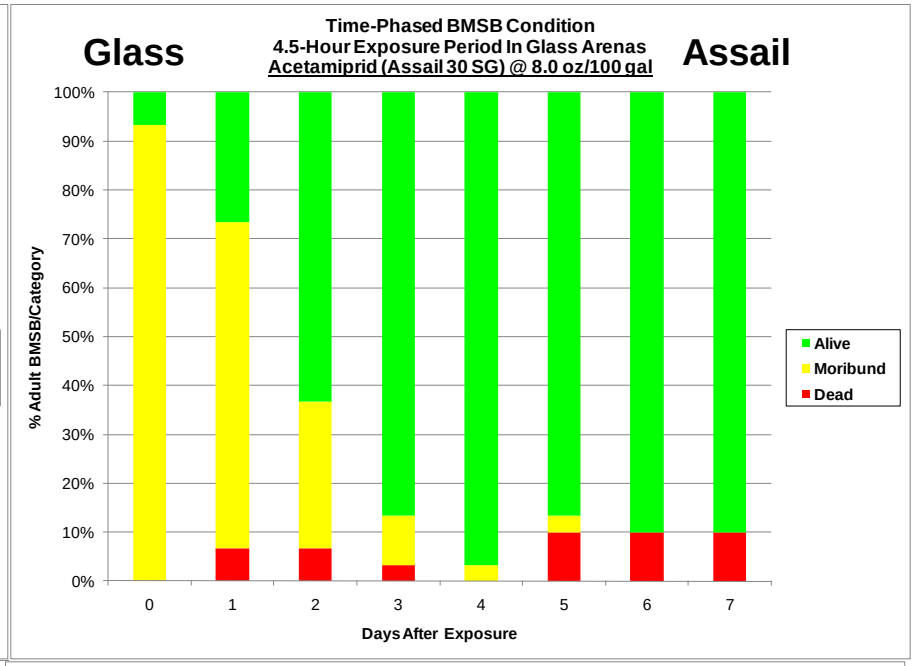


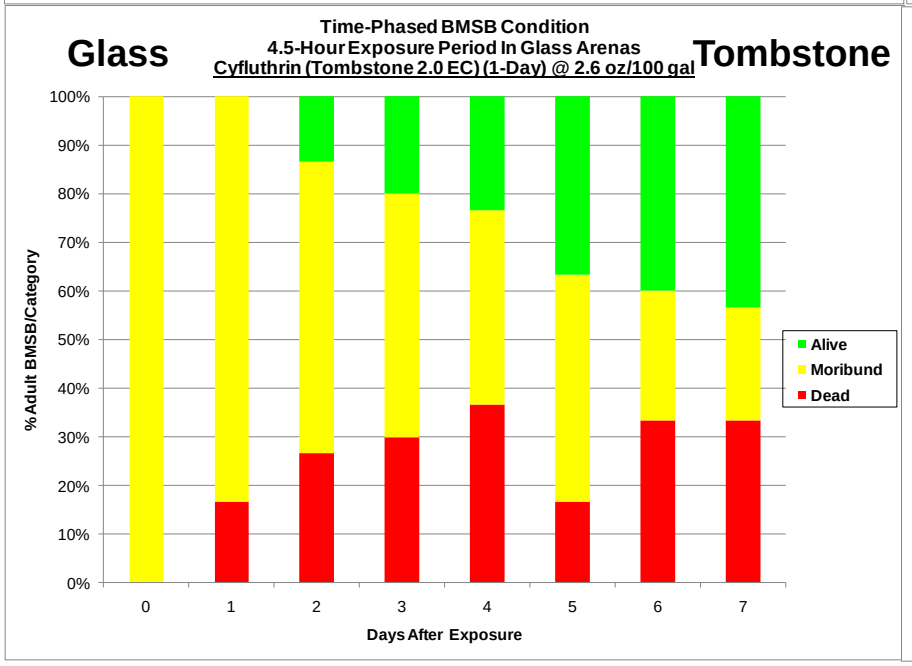


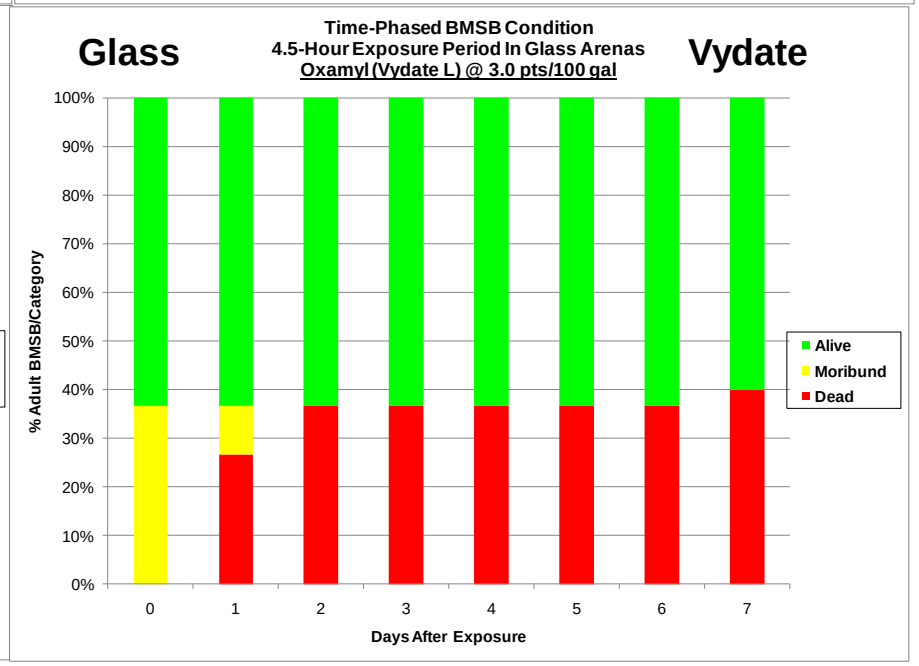


Weaker Materials









BMSB Toxicity Testing
Lethality Index

$$\text{Lethality Index} = \left[\frac{\Sigma \text{ Day 0-7}}{[(\text{BMSB Alive} \times 0.0) + (\text{BMSB Moribund} \times 0.5) + (\text{BMSB Dead} \times 1.0)]} \right] \times 100$$

$$\frac{\Sigma \text{ Day 0-7}}{240}$$

The maximum value of the Lethality Index for each material is 100.0; the minimum value is 0.0, and compounds are ranked in descending order of value.

* After testing ~45 materials, the Lethality Index was modified to accommodate four conditional categories: Alive (0.0); Affected (0.25); Moribund (0.75); and Dead (1.0). This change in conditional interpretation does not change the comparability of Lethality Index across tested materials.

BMSB Toxicity Testing
Lethality Index

Active Ingredient	Trade Name	Lethality Index	Active Ingredient	Trade Name	Lethality Index
Chlorpyrifos/Gamma-Cyhalothrin	Cobalt	**95.4**	Oxamyl	Vydate	**46.8**
Dimethoate	Cygon	**93.3**	MBI-203	MBI-203	**43.4**
Malathion	Malathion	**92.5**	Esfenvalerate	Asana	**43.3**
Bifenthrin	Brigade	**91.5**	Imidacloprid	Provado	**40.0**
Endosulfan	Thionex	**90.4**	Tolfenpyrad SC	Tolfenpyrad SC	**36.5**
Methidathion	Supracide	**90.4**	MBI-205	MBI-205	**35.7**
Methomyl	Lannate	**90.1**	Tolfenpyrad EC	Tolfenpyrad EC	**33.3**
Chlorpyrifos	Lorsban	**89.0**	Pyrifluquinazon	Pyrifluquinazon	**28.3**
Acephate	Orthene	**87.5**	Kaolin Clay	Surround	**23.1**
Fenpropathrin	Danitol	**78.3**	Diazinon	Diazinon	**20.4**
Permethrin	Permethrin	**77.1**	Phosmet	Imidan	**20.0**
Azinphosmethyl	Guthion	**71.3**	Acetamiprid	Assail	**18.8**
Dinotefuran	Safari	**67.3**	Thiacloprid	Calypso	**18.3**
Kaolin Clay/Thiamethoxam	Particle Delivery	**66.7**	Abamectin	Agri-Mek	**16.3**
Formetanate HCl	Carzol	**63.5**	Indoxacarb	Avaunt	**11.3**
Gamma-Cyhalothrin	Proaxis	**59.0**	Spirotetramat	Movento	**9.8**
Zinc Dimethyldithiocarbamate	Ziram	**57.5**	Carbaryl	Sevin	**9.2**
Thiamethoxam	Actara	**56.3**	Water	Control 6	**9.2**
Clothianidin	Clutch	**55.6**	Flonicamid	Beleaf	**7.7**
Beta-Cyfluthrin	Baythroid	**54.8**	Water	Control 2	**6.9**
Lambda-Cyhalothrin	Warrior	**52.9**	Water	Control 3	**6.3**
Zeta-Cypermethrin	Mustang Max	**52.1**	Water	Control 5	**6.0**
Cyfluthrin	Tombstone	**49.0**	Water	Control 4	**4.2**
MBI-206	MBI-206	**48.4**	Cyantraniliprole	Cyazypyr	**1.7**

Monitoring BMSB Threat in Commercial Orchards in 2011

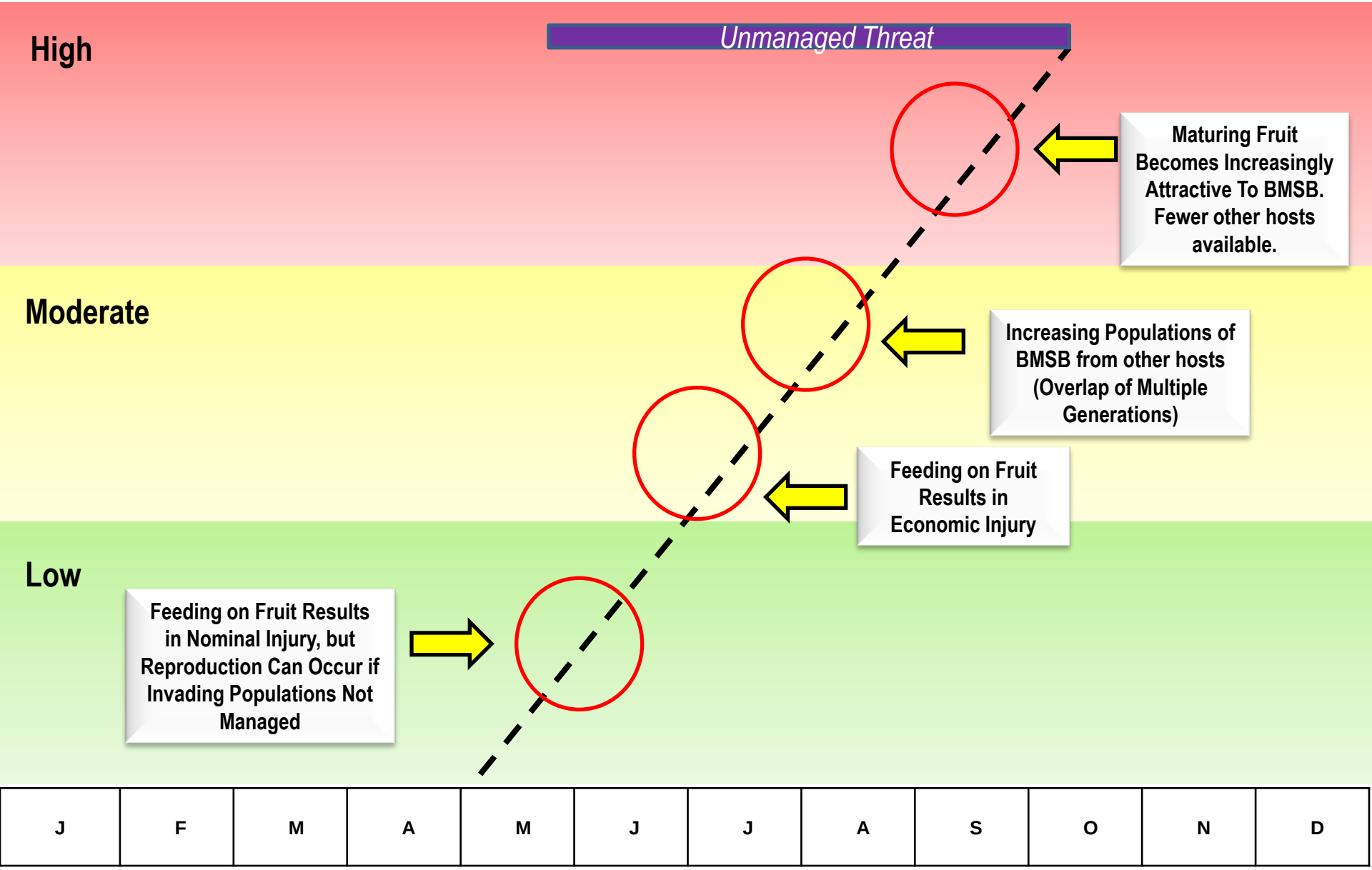
Growers Dealt With Threat With Threat With Aggressive Insecticide Programs

- The single most important pest growers attempted to manage was BMSB.
- Growers used broad-spectrum insecticides against BMSB.
- Growers treated much more frequently. Often 2-4x more applications than in prior years.
- Growers treated areas outside orchards (bordering wood lots and hedgerows).
- If a grower began to ease up, increases in injury soon were detected.

Impact of Aggressive Insecticide Programs

- Costs are up tremendously. Costs include materials (insecticides, fuel, spray equipment) and labor.
- Growers are relying on materials that are slated for cancellation.
- Integrated Pest Management (IPM) programs have been devastated because of need for broad spectrum insecticides. Secondary pest problems are requiring treatment.
- This approach is not sustainable.

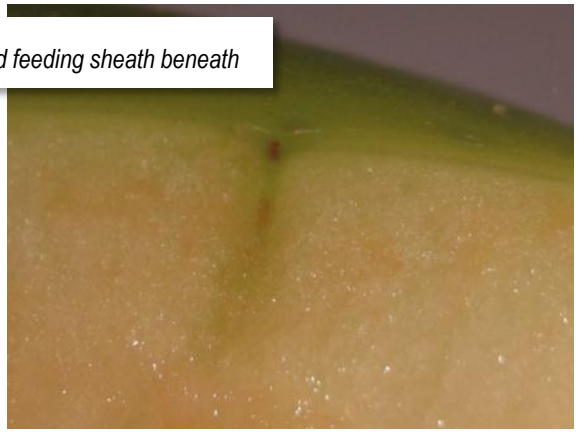
BMSB Threat To Apples



Early Season Superficial Injury

Early season feeding results in nominal injury with discolored dot and feeding sheath beneath





Mid-Season Economic Injury

Mid season feeding results in possible discolored depressions and flesh surrounding feeding sheath appearing corky



Mid-Late Season Economic Injury

Mid-late season feeding results in discolored depressions with larger, corky areas in flesh



JUNE 2011

SPRAY SCHEDULE - BMSB

* every other row lg. apples, peaches
* every 4th row Bellis apples

			1	2 — ARMS in stone fruit, pome fruit + brambles	3 apples - peaches -	McHenry Highland Festival* Blueberries Brambles Cherries (4th)
5	6 apples peaches, plums strawberries (OUTSIDE)	7 cherries ½ potatoes tomatoes vegetables	8 cherries ½ ½ brambles ½ blueberry blackberry	9 apples peaches, plums (INSIDE)	10 blueberries 39/40 44 brambles 13, 15, 16, 44, 41	Early Summer Seasrates begin this weekend Crack spray cherries 11
12 Apples Peaches (OUTSIDE)	13 veg. tomatoes cherries grapes, gooseb plums, apricot	14 Blueberries Brambles	15 Apples peaches (IPSIDE) Blueb. (admire)	16 Crack spray cherries cherries tomatoes, flowers	17 Blueberries brambles vegetables cherries Crack spray	Peach Apple (OUTSIDE 18
Father's Day 19	20 Brambles, Blueberries grapes, gooseberries (OUTSIDE)	21 Peaches apples (INSIDE)	22 cherries/plums (inside)	23 Bramble (inside) Blueberry (inside)	24 peach apple (outside)	Summer Season rat begin this weekend 25
Brambles Blueberries (outside) (#50/48) 26	27 apple pear inside cherry	28 tomatoes veg. flowers potatoes	29 Brambles Blueberries (inside)	30 Apples Peaches (OUTSIDE)	7/1 tomatoes, veg potatoes, flowers	7/2 woods edge ostlers

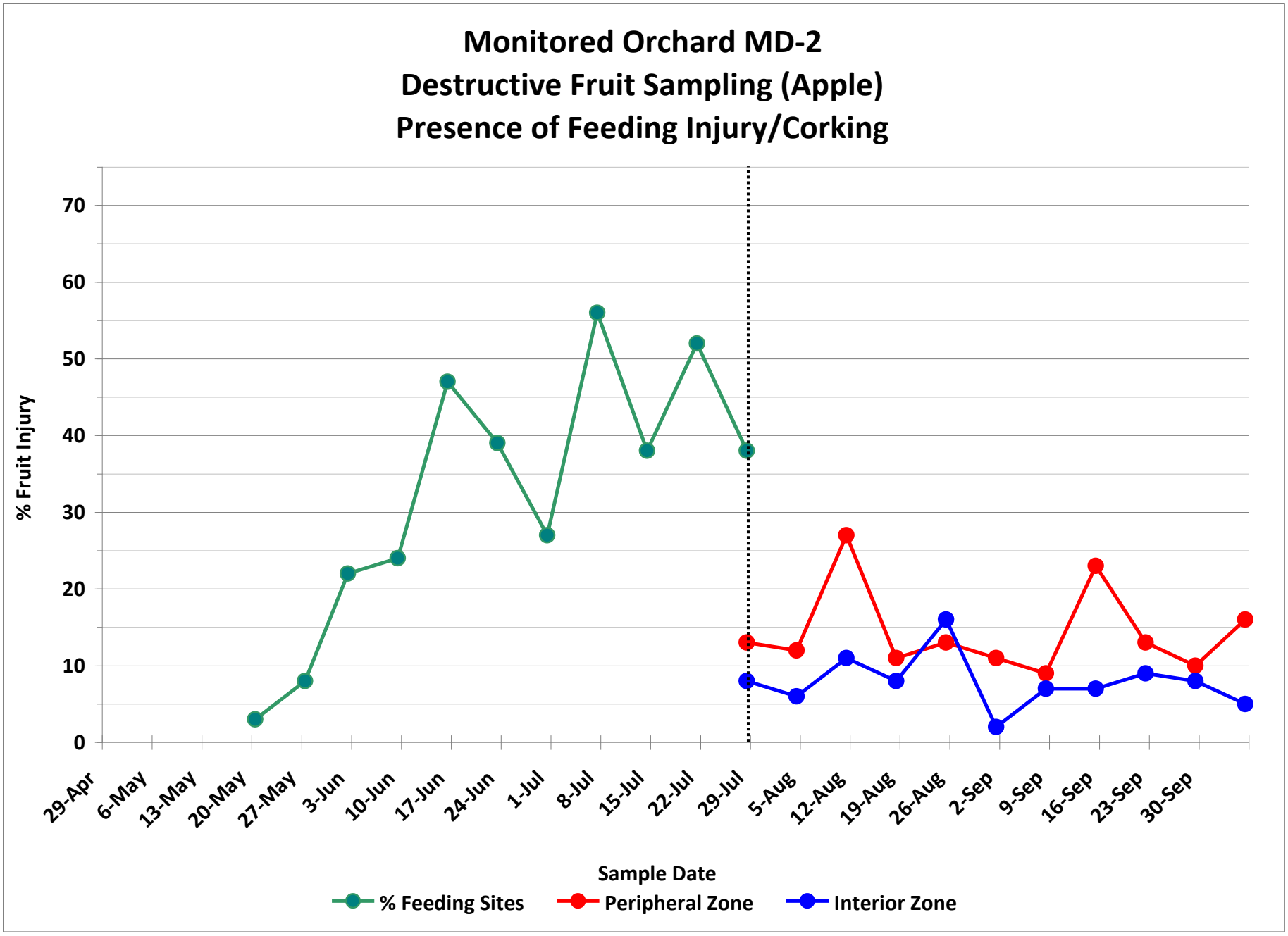
BMSB - SPRAY SCHEDULE July 2011

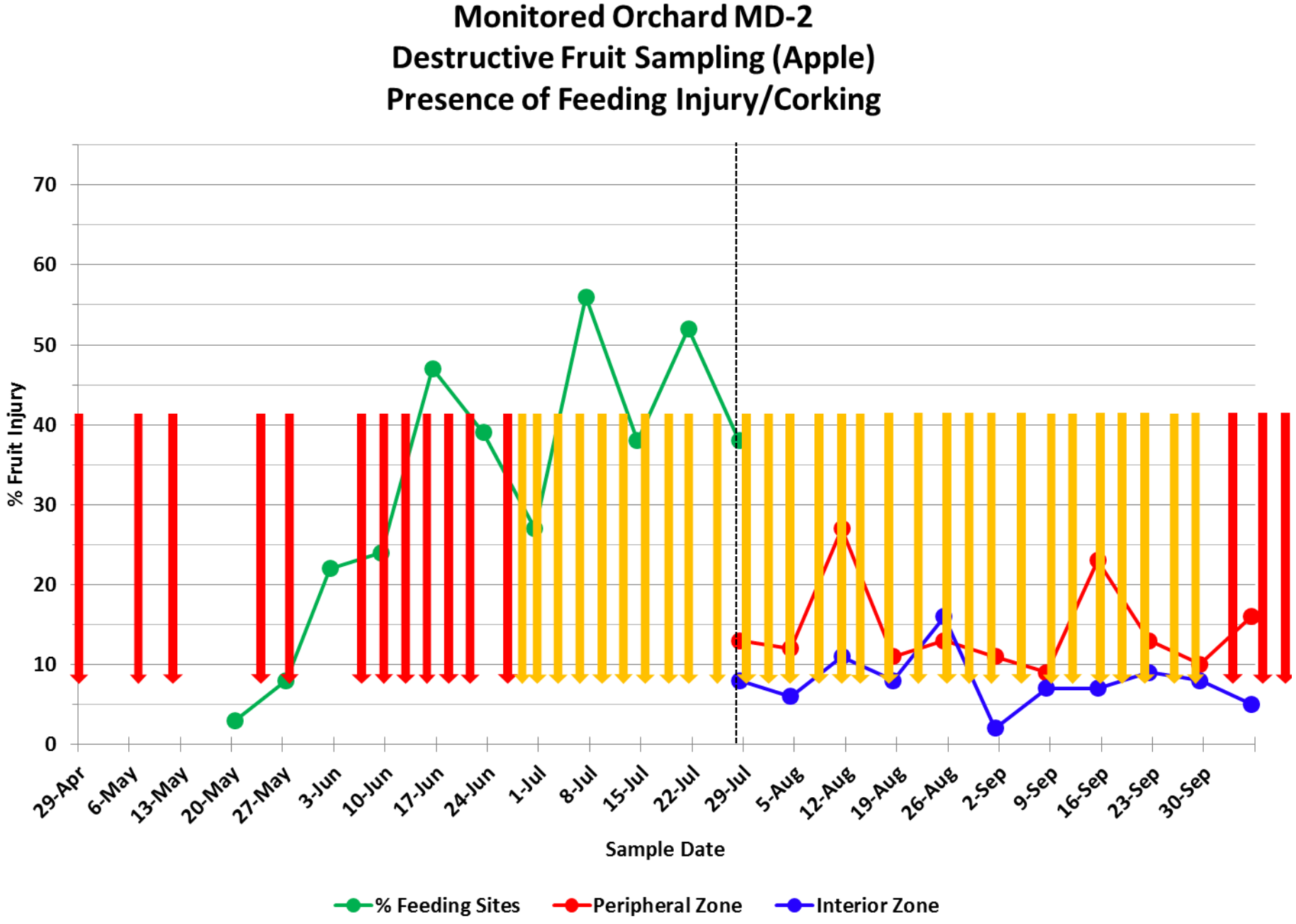
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
JUNE: 1 2 3 4 / 5 6 7 8 9 10 11 / 12 13 14 15 16 17 18 / 19 20 21 22 23 24 25 / 26 27 28 29 30	AUGUST: 1 2 3 4 5 6 / 7 8 9 10 11 12 13 / 14 15 16 17 18 19 20 / 21 22 23 24 25 26 27 / 28 29 30 31			(12, 13, 15 Brigade)	1 tomatoes, vegs potatoes, flowers	2 woodsedge's (sutton field) (barn field) (Shipley field) ORthene
3 Peaches apples (inside)	4 Cherries full coverage ORthene postharvest Independence Day	grapes 5 (outside) blueberries brambles	6 apples peaches (outside)	7 (1x week)	8 tomatoes potatoes, vegs, flowers (OUTSIDE)	9 Apples peaches (INSIDE)
10 (ORthene) farm perimeter (inside)	11 tomatoes vegs flowers (inside) Brambles Blueberries	12 apples peaches (outside)	13 (done Sunday AM) (1x per wk)	14 tomatoes vegs. flowers potatoes (outside)	15 apples peaches (inside)	16
17 (see 7/14)	18 apples peaches (outside)	19	20 (outside) blueberries Brambles	21 apples peaches (inside)	22 tomatoes Vegs. flowers	23
Monday Aug (1st) 24 raspberries blackberries (outside) 31 flowers vegs tomatoes (outside)	25 apples peaches (outside) blueberries brambles (inside)	26 sprayed Tuesday Wed	27 Pumpkins	28 flowers Vegs, tomatoes apples peaches (inside)	29	30

apples peaches (outside) (inside)

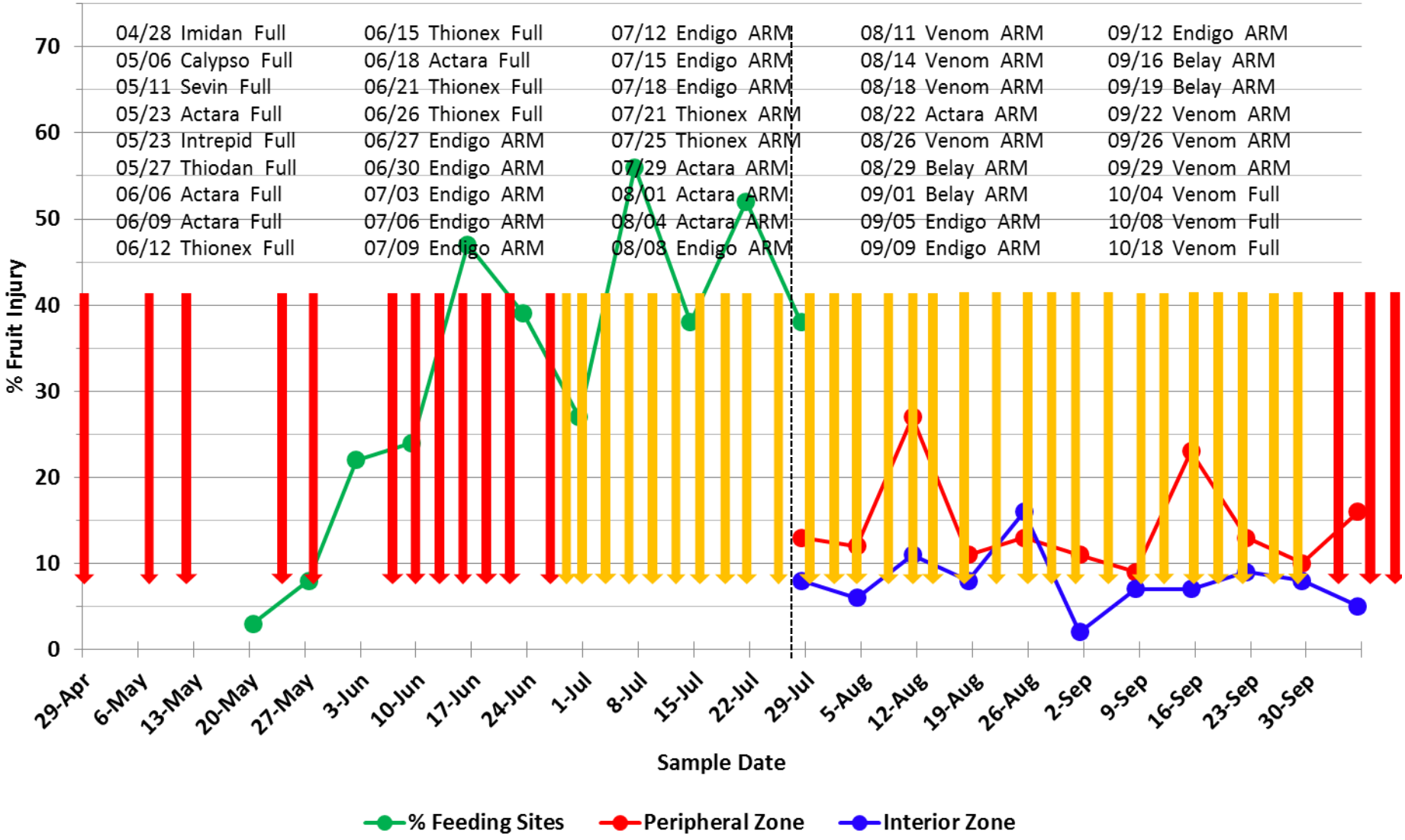
Stayman cracking
Retain apples galas
Stubs rous [illegible] NOT Finished

(potatoes - 1 TIME weekly)


Monitored Orchard MD-2
Destructive Fruit Sampling (Apple)
Presence of Feeding Injury/Corking
% Fruit Injury
0
10
20
30
40
50
60
70
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep
9-Sep
16-Sep
23-Sep
30-Sep
Sample Date
% Feeding Sites
Peripheral Zone
Interior Zone


Monitored Orchard MD-2
Destructive Fruit Sampling (Apple)
Presence of Feeding Injury/Corking
% Fruit Injury
0
10
20
30
40
50
60
70
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep
9-Sep
16-Sep
23-Sep
30-Sep
Sample Date
% Feeding Sites
Peripheral Zone
Interior Zone

Monitored Orchard MD-2
Destructive Fruit Sampling (Apple)
Presence of Feeding Injury/Corking



Differential Harvest Has Been Necessary

Losses of 5-15% being reported so far.

Development of Effective Monitoring Traps

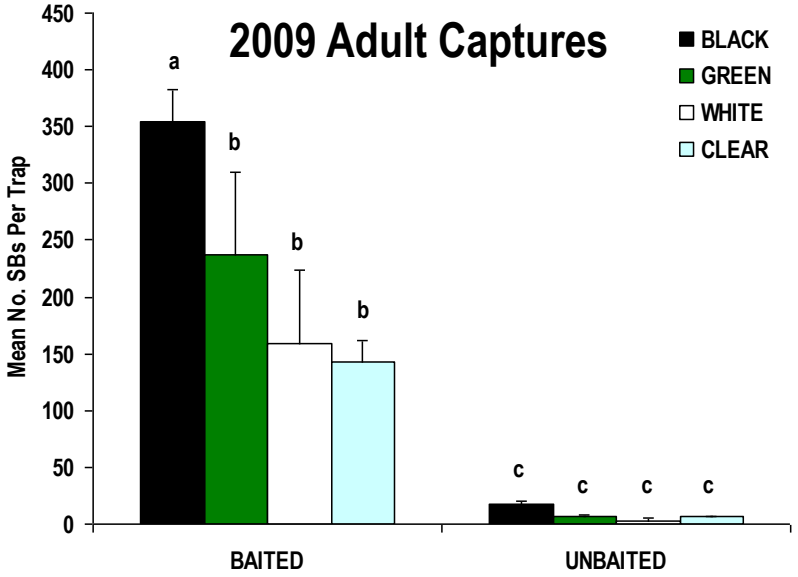
- Presence, abundance, and seasonal activity of BMSB.
- Growers can make informed management decisions.
- Four key components
  - Olfactory cues
  - Visual cues
  - Capture mechanism
  - Deployment strategy

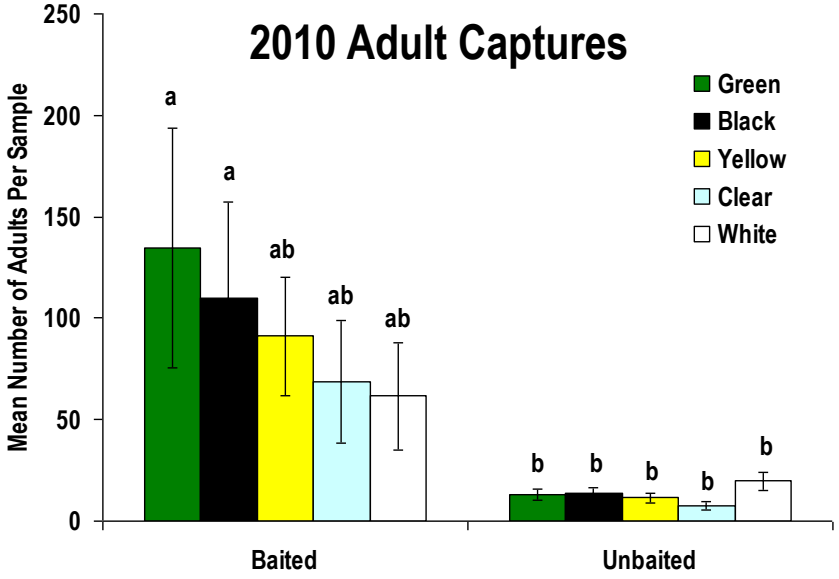
Visual Cues

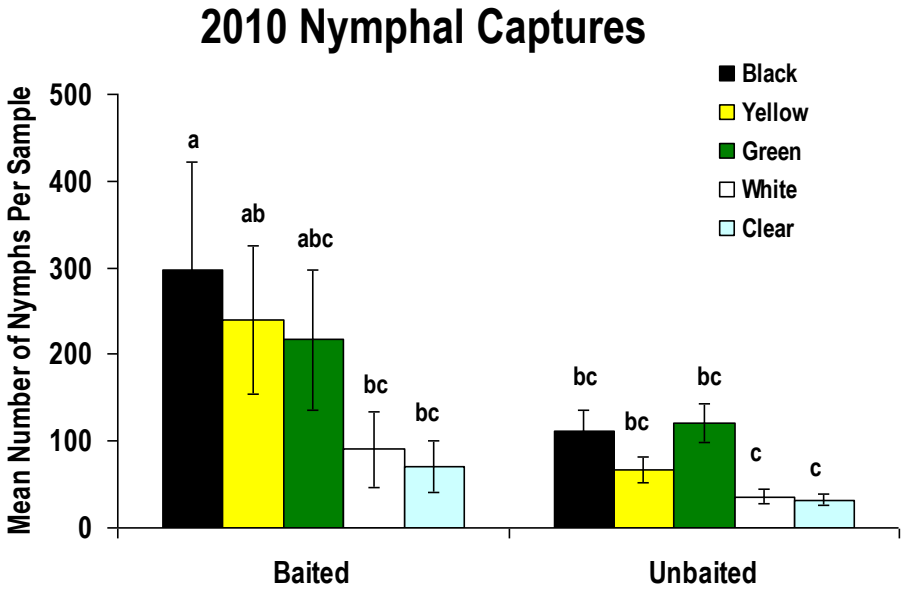
Black	Green	Yellow	White	Clear
				
Trunk Mimic	Foliar Stimulus	Foliar Stimulus	Unapparent Stimulus	Unapparent Stimulus

- Responses to visual stimuli associated with trap bases.
- Baited with methyl (2E, 4E, 6Z)-decatrienoate or left unbaited.
- Traps deployed at the periphery of orchards blocks
- Captures from October 7-November 17, 2009 and July 23-October 14, 2010.

Greatest Adult and Nymphal Captures in Baited Traps with Dark Visual Base







Our Only Attractant Fails During the Early- and Mid-Season

Methyl (*2E,4E,6Z*)-decatrieonate attractive to adults only during the late-season. Confirmed in MD, NJ, PA, VA, WV and other states in 2011 not attractive in early season, despite reports in Asian literature.

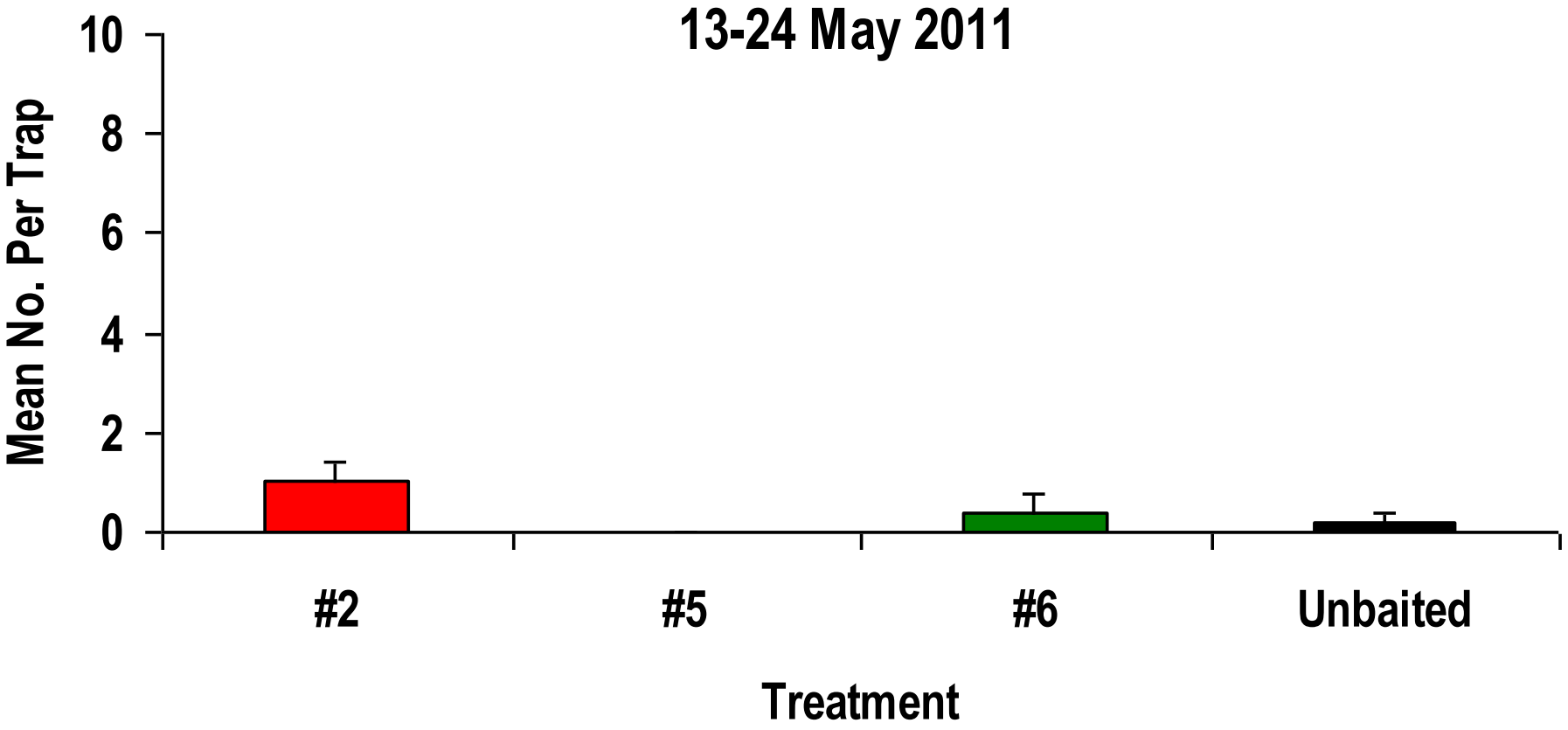
How Can We Improve our Monitoring Traps

- ***Integrate Optimized Olfactory Stimuli***
  - A season-long olfactory attractant for BMSB.
  - Identification of a potential male-produced aggregation pheromone.

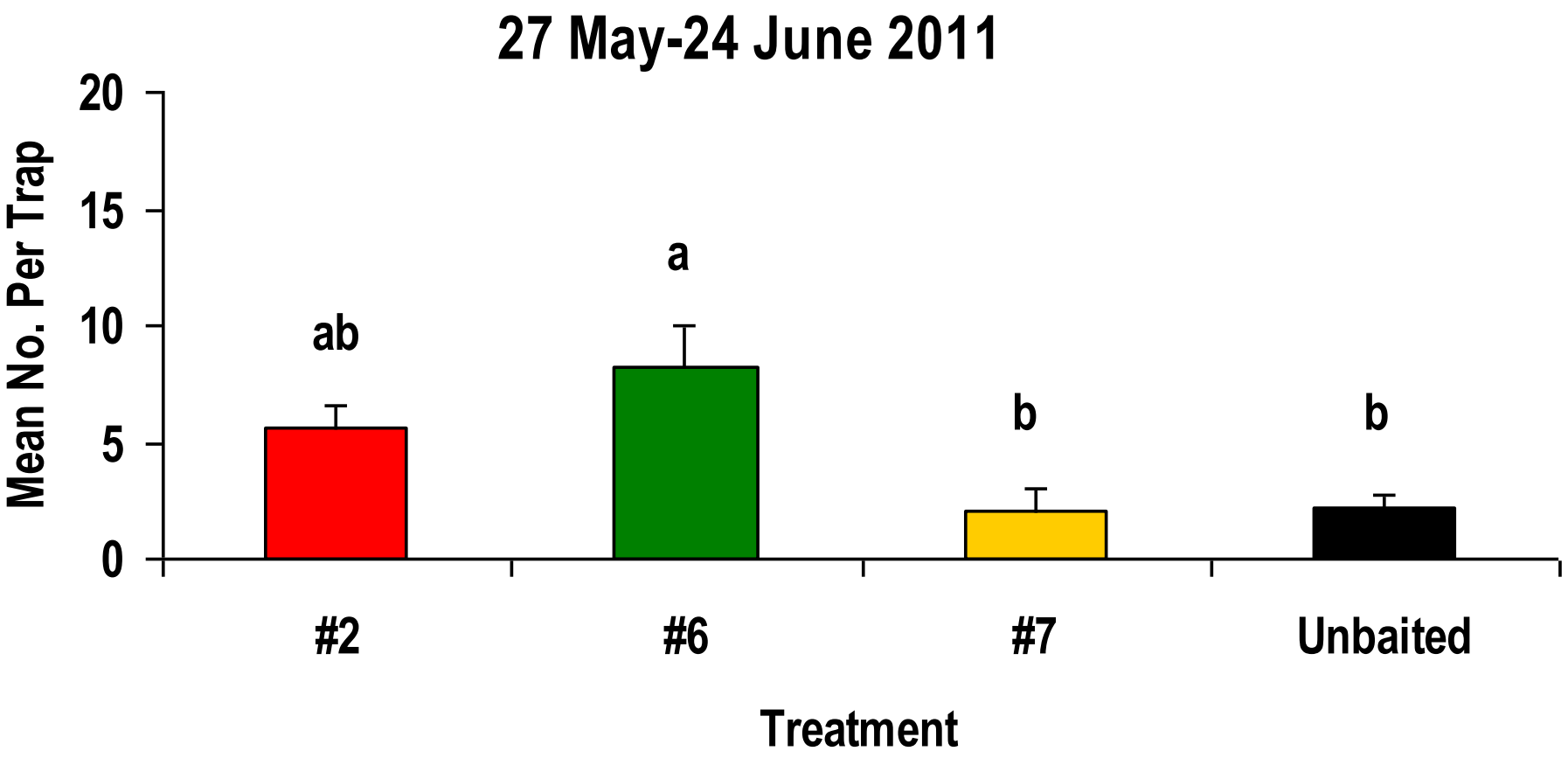
- ***Integrate Visual Stimuli***
  - Observations of attraction to UV and visible light.
  - Optimized and specific wavelengths and intensity.

Progress Toward Identification of BMSB Aggregation Pheromone

Early Season Trial Indicates Promising Activity



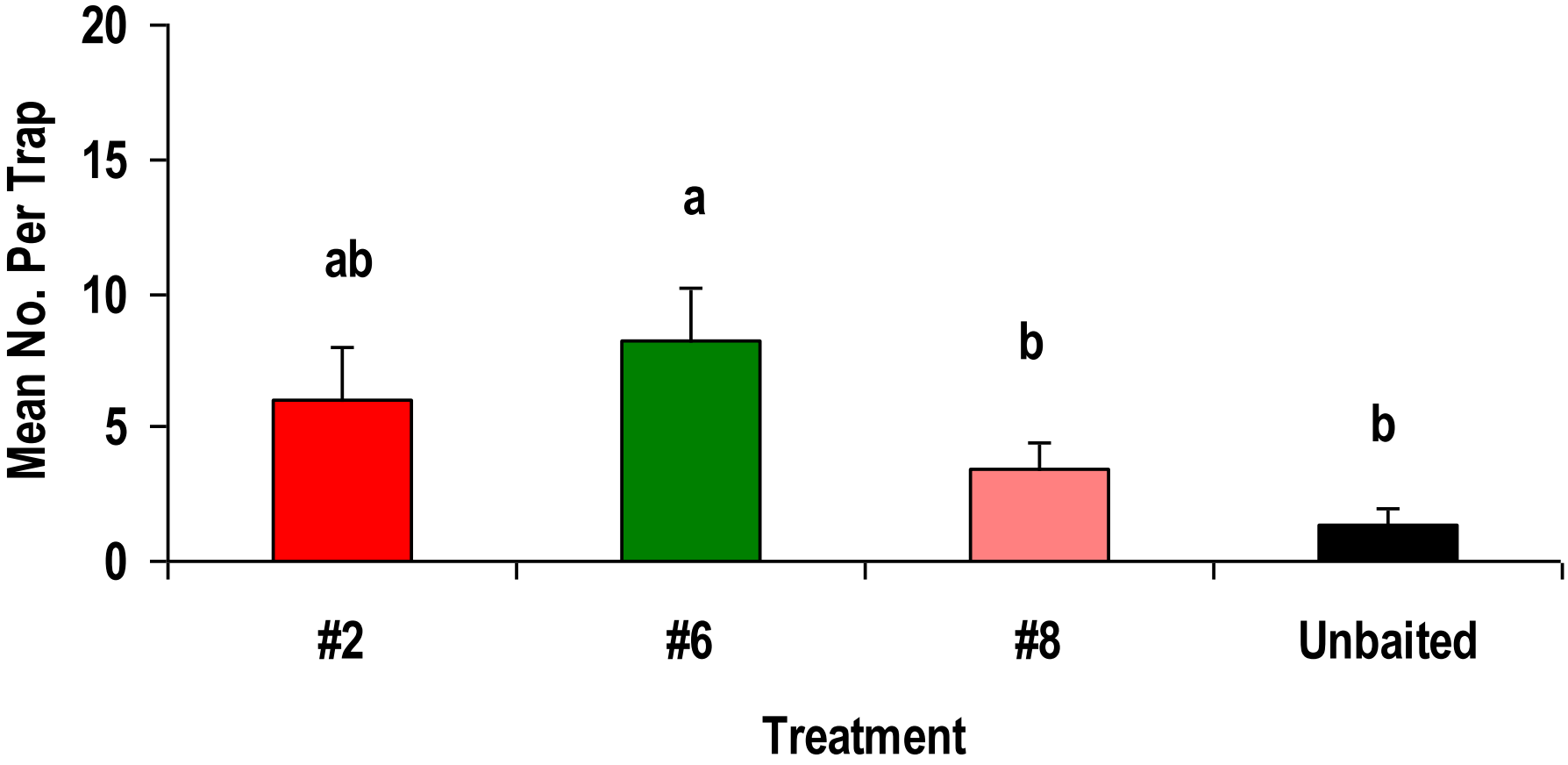
Two Treatments Show Significant Behavioral Activity



Traps baited with #6 capture ~4x more than control

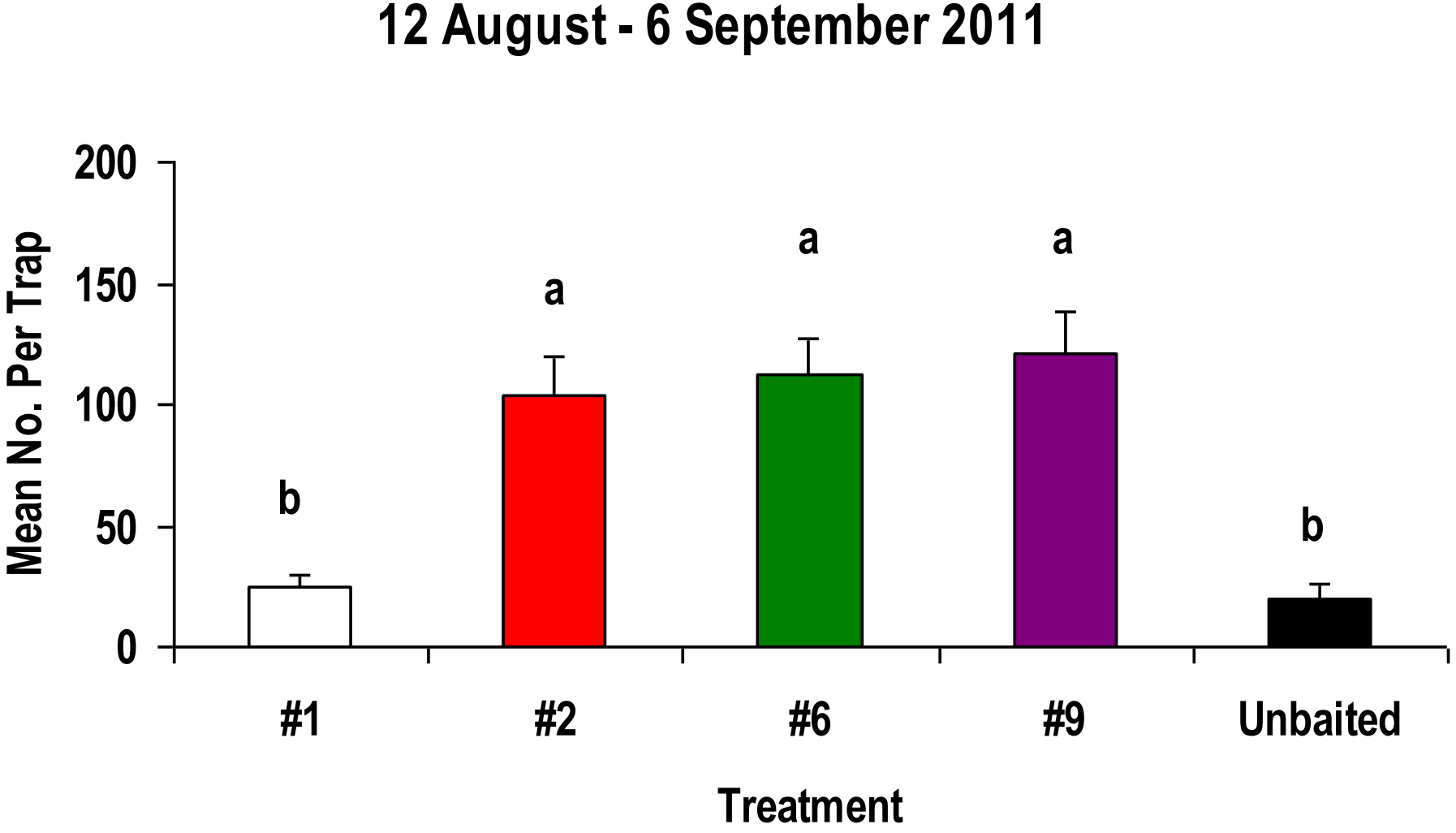
#6 and #2 Continue to Demonstrate Significant Activity

8 July - 2 August 2011



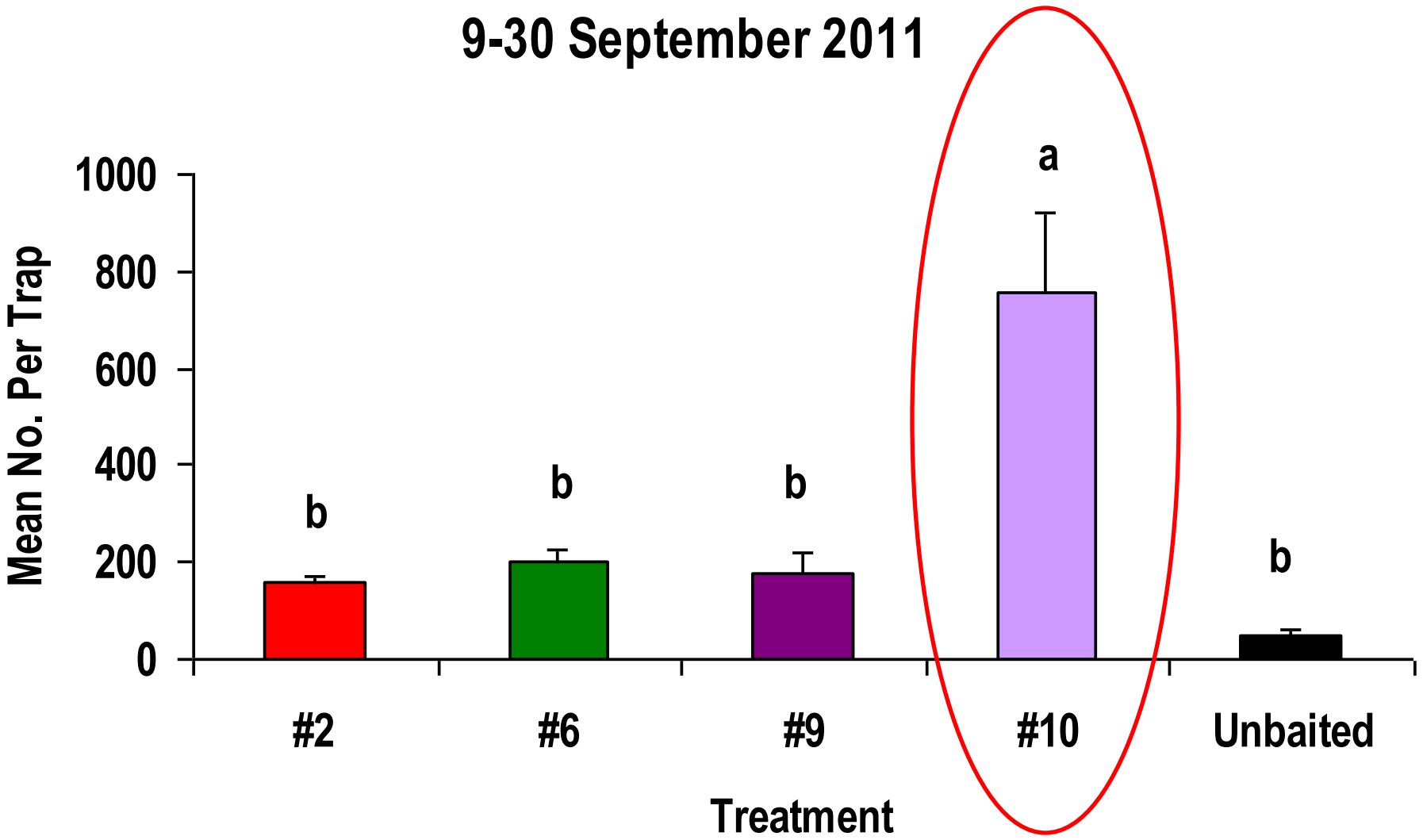
Traps baited with #6 capture ~6x more than control

Several Treatments Demonstrate Significant Activity



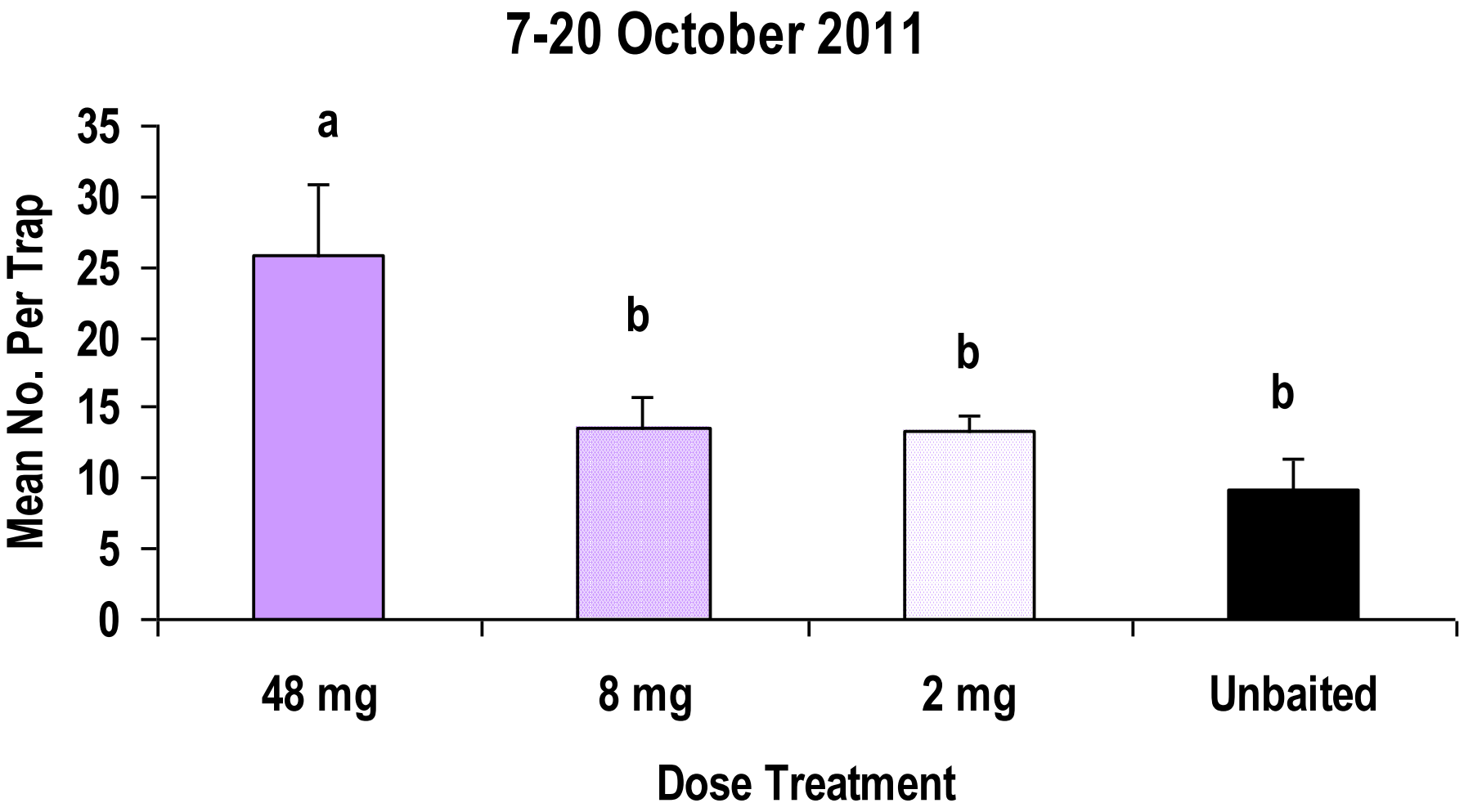
Traps baited with #2,6 and 9 capture ~6x more than control

Captures in Traps Baited With #10 Significantly Greater



Traps baited with #10 captured ~15x more than control and ~3-4x more than other treatments.

Significant Dose-Response Detected



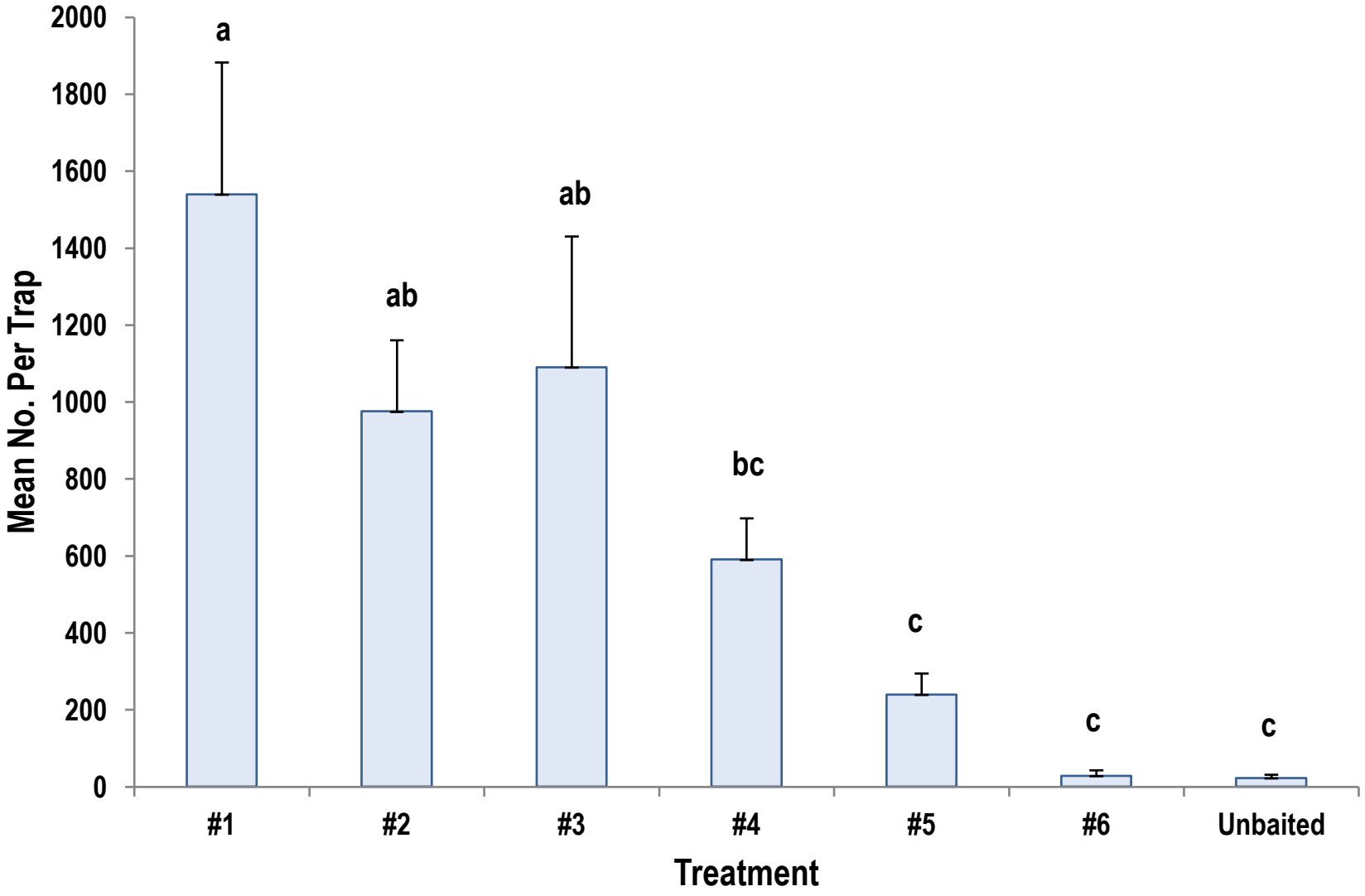
What's Next?

- Documenting early-season attraction to #10.
- Formulation, utility and commercialization.
- Behavior, biology, and ecology.

Visual Cues

Identifying Optimal Wavelengths and Intensities of Light

Traps Augmented With Light-Based Stimuli Captured 13, 457 Adult BMSB in ~6 Weeks During Late Summer



What's Next?

- Documenting early-season attraction to light-based stimuli.
- Formulation, utility and commercialization.
- Behavior, biology, and ecology.

BMSB is a Landscape-level Threat

Long-Term Solutions

Strategies To Reduce Populations Across Entire Landscape

Current Research and Collaborations

- **We have formed a nationwide team of over 50 research and Extension professionals representing 14 institutions in 10 states.**
- **USDA-NIFA Specialty Crop Research Initiative, entitled "*Biology, Ecology, and Management of Brown Marmorated Stink Bug in Orchard Crops, Small Fruit, Grapes, Vegetables, and Ornamentals*" funded in 2011.**
- **BMSB will require a sustained cooperative, collaborative, and integrated approach for research and Extension on a national scale.**

Acknowledgements

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