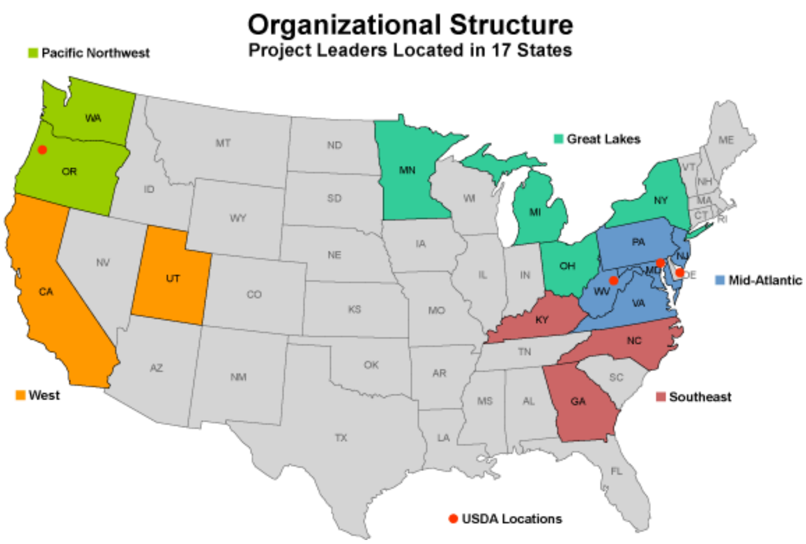
Management of Brown Marmorated Stink Bug in US Specialty Crops

2017

ANNUAL REPORT



The information contained in this report is based upon work that was supported by the USDA National Institute of Food and Agriculture, Specialty Crop Research Initiative under award number 2016-51181-25409.

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BMSB SCRI Stakeholder Advisory Panel Meeting

January 9, 2018, Hilton Portland Downtown, Portland, OR

Broadway III/IV

Time	Lead Presenter	Title
8:00 – 8:30	Arrival – coffee, tea, cold drinks, fruit, scones	
8:30-8:45	Jim Walgenbach	Introductions and purpose
Distribution and Pest Status		
8:45 – 9:45	Kent Daane/Diane Alston	Western Region
	Betsy Beers	Pacific Northwest Region
	Larry Gut	Great Lakes Region
	Mike Toews	Southeastern Region
9:45-10:10		Discussion and updating of distribution map
10:10 – 10:30	BREAK	
Biological Control		
10:30-10:50	Kim Hoelmer	Distribution and impact of *Trissolcus japonicus*, and status of petition to release quarantined populations.
10:50-11:05	Nik Wiman	Efforts to redistribute adventive populations of *T. japonicus.*
11:05-11:20	Rebeccah Waterworth	Native natural enemies: variation among regions and habitats.
11:20-11:40	Ann Hajek/Art Agnello	Microsporidia and other entomopathogens.
11:40-12:00		Discussion
12:00-1:00	Catered Lunch	
Landscape Ecology		
1:00 – 1:20	Dave Crowder	National monitoring program and modeling of BMSB.
1:20 – 1:35	Tracy Leskey	Coordinated trapping study and assessment of panel trap efficiency.
1:35-2:00		Discussion
Management Strategies		
Trapping and Insecticides		
2:00-2:15	Jim Walgenbach	Use of trapping for management decisions.
2:15-2:30	Greg Krawczyk	Regional bifenthrin/thiamethoxam bioassay study.
2:30-2:45	David Lowenstein	Insecticide effects on natural enemies.
2:45-3:00		Discussion
3:00-3:15	BREAK	
Behavioral based		
3:15-3:30	Anne Nielsen	Crop perimeter restructuring (aka border sprays).
3:30-4:00	Tom Kuhar	Use of insecticide-impregnated netting.
4:00-4:15	Tracy Leskey	Attract and kill.
4:15-4:30		Discussion
Economics		
4:30-4:45	Jayson Harper	Update on survey to assess economics of biocontrol.
Outreach		
4:45-5:00	Chris Gonzales	Outreach activities and plans for 2018.
5:00-5:30		Discussion and Wrap Up

Project Goal and Objectives

The overall goal of this project is to develop environmentally and economically sustainable management programs for the brown marmorated stink bug (BMSB) that focus on biological control and management strategies that are informed by landscape level risk and compatible with biological control. To achieve this goal, the following specific objectives have been set:

(1) Predict risk from BMSB damage through enhanced understanding of agroecology and landscape ecology.

1a. Predict risk from BMSB damage through enhanced understanding of agroecology and landscape ecology.

1b. Assess suitability of landscapes for BMSB based on host distribution.

1c. Integrate landscape-level habitat maps and data on abiotic factors to predict BMSB distribution and risk.

(2) Implement widespread biological control of BMSB, incorporating exotic Asian parasitoids and native natural enemies.

2a. Asian parasitoids
- i. Determine distribution/range of adventive *T. japonicus* in US.
- ii. Complete host range evaluations and petition for field release of quarantine T. japonicus.
- iii. Determine habitat preferences and role of kairomones in host location
- iv. Measure impact on BMSB populations an d non-targets

2b. Native parasitoids
- *i.* Document regional differences in key species of native parasitoids and impacts on BMSB and native stink bugs
- *ii.* Assess potential adaptation of native parasitoids to BMSB

2c. Document regional and habitat differences in native predators impacts on BMSB populations.

2d. Identify entomopathogens of BMSB that contribute to BMSB population regulation.

(3) Develop management tools and strategies that are compatible with biological control and informed by risk from landscape factors.

3a. Develop decision support tools to assess BMSB abundance and to mitigate damage.
- i. Optimize trap design for monitoring and surveillance.
- ii. Determine the relationship between captures in traps and crop injury.

3b. Identify effective uses of insecticides that minimize impacts on natural enemies.
- i. Evaluate new insecticides and threat of resistance
- ii. Impact of insecticides on natural enemies.

3c. Improve agroecosystem sustainability through spatially focused management or habitat manipulation.
- i. Impact of behaviorally-based management on BMSB and natural enemies.

ii. Refine and expand trap crop utilization within the agroecosystem.
iii. Conserve beneficial insects to enhance biological control of BMSB.

3d. Integrate IPM tools across landscape factors.

(4) Managing the Economic Consequences of BMSB Damage.

4.a. Assess economic potential of biological control of BMSB on specialty crops.

4.b. Develop estimates of the cost and benefits of specific management practices for BMSB.

4.c. Assist with the development of program evaluation tools including survey instruments.

(5) Outreach Plan – Deliver new information on BMSB to stakeholders.

5.a. Inspire the next generation of invasive pest experts.

5.b. Build upon existing BMSB outreach resources, develop and maintain a knowledge repository that captures lessons, insights, and success stories over time.

5.c. Expand relevancy of BMSB outreach resources to all U.S. regions.

5.d. Evaluate social benefits of improved conditions resulting from increased awareness and knowledge of sustainable practices and their adoption.

Project Participants[1]

Project Director: Jim Walgenbach, NC State University*

Co-Project Directors:

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Objective 2a-c, Kim Hoelmer
Objective 2d, Ann Hajek
Objective 3, Anne Nielsen
Objective 4, Jayson Harper
Objective 5, Steve Young

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Objective 1: Predict risk from BMSB damage through enhanced understanding of agroecology and landscape ecology.

Project: National monitoring program for BMSB

Background: A goal of Objective 1 is to develop tools that predict where BMSB will become established and to what extent it will develop into a key pest of specialty crops. Two key factors anticipated to mediate establishment, as well as variation in population dynamics within established regions, include climate and host plant availability. Host plants include not only specialty crops, but alternative crops (e.g., soybean, corn, cotton) and non-managed habitats (e.g., wooded areas, ditch banks). The first step in developing ecological models to predict BMSB abundance and phenology, is to understand its current distribution and environmental and plant fauna associated with population fluctuation across the various ecoregions where BMSB is predicted to be problematic (Fig. 1).

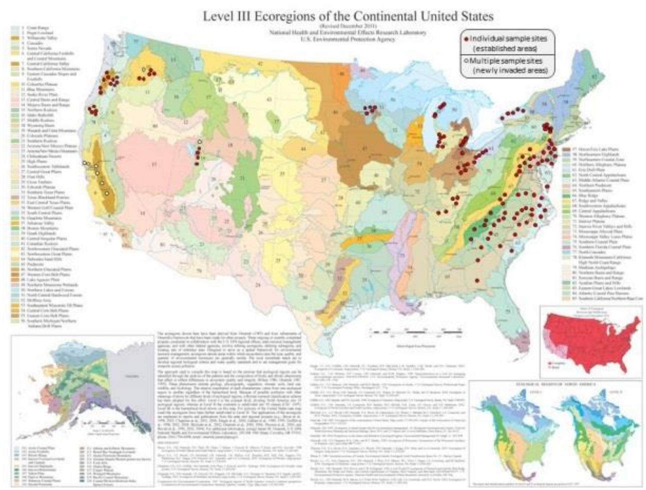


Figure 1. Map showing ecoregions of the United States and areas where BMSB sampling was proposed in the original proposal (shown in black circles)

What was Done: A nationwide network of pheromone traps (Fig. 2) was established to monitor BMSB abundance and phenology on a regional basis, and to detect expansion of BMSB into new areas. A summary of the network is shown below. A total of 268 trapping sites were monitored across 15 states and over 25 ecoregions, with a total of 26 PIs participating in the objective. A trapping site consisted of a unique location with 3 sticky panel traps baited with BMSB pheromone and synergist (MDT) deployed at the interface of wooded habitats and host crops. Each of the nearly 800 traps were monitored from early spring into the fall.

	BMSB sampling summary
States	15
Research groups	26
Sampling sites	268
BMSB individuals trapped	2066
Climatic Range	
Mean tp (ºC)	11.57 (5.07 - 18.26)
Minimum tp (ºC)	5.26 (-2.88 – 12.03)
Maximum tp (ºC)	17.87 (12.79 – 24.48)
Precipitation (mm)	705.50 (190.67 – 1841.45)
Elevational range (m)	541.63 (3-1845)
Land-use (within 5K buffer)	15 land-use classes (+82 crop types)

Figure 2. BMSB pherormone trap

Result:

To date we have been highly successful in establishing a standardized nationwide monitoring effort for BMSB. Our sampling network encompasses both regions where BMSB is already well established (eastern and northeastern US states) as well as regions where BMSB is not yet established but has high potential for invasion (west coast, upper Midwest). Data from 2017 shows a high degree of variation in the abundance of BMSB throughout the USA (Fig. 3).

We will continue the sampling network in the coming years, which will provide a comprehensive dataset showing variation in BMSB abundance across many locations and time points. These data will be incorporated into geographical information systems software to explore ecological and environmental factors affecting BMSB population dynamics and invasion risk. We expect to make progress on these analyses in 2018, but will complete them when all data is collected.

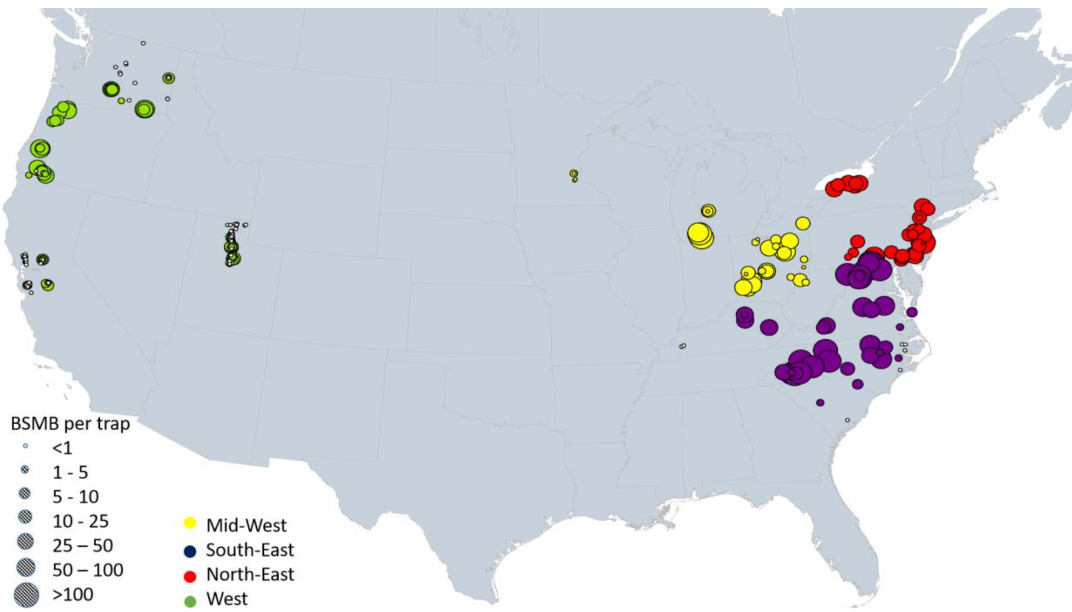


Figure 3. Graphical depiction of the BMSB trap catches from 2017. The different size circles represents the number of BMSB captured at each sampling location. As can be seen, populations were highest in the coastal states of NC and Virginia, and diminished further inland. Populations were generally low in the upper Midwest and the west coast and in Utah (areas actively being invaded), although BMSB was detected at most sampling locations at low density. As the project moves forward, we will integrate maps of habitat and environmental factors to explore how they affect BMSB abundance.

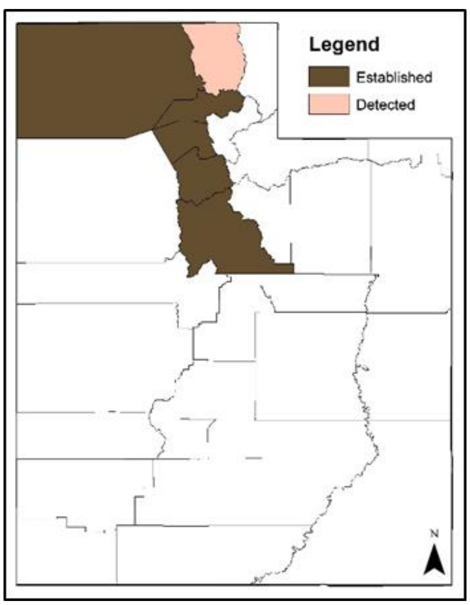
Objective 1: Predict risk from BMSB damage through enhanced understanding of agroecology and landscape ecology.

Project: BMSB Spread and pest status in Western Region (CA & UT)

Background: The western region of the US is an area where BMSB is currently expanding into new areas and where high-value specialty crops are at risk. In California, BMSB was first detected in 2006 in Pasadena and San Marino, but those populations appear to have shown limited capacity for expansion. In 2013, a substantial population was observed in Sacramento, and subsequent detections in more rural areas have raised concerns about movement into agricultural areas. In Utah, BMSB was first detected in 2012 in Salt Lake City, and by 2016 it was causing nuisance problems in northern Utah.

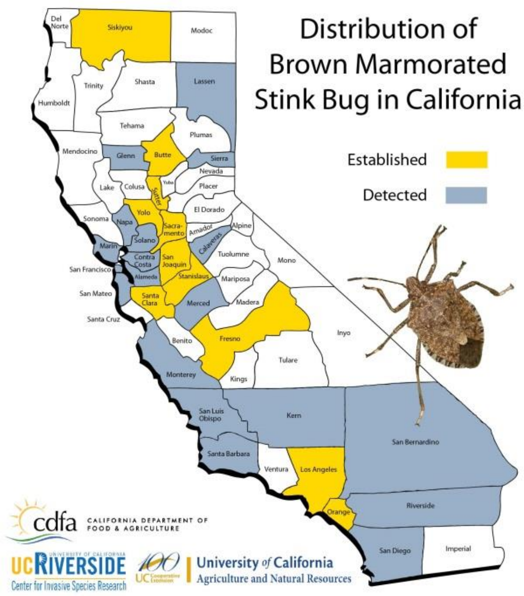
What was Done: Studies were conducted to help characterize BMSB damage symptoms on new specialty crops not previously exposed to the pest. To monitor the spread and pest status of BMSB, a network of pheromone traps in both states were established and monitored from the spring through autumn in cooperation with extension personnel in both urban and agricultural areas.

Results: In Utah, BMSB is now considered to be established in the northern counties of Box Elder, Weber, Davis Salt Lake and Utah, and has been detected, but is not yet established in Cache County. Economic crop damage was observed for the first time during 2017 on peach, apple, popcorn and squash. Crop injury occurred in commercial fruit orchards in Weber, Salt Lake and Utah counties; whereas vegetable crop injury was detected in a large suburban community garden in Salt Lake City. Surveys for host plant use in the suburban-agriculture landscapes of northern Utah found BMSB life stages residing 49 species from 20 plant families. The most common plant families and those with the highest BMSB populations included Aceraceae (maple, boxelder), Bignoniaceae (catalpa, trumpet vine), Fabaceae (Siberian pea shrub, locust), Oleaceae (privet, lilac), and Rosaceae (apple, cherry, peach, plum).



County-level detection of BMSB as of 2017, and damage observed on peach, apple and popcorn.

In California, BMSB is now established in 9 counties and has been detected in an additional 29 counties. Specialty crops of concern at this time include almonds, stone fruits and vineyards in Northern California. Damaging populations in almonds in 2017 represent the first report of BMSB damage to this crop; approximately 2.8% of nuts were damaged in this orchard. Laboratory feeding studies have also demonstrated that BMSB can injury citrus and avocados.



Various forms of damage to almond inflicted by BMSB.

Objective 2. Implement widespread biological control of BMSB, incorporating exotic Asian parasitoids and native natural enemies.

Project: Distribution and range of adventive populations of *Trissolcus japonicus*.

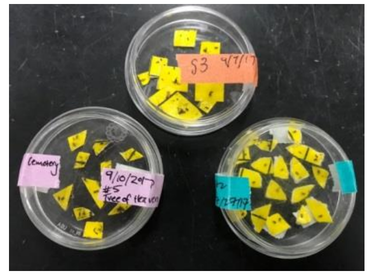
Background: *Trissolcus japonicus*, commonly referred to as the samurai wasp, is an exotic parasitic wasp that is an important natural enemy of BMSB in its native Asian range. *T. japonicus* is an egg parasitoid that deposits its eggs into BMSB eggs, and whose progeny then consume the egg and emerge as adults. In its native Asian range, *T. japonicus* typically parasitizes 60-90% of BMSB eggs, and is an important biological control agent that helps maintain populations at low levels. This parasitoid was selected as a candidate for a classical biological control program of BMSB in the US, and has been undergoing risk analysis studies in quarantine laboratories at the USDA Biological Control Laboratory in Newark, DE, and cooperating labs in Oregon, Michigan, Florida and California. These tests are now largely complete and a petition to release *T. japonicus* in the US is in preparation for review by USDA-APHIS.

While conducting surveys for native natural enemies attacking BMSB, BMSB eggs parasitized by *T. japonicus* were detected at several US locations in 2014, 2015 and 2016. Genetic testing showed that these "adventive" populations were different from those in quarantine culture for risk evaluations. Although it is unknown how these adventive populations arrived in the US, their spread and impact on BMSB and native natural enemies is being actively monitored.

What was Done: Surveys were conducted across the US to detect new adventive populations of *T. japonicus* and to monitor its spread from previously areas of detection. Several different methods were used to monitor *T. japonicus*, including deployment of laboratory reared sentinel egg masses, collection of wild egg masses from managed and non-managed habitats, and the use of yellow sticky cards. In New York and Oregon, efforts were also undertaken to redistribute adventive populations and enhance their establishment by rearing parasitoids in the laboratory and releasing them in different areas of their states.

Sentinel egg masses from BMSB laboratory colonies are deployed in crops and wooded habitats. Both frozen and fresh egg masses can be used.

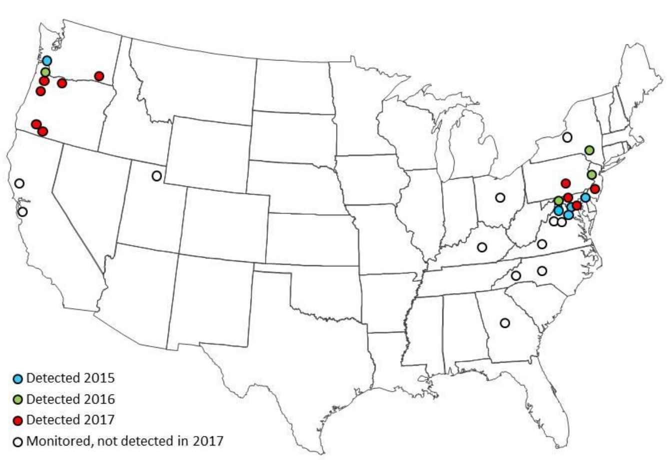
Virginia Tech students collecting naturally laid eggs from felled *Ailanthus altissima* tree (tree of heaven).

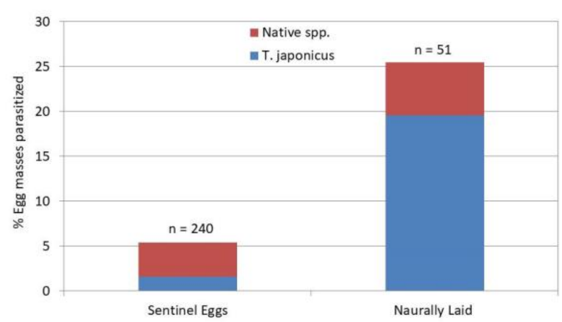


Deployment of yellow sticky cards in tree canopy (left) and preparation of samples for shipment and identification (top). Project collaborator Dr. Elijah Talamas, FL Dept Ag & Consumer Serv, confirms all *T. japonicus* identifications.

Results: In 2017, there have been several new *T. japonicus* detections; all were in regions where it had been detected in previous years, including the Pacific Northwest and mid-Atlantic states. Emergence of *T. japonicus* from a sentinel egg mass in a New Jersey peach orchard was the first detection from an agricultural setting. Detection near Walla Walla, Washington, is considered significant, because the arid shrub-steppe habitat in this area is dramatically different than previous detections near the temperate coastal region. Several of the new detections in Oregon in 2017 were in association with efforts to re-distribute the parasitoid. A detection in southeastern Pennsylvania is the first record from that state. These recoveries demonstrate that *T. japonicus* has established in these areas and its populations are expanding. Surveys in several areas have shown that parasitism of BMSB eggs by *T. japonicus* is increasing. Laboratory studies demonstrated that *T. japonicus* have a clear preference for BMSB eggs when compared with *Podisus maculiventris* (the spined soldier bug, SSB), an agriculturally important predatory stink bug. These studies found that *T. japonicus* responded to the presence of BMSB and SSB kairomones on leaf surfaces by searching longer and more intensively for BMSB than for SSB. In addition, BMSB egg masses were attacked more successfully by female wasps, with higher rates of progeny produced.

Distribution of *Trissolcus japonicus as* of December, 2017





Percentage of sentinel and naturally laid egg masses parasitized by *Trissolcus japonicus* and native parasitoids. Virginia Tech study in Winchester, VA, 2016 and 2017.

Objective 2. Implement widespread biologic control of BMSB, incorporating exotic Asian parasitoids and native natural enemies.

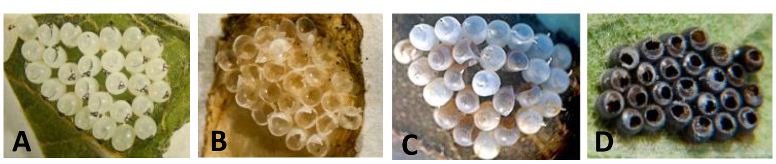
Project: Impact of native natural enemies: Regional complexes and habitat differences.

Background: A major goal of this project is to maximize the impact of biological control agents – both exotic egg parasitoids, native parasitoids and predators – on BMSB populations. As a landscape level insect that is highly mobile and utilizes a diversity of managed and non-managed habitats, biological control may be the most powerful population regulatory factor at our disposal. Understanding the identity and impact of complexes of native natural enemies among different locations and habitats is critical to maximizing their impacts across agroecosystems.

What was Done: This research was complementary to monitoring for *T. japonicus* across the country. Sentinel egg masses (fresh and frozen), collection of naturally laid BMSB eggs, and yellow sticky cards were used to monitor for native natural enemies and to assess their impact in different habitats. Participation included 15 co-PIs representing 13 states in all regions of the country. Habitats monitored included specialty and field crops, landscape ornamentals, and non-managed wooded areas in both urban and rural sites. Sentinel and wild eggs were retrieved from the field and eggs were assessed for parasitism and predation (both chewing and sucking predators), and held to allow parasitoids to emerge. All non-hatched eggs were then dissected to look for evidence of parasitism (e.g., partially developed parasitoid).

Anastatus reduvii is a generalist egg parasitoid that is commonly collected from BMSB eggs in arboreal habitats.

Telenomus podisi is a parasitoid of native brown stink bugs in vegetables and field crops, but has difficulty completing development in BMSB eggs.



Examples of normal, hatched BMSB eggs (A), eggs attacked by chewing (B) predators, stylet sheaths of sucking predators emerging from eggs (C), and eggs from which parasitoids emerged (D).

Results: (summarized by R. Waterworth and P. Shrewsbury, UMD): Results presented below have been summarized from partial data that was submitted to date for 2017. Not all collaborators submitted data, and of those that did, not all sample results have been processed. Therefore, these are preliminary results which may change when the dataset is completed.

Data have been analyzed by region and habitat category. States that submitted data within each region include: West (Utah), Pacific Northwest (Washington, Oregon), Southeast (Kentucky, North Carolina), and Mid-Atlantic (Maryland, Delaware, Pennsylvania, Virginia). Habitat categories include: semi-natural (campuses, parks), forests (wooded edges), ornamentals (nurseries, and urban landscapes), orchards (cherry, peach, apple, hazelnut), and field/vegetable crops (corn, soybean, peppers). Results are presented from two types of sentinel egg masses: fresh and frozen. A survey is a unique combination of researcher, sampling period within 2017, habitat category, and egg mass type.

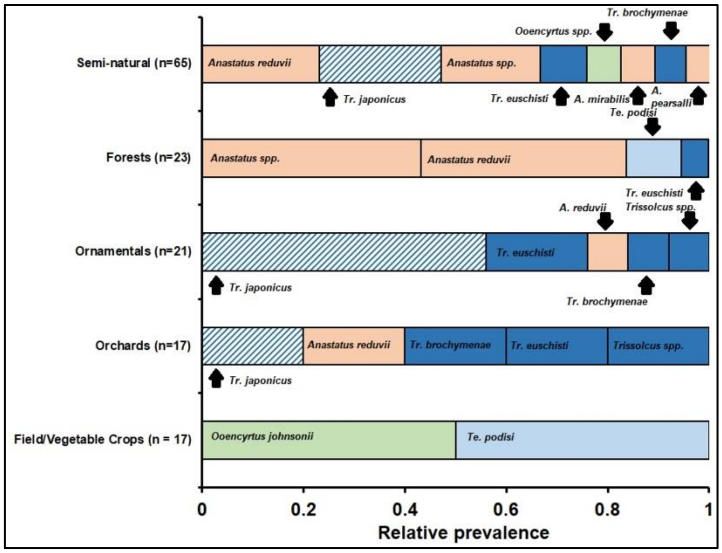


Figure 1. **Relative prevalence** of parasitoids **emerged from fresh sentinel BMSB egg masses** used in surveys in each of five habitat categories (n = number of surveys). For each category, species are color-coded by parasitoid genus. Dark-blue hashed bars denote the prevalence of *Trissolcus japonicus*, a non-native parasitoid species. All other species are native (solid colors).

Fig. 1 – summary points

- Parasitoids from three insect families emerged from egg masses in five habitats
- *Anastatus* species were most prevalent in forests and semi-natural habitats
- *Trissolcus* species dominated ornamentals and orchards, with non-native *Tr. japonicus* most prevalent in ornamentals
- Highest diversity (# of species) emerged from egg masses in semi-natural habitats (campuses, parks)

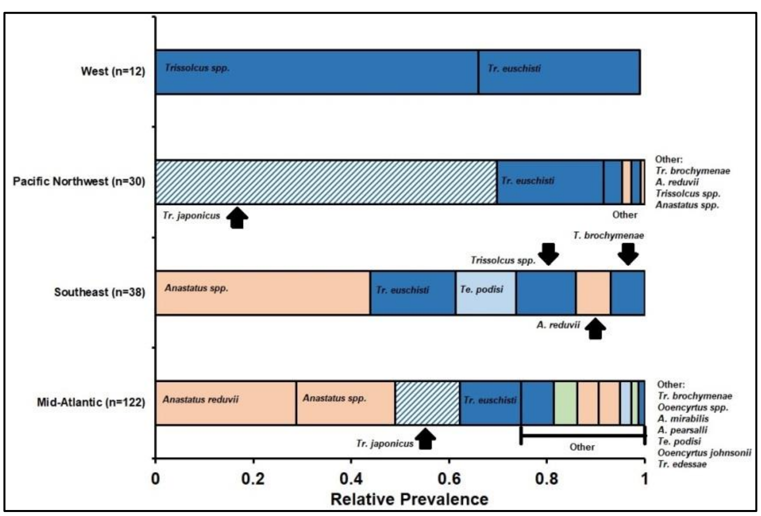


Figure 2. **Relative prevalence** of parasitoids **emerged from both fresh and frozen sentinel BMSB egg masses** used in surveys in four regions (n=number of surveys). Species are color-coded by parasitoid genus.

Fig. 2 - summary points

- Non-native *Tr. japonicus* was only collected in the Pacific NW and Mid-Atlantic
- *Anastatus* spp. were most prevalent in Southeast and Mid-Atlantic regions
- Highest diversity of species in the mid-Atlantic

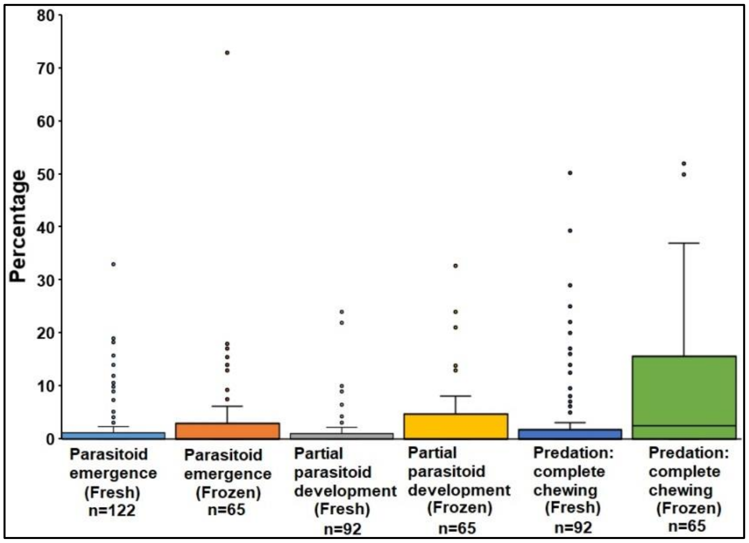


Figure 3. Box plots showing the ranges of reported mean egg parasitism and predation of sentinel BMSB eggs by native parasitoids and predators. All surveys with successful *Trissolcus japonicus* emergence were excluded. Horizontal lines show medians, boxes contain the 25th-75th percentiles, whiskers show the upper and lower deciles, and points show outliers. “Partial parasitoid development” refers to only unsuccessful parasitism (unemerged/partially developed parasitoids) detected with dissections. “Complete chewing” refers to only egg masses that were entirely removed from their substrate by predators. “Fresh” and “frozen” refer to either healthy or freeze-dried eggs, respectively, when deployed. Samples sizes refer to the number of surveys.

Fig. 3 – summary points

- Parasitoid emergence and partial parasitoid development were low overall, though slightly higher in frozen eggs
- Predation of fresh egg masses by complete chewing was low overall, though reported means reached > 50%
- Similar to other studies, predation was higher on frozen egg masses

Conclusions:

- Preliminary results from the 2017 field season support previous work that certain parasitoid species are more prevalent in specific habitats, though the same species occur in different habitats.
- Parasitoids of BMSB were heavily surveyed in the mid-Atlantic region.
- The combination of parasitoid emergence, partial parasitoid development, and predation by complete chewing of fresh egg masses was low overall. Predation values are underestimated as other types of egg feeding were not included in this analysis.
- Need to incorporate additional 2017 data and sample over multiple years to elucidate more robust patterns in habitat preferences and regional occurrence

Object 3. Develop management tools and strategies that are compatible with biological control and informed by risk from landscape factors.

Project: Comparison of pyramid and sticky panel pheromone traps across the USA.

Background: Standard black pyramid traps, baited with BMSB pheromone and pheromone synergist, have proven to be effective for monitoring BMSB populations throughout the growing season. However, their size and bulkiness make them time-consuming to deploy and unsuitable for some cropping systems. The goal of this objective was to evaluate a simpler, more user friendly trap that can be used as an alternative to the standard pyramid trap. Previous work indicated that sticky panel traps mounted on 4-foot stakes and baited with standard Trécé BMSB dual lures (murgantiol+MDT) were promising replacements for pyramids. A national comparison of sticky traps to pyramids was conducted to test their relative sensitivity and efficiency.

What was done: Trap comparisons were conducted in >50 locations located in over 14 states. Most trapping sites were at the interface between BMSB-susceptible crops and woods containing wild BMSB host plants (Fig. 1). The traps in Utah were deployed in residential areas with known BMSB host plants. Each trapping site consisted of 3 pyramid and 3 sticky traps deployed in a line at 50-meter intervals. All traps were baited with standard BMSB Trécé lures + MDT synergist and checked weekly from spring through fall. Mean weekly captures between pyramid and sticky traps across sites were analyzed using Repeated Measures ANOVA, and Pearson Correlation was used to examine the relationship between captures in pyramid and sticky panel traps. The season-long analysis was done from May 29 to October 6. To compare sensitivity of the traps at various points in the season, the trapping period was divided into early (April 17 to June 16), mid (June 17 and Aug 11) and late (August 12 to October 20) and captures were analyzed among sites during these periods. Due to unequal trapping periods among some sites, only certain sites were used during analyses.

Fig. 1. Standard black pyramid trap and the new sticky panel trap.

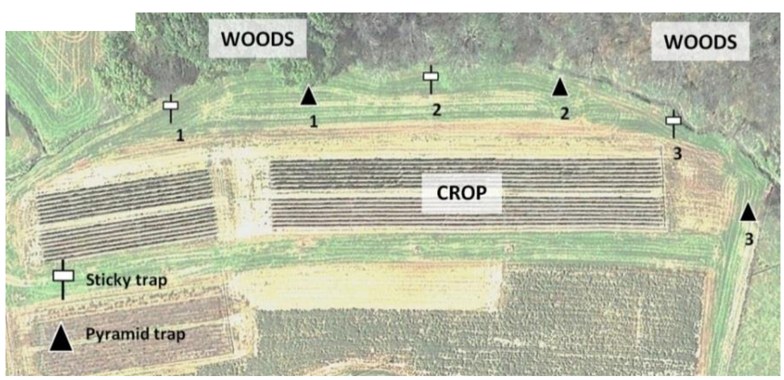


Fig. 2. Illustration of experimental design at one of greater than 47 locations across the country.

Results:

Season-long captures in pyramid and sticky panel traps across the USA are shown in Fig. 3. Captures of BMSB adults and nymphs across 47 sites from May 29 to October 6 were significantly greater in pyramid vs. sticky panel traps (Figure 4, adults: $F_{1,152} = 26.0493$, $P > 0.0001$; nymphs: $F_{1,153} = 6.1562$, $P = 0.0142$). Also, there were significant positive correlations between weekly captures in pyramid and sticky panel traps for both adults and nymphs (Fig. 4).

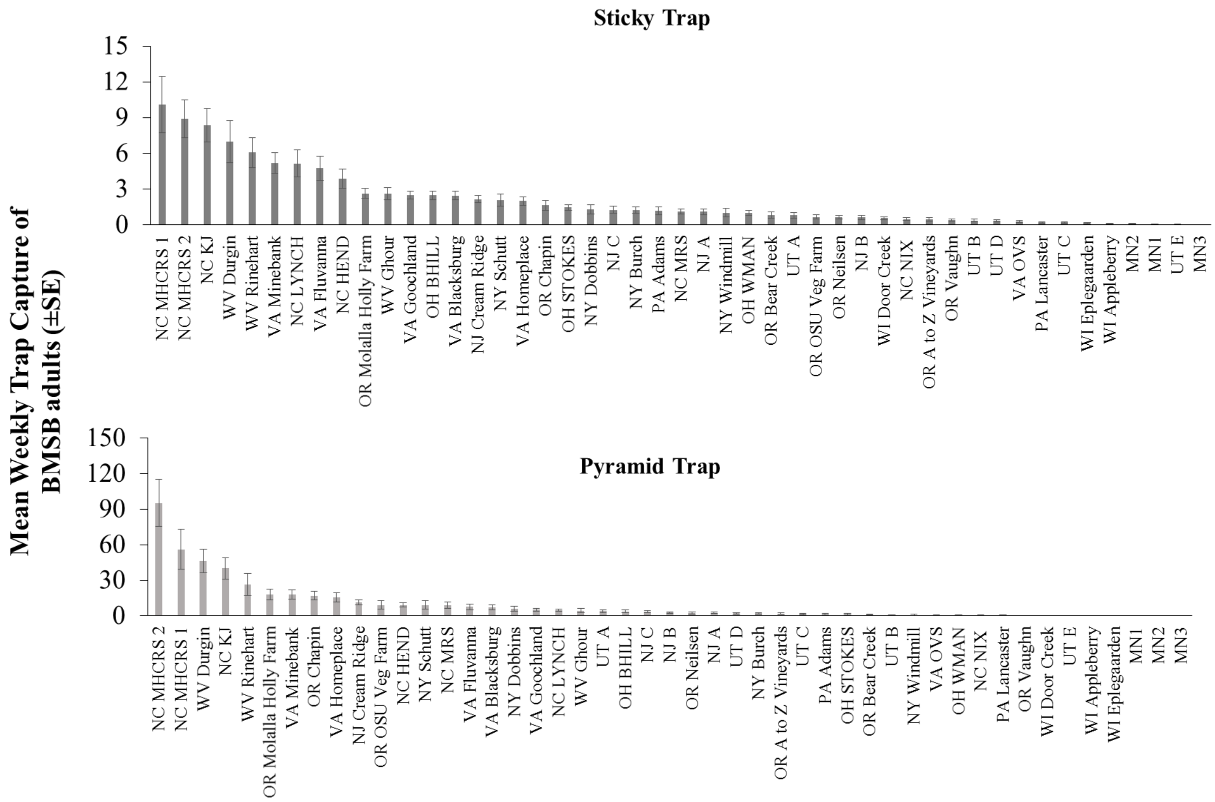


Fig. 3. Season long captures of adult BMSB at various trapping sites. 2017.

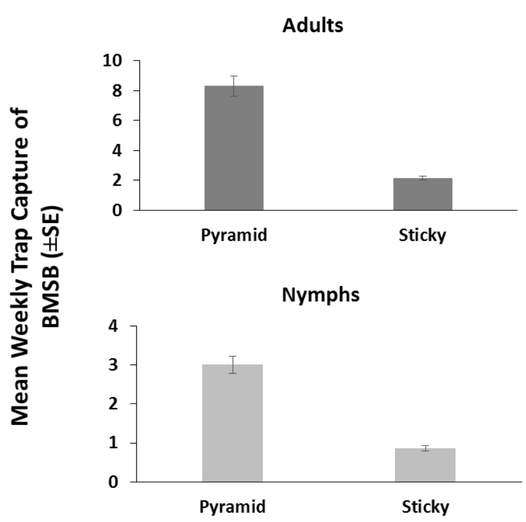


Fig. 4. Season-long BMSB captures in pyramid and sticky traps across all sites.

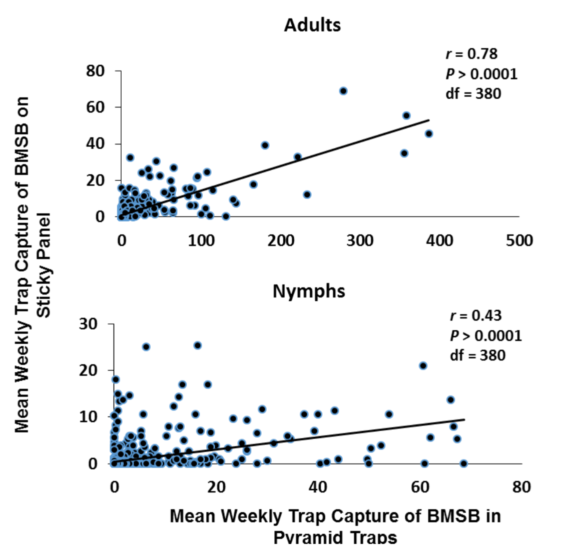


Fig. 5. Pearson correlation coefficients between season-long pyramid and sticky panel traps.

Adult captures were significantly greater in pyramid vs sticky traps in the early season (Fig. 6, $F_{1,93} = 6.87$, $P = 0.0103$), as were adult and nymphs in the late season (adults: $F_{1,210} = 2.0$, $P = 0.159$; nymphs: $F_{1,210} = 3.88$, $P = 0.\ 0$). No significant differences were detected in the mid-season period (adults: $F_{1,210} = 2.0$, $P = 0.159$; nymphs: $F_{1,210} = 3.88$, $P = 0.05$). Importantly, significant positive correlations between pyramid and sticky traps for both adults and nymphs occurred during the early, mid and late season (Fig. 7).

In summary, pyramid traps captured numerically higher numbers of BMSB than sticky panel traps, but significant positive correlations between their captures indicate that sticky panel traps are equally effective in detecting BMSB presence, abundance and seasonal activity of BMSB throughout the season.

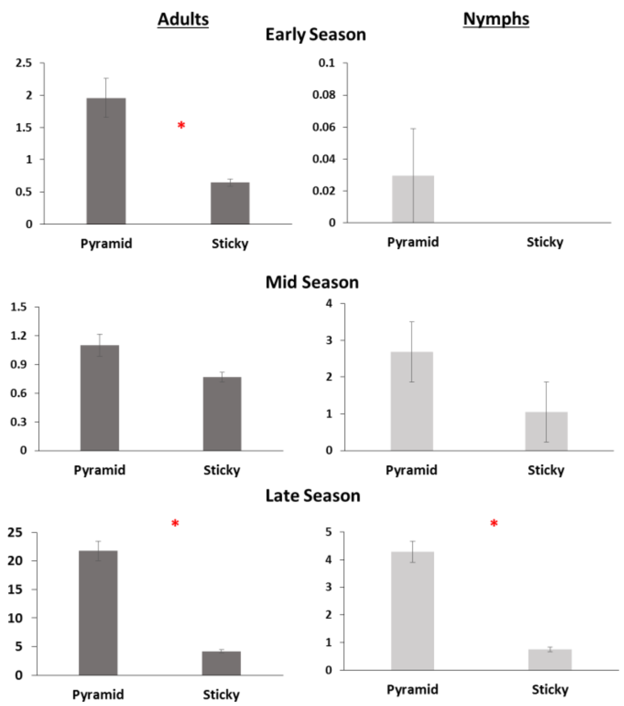


Fig. 6. Seasonal BMSB captures on pyramid and sticky panel traps. * denotes significant differences between trap types.

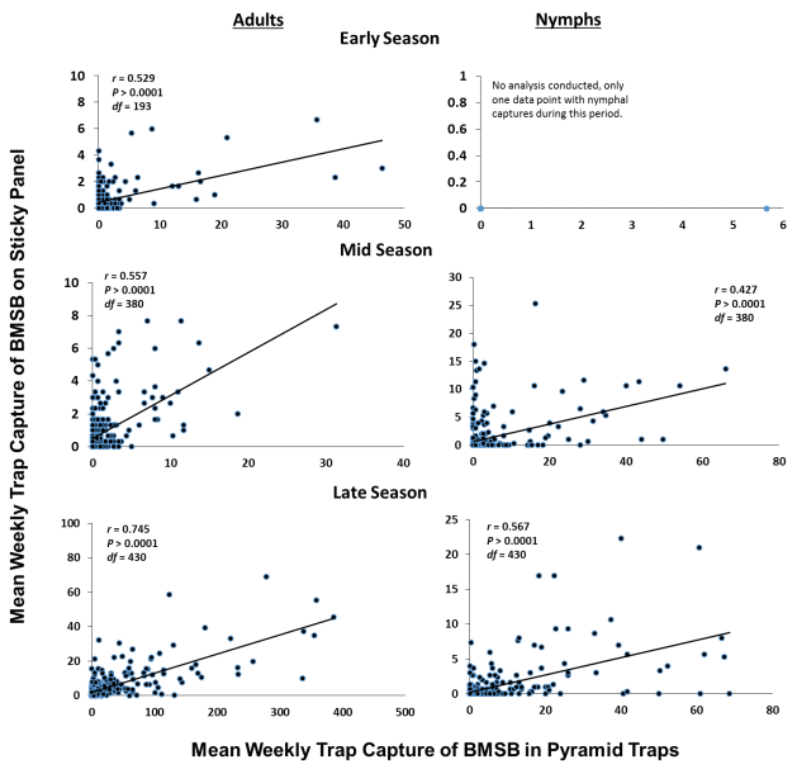
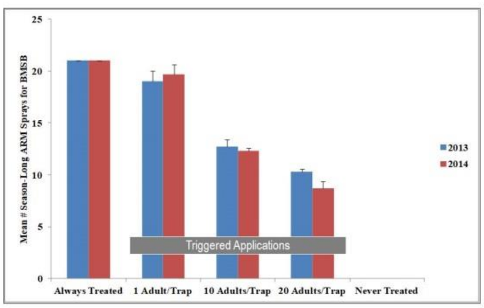


Fig. 7. Pearson correlation coefficients between pyramid and sticky panel traps at different times of the year.

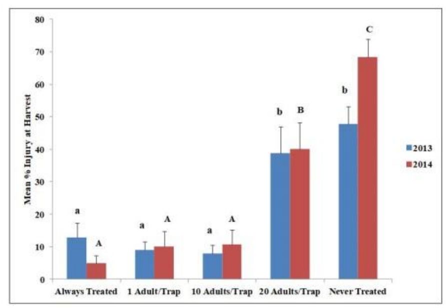
Object 3. Develop management tools and strategies that are compatible with biological control and informed by risk from landscape factors.

Project: Pheromone traps as pest management decision aid tools in specialty crops.

Background: Identification of the BMSB male-produced aggregation pheromone and the synergistic action of methyl decatrienoate (MTD), the aggregation pheromone of the related Asian stink bug *Plautia stali*, provided the essential tools for season-long monitoring of both BMSB adults and nymphs. Use of these olfactory cues in combination with a black pyramid trap proved to be a highly attractive trap across a diversity of climates and landscapes. The ability to effectively monitor BMSB created the opportunity to develop monitoring programs to improve the pest control decision process. Indeed, USDA-ARS studies in WV apples in 2013 and 2014 demonstrated that applying insecticides for BMSB l based on a pyramid trap threshold of 10 bugs/trap led to a 40% reduction in insecticide use with concomitant increase in damage compared to grower standards.



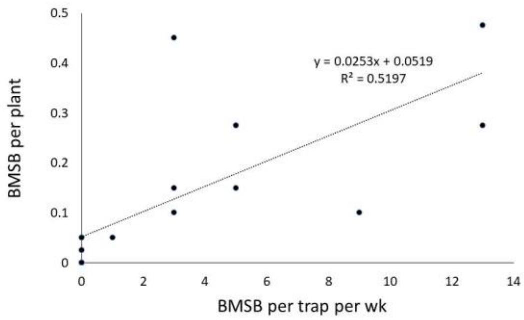
Number of alternate row middle (ARM) insecticide sprays for BMSB based in a standard "always sprayed" plot versus sprays triggered by pheromone trap thresholds of 1, 10 and 20 adults per trap. Short et al. 2016. J. Pest. Sci.



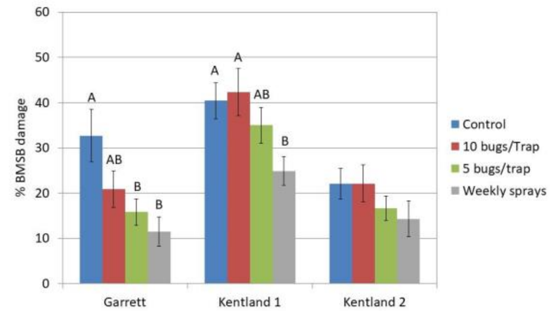
BMSB injury in WV apples when applying insecticides weekly versus a pheromone trap threshold of 1, 10 or 20 bugs per trap. Short et al. 2016. J. Pest. Sci.

What was Down: Following the success of pheromone traps for dictating sprays in WV apples, studies were initiated to expand this technology to other areas of the control, different cropping systems, and to more clearly interpret the relationship between BMSB pheromone trap captures, population abundance in crops, and crop damage. In 2017, research was conducted on apples in NC and WV, peaches in NJ, sweet corn in Ohio, and peppers in VA. All of this work was aimed at using pheromone trap captures to make informed pest management decisions, primarily by optimizing insecticide applications.

Results: Initial results with experiments at Virginia Tech to correlate BMSB trap captures with both BMSB populations and damage in peppers show promising results. There was a positive relationship between trap captures and BMSB counts on adjacent pepper plants. Also, when testing traps for use in triggering insecticide applications, a trap capture threshold of five bugs/trap reduced insecticides from an average 6 in the weekly spray treatment to only two in the trap threshold treatment, with no significant reduction in crop damage. This research will be expanded in 2018 to evaluate this threshold concept over a broader geographic range.

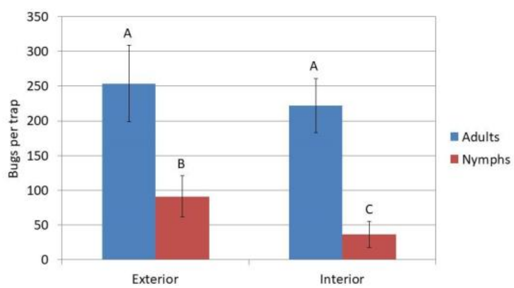


Relationship between BMSB captured in pheromone traps versus number observed on pepper plant. Virginia Tech, 2017.

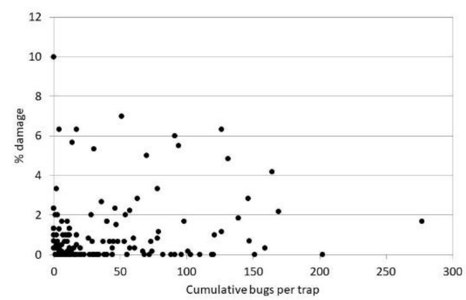


BMSB damage to peppers sprayed with insecticides based pheromone trap thresholds of 10 and 5 bugs per trap, compared to weekly sprays and non-sprayed fruit.

In NC apples, studies examined the capture of BMSB in traps on the periphery of orchards adjacent to wooded areas and in the interior of 14 commercial orchards over a two-year period, and found no difference in exterior vs interior orchards, except that few nymphs were captured in the interior of the orchard. Surprisingly, there was no statistical relationship between pheromone trap captures and damage levels in orchards. The fact that orchards were sprayed with insecticides for BMSB may help to explain instances of low damage/high capture, but not the opposite. It is also possible that other factors may have affected BMSB capture in traps, such as nearby attractive host plants.



Capture of BMSB in pheromone traps located on the exterior and interior of apple orchards. North Carolina, 2017.



No statistical relationship between 4-wk cumulative pheromone trap capture and damage to apples in NC, 2017.

Recently, the use of panel sticky traps has become a popular alternative to the standard pyramid trap as a more user friendly alternative to the standard pyramid trap, and on-going studies are correlating captures of the two types. In addition, cooperative studies between the USDA-ARS and Michigan State University are investing the active space of a BMSB pheromone trap, and factors influencing trap captures.

Objective 3. Develop management tools and strategies that are compatible with biological control and informed by risk from landscape factors.

Project: Examining insecticide effects on natural enemies of BMSB.

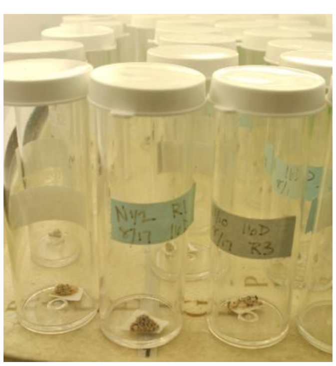
Background: Native natural enemies provide valuable biological control of agricultural insect pests, such as BMSB. BMSB is a new threat to crops in the US, necessitating increased use of broad-spectrum insecticides. Reliance on these products is not compatible with the needs of IPM or organically-certified programs. Information is needed on the role of native natural enemies in biological control and how to conserve natural enemies in agricultural systems.

What was Done: Laboratory bioassays were conducted in two laboratories to evaluate the effects of insecticides two parasitoids of BMSB; in NC the native species *Anastatus reduvii* and *Telenomus podisi* was tested against four different OMRI-approved insecticides at 0.1, 0.5 and 1X field rates, and in OR the Asian parasitoid was tested against 1 OMRI and 4 conventional insecticides. In NC, adult parasitoids were exposed to dried pesticide residues on filter paper and checked for mortality 24 and 48 hrs post-setup. In Bioassay 2, feeding treatments were set-up with <24 hr old *A. reduvii* placed individually in vials with insecticide-laced sucrose as the sole food source. Bioassay 3 examined adult emergence from parasitized egg masses saturated with insecticide treatments and allowed to dry. In OR, T. japonicus was exposed to dried insecticide on glass slide held within Munger cells. old) inside each Munger cell. There were a minimum of 10 replicates for each compound. Mortality was assessed at 1, 2, 4, 6, and 24 hours, afterwhich surviving adults were presented with BMSB egg masses.

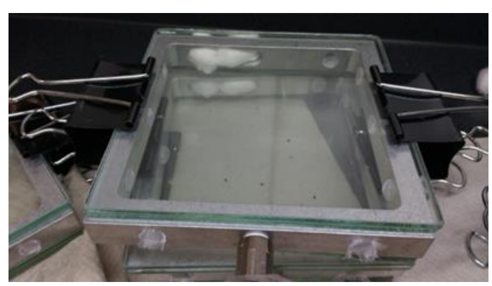
Insecticides tested against parasitoids in NC and OR.

Anastatus reduvii (NC)	*Trissolcus japonicus* (OR)
*Entrust (spinosad) *Neemix (azadirachtin) *Pyganic (pyrethrin) *Azera (pyrethrin + azadirachtin)	*Entrust (spinosad) Actara (thiamethoxam) Asana (esfenvalerate) Admire (imidacloprid) Altacor (chlorantraniliprole) Exirel (cyantraniliprole)

*OMRI approved



Insecticide exposure technique used against *A. reduvii* in NC (left).



Insecticide exposure using Munger cells used against *T. japonicus* in OR (above).

Results (NC):

When exposed to dried residue of Entrust on substrate in Bioassay 1, Entrust exhibited the highest toxicity to both parasitoid species. Other than low levels of mortality caused by Pyganic against A. reduvii, none of the other insecticides exhibited toxic effects. In Bioassay 2, ingestion of all insecticide-laced sucrose treatments, with the exception of 0.1X Neemix, resulted in reduced longevity of *Anastatus reduvii* compared to the control. Finally, in Bioassay 3 significantly fewer parasitoids emerged from eggs submerged in 1X Entrust versus all other treatments for both species (*T. podisi*: DF= 9, F= 5.76, P <.0001). Emergence of *A. reduvii* from eggs treated with 0.5X Entrust, and 0.5X and 1X PyGanic was significantly lower than the Control (DF= 9, F= 47.83, P <.0001). Bioassay 4 showed that emerged females from eggs treated post-parasitism had a significantly shorter lifespan in 1X Entrust treatments than all other treatments. In general, Entrust (active ingredient: Spinosad) and in some cases PyGanic (Pyrethrin), especially at higher doses, had negative impacts on both parasitoids.

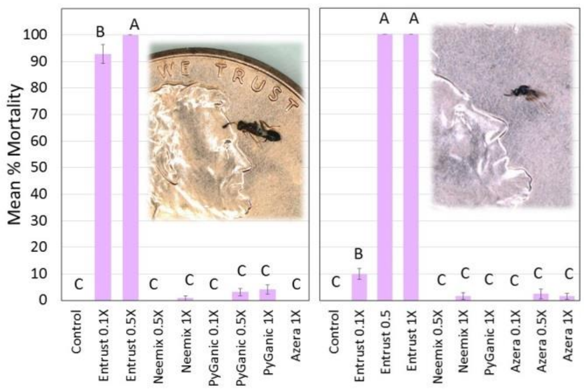


Fig. 1. **Bioassay 1** Mean percent mortality of *A. reduvii* (left) (24 hrs: DF= 8, F= 321, P <.0001; 48 hrs: DF=8, F=327, P <.0001) and *T. podisi* (right) (24 hrs: DF=10, F= 526, P <.0001; 48 hrs: DF= 10, F= 488, P <.0001) 24 and 48 hrs post exposure to dried insecticide on substrate.

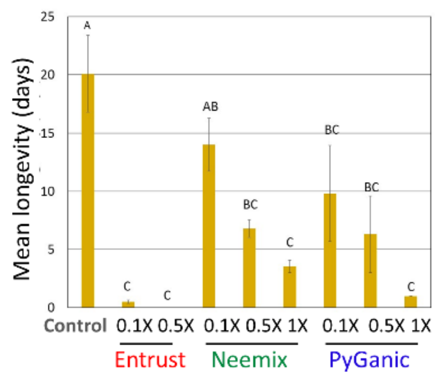


Fig. 2. **Bioassay 2** Mean longevity of *A. reduvii* post-exposure to insecticide-laced sucrose (DF= 8, F= 9.84, P <.0001).

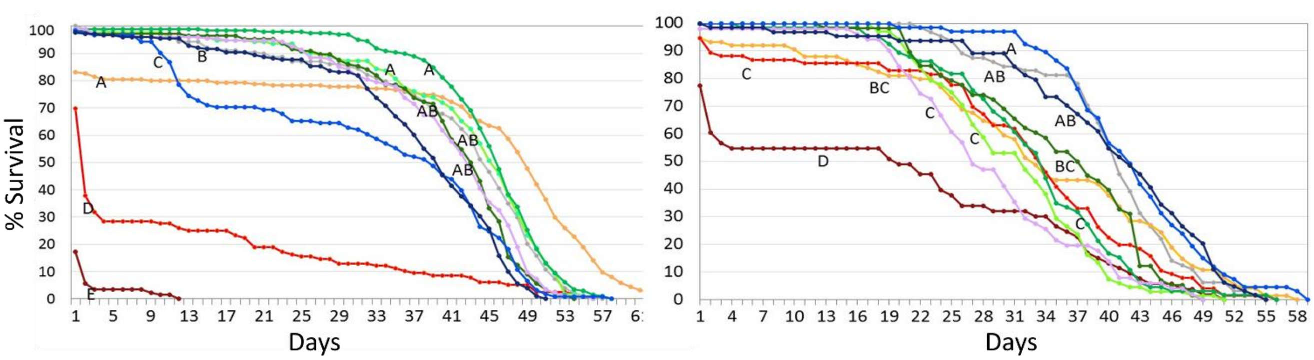
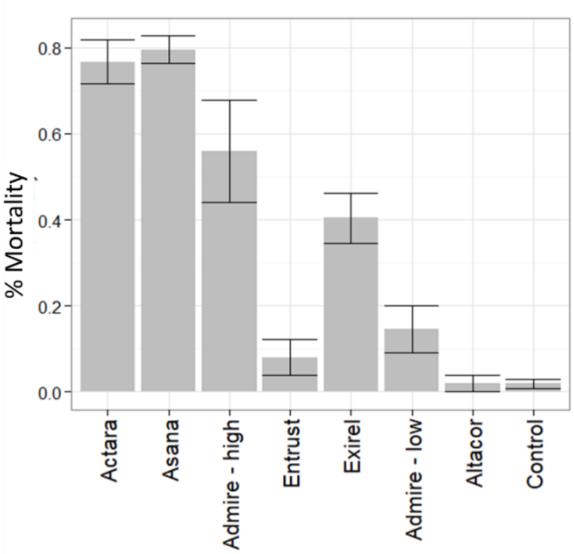


Fig. 3 **Bioassay 4** Percent daily survival of all emerged female *A. reduvii* (left) (DF= 9, F= 120.30, P <.0001) and *T. podisi* (right) (DF= 9, F= 21.39, P <.0001) from parasitized egg masses submerged in Bioassay 3 treatments.

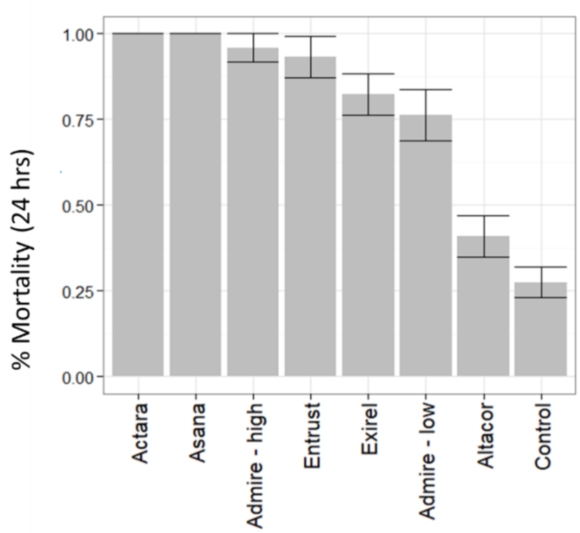
Results (OR):

More than 50% of wasps died within an hour of being exposed to Actara, Asana, and Admire Pro (2.8 fl oz / acre only). After 24 hours, mortality in all treatments, except for Altacor, was above

75% and significantly greater than the control (DF = 7, F = 51.1, P < 0.001, Fig. 3). Egg masses presented to wasps alive after 24 hours only emerged in the control and Altacor treatment. Additional application rates and residues with longer drying periods (3-7 days) will be tested and analyzed in the upcoming year.



Mean % *T. japonicus* mortality (± SE) 1 hour after exposure to chemicals. Admire Pro High rate = 2.8 fl oz and Low rate = 1.2 fl oz per acre.



Mean % *T. japonicus* mortality (± SE) 24 hours after exposure to chemicals. Admire Pro High rate = 2.8 fl oz and Low rate = 1.2 fl oz per acre.

Objective 3. Develop management tools and strategies that are compatible with biological control and informed by risk from landscape factors.

Project: Attract and kill management strategy

Background: Following the identification of BMSB pheromone and pheromone synergist, we developed trap-based treatment thresholds for managing this pest in apple that reduced insecticide inputs by over 40%. We also explored the potential for attract-and-kill (AK) implementation in commercial apple orchards to effectively manage BMSB. Over two years at farms in NJ, PA, VA, WV and MD, we found that the use of attract and kill (perimeter row apple trees baited with pheromonal stimuli and treated with insecticides weekly (Fig.1)) effectively controlled BMSB compared with standard grower practices with the crop area treated with insecticide applied against BMSB reduced by up to 97% in attract and kill blocks. However, weekly insecticide treatments are difficult for growers to manage. Methods for reducing in-orchard time for growers are needed to increase the likelihood of adoption.


Fig. 1.

What was Done: The efficacy of attract-and-kill, full perimeter and threshold management of BMSB was compared with untreated control plots. Six treatments were replicated in each of three experimental apple orchards in 2015 and 2016: 1) attract-and-kill at 7-d spray intervals, 2) attract-and-kill at 14-d spray intervals, 3) perimeter at 7-d spray intervals, 4) perimeter at 14-d spray intervals, 5) treatment threshold (blocks treated with two ARM sprays when 10 adults per trap were captured cumulatively), and 6) untreated control. If any of the traps in the attract-and-kill or perimeter treated plots reached the cumulative threshold, then the entire plot was treated with two consecutive alternate row middle sprays.

To evaluate if long-lasting insecticide-treated nets (LLINs) could be substituted for insecticide sprays in attract and kill trees, Vestergaard (D-Terrence) netting was cut into 1 m square pieces and hung on perimeter trees every 50 m in three commercial apple orchards. Each tree received three squares (Fig. 2). Each net contained 1 high dose Trécé lure that was replaced at 8-wk intervals. The netting was never replaced. Nets and lures constituted the BMSB management for the plot. The standard plot at each farm was managed following the grower's standard program. Three baited pyramid traps were placed in the interior of both plots to determine if BMSB populations had invaded the plot and further management was necessary. If a


Fig. 2.

threshold was reached, the growers were advised that intervention may be necessary. Growers were not required to spray at this time; only advised. At harvest, fruit samples were collected.

Finally, to evaluate the relative lethality of LLINs and their orientation in apple trees, four treatments were assessed in experimental apple orchards: 1) weekly bifenthrin spray (1 lb/A), 2) horizontally positioned LLINs, 3) vertically positioned LLINs, and 4) untreated control. All apple trees were baited with three high dose Trécé lures. On trees treated with netting, the lures were attached to the netting. Horizontally positioned netting was deployed in the same manner as in the commercial attract-and-kill trials reported above. The vertically positioned netting was equal in size to the horizontally positioned netting, but deployed from the bottom to the top of canopy of the apple tree. Beneath each treatment tree, a tarp was deployed covering the entire lower canopy. After 48 h and 144 h, the number of dead/moribund BMSB adults, nymphs, other stink bugs, and beneficial insects was recorded and removed from the tarp.

Results:

Significantly less BMSB injury was present in apple blocks protected by attract-and-kill at 7- and 14-day spray intervals (~6-18%), perimeter sprays at 7- and 14-day intervals (~3-12%), and treatment threshold-triggered sprays (~6-8%) compared with the untreated control (~26-33%). In general, more injury was present when spray intervals were stretched to 14d and blocks managed by a trap-based treatment threshold required less intervention (Fig 3).

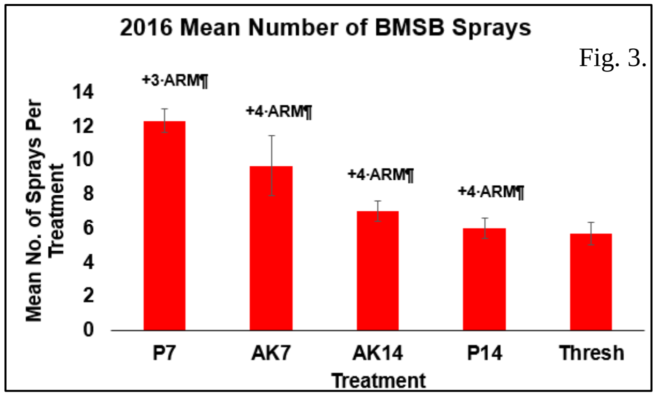


Fig. 3.

In commercial orchard blocks protected by baited LLINs affixed to border row apple trees, percent fruit injury in the plot interior at harvest averaged 0.02 + 0.01 SE in compared with 0.13 + 0.02SE in grower standard plots. Baited LLINs provided equivalent protection to standard grower programs. This work will be repeated in 2018.

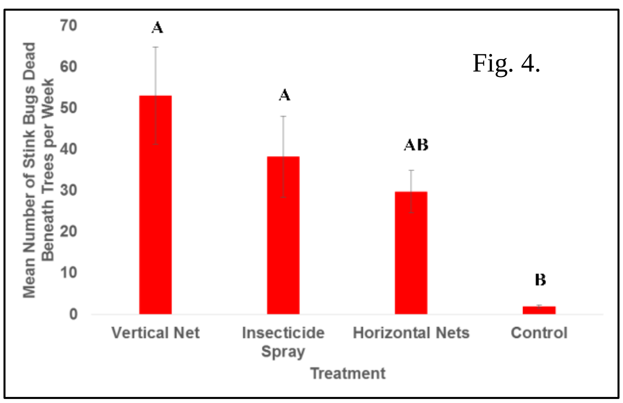


Fig. 4.

Finally, among vertical nets, horizontal nets, insecticide sprays and control, significantly more BMSB were recovered from trees with vertical nets or that were sprayed weekly compared with the control, with horizontal nets being intermediate (Fig. 4) indicating that a vertical orientation may be more effective at killing foraging BMSB..

Objective 3. Develop management tools and strategies that are compatible with biological control and informed by risk from landscape factors.

Project: Crop perimeter restructuring (aka border sprays) IPM

Background: This project aims to develop management tactics for BMSB that reduce insecticide inputs and may improve orchard sustainability. Since its introduction, BMSB has become a serious orchard pest that has caused growers to crop IPM friendly tactics with intense applications. This project aims to reduce insecticide inputs and improve orchard sustainability with a systems-level approach termed IPM-CPR (Crop Perimeter Restructuring). Border sprays constitute the orchard border plus the first full row, which is approximately 25% of a 5-acre block. IPM-CPR has previously shown to be successful in NJ peach orchards, and in 2016 and 2017 we expanded trials. In addition to managing the key orchard pests, we will look at the impact of IPM-CPR on beneficial insects, such as insect predators and pollinators.

What has been Done: Studies were conducted in blocks of apple and peaches with a wooded border and history of BMSB problems. 2017 was an early spring, which in some cases resulted in early harvests, allowing the crop to escape high BMSB pressure.

Apple: IPM-CPR was evaluated in apples in two NJ, 1 WV, and 1 VA farm. The aim was to compare a 5 acre CPR block to a similar sized block using standard practices. BMSB was monitored using 4 black pyramid pheromone (Trécé) traps on the border and 2 on the interior of each 5-acre block (Fig 1). For management decisions, we incorporated the trap-based threshold developed by Leskey and Short. Growers applied a single early season full block spray if trap numbers reached a cumulative threshold of 10. The threshold was reset and border sprays (border plus 1st full row) were initiated when the threshold was again reached, usually mid-July (Fig 1). Border sprays continued weekly until harvest. Inclusion of a decision-support tool for growers will permit growers to determine if populations have 'breached' the border and to rate effectiveness of the method. Stink bug injury and severity was evaluated at harvest by peeling fruit.

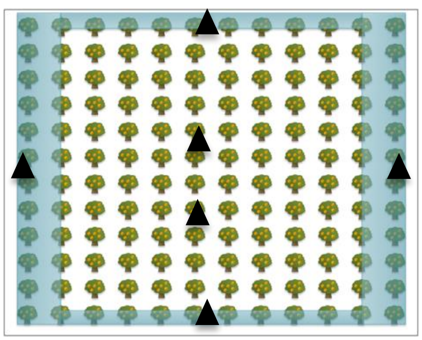


Figure 1. Plot schematic of border sprays. Shaded blue area indicates area sprayed during border spray application.

Peach: With 3 years of success in using IPM-CPR tactic in NJ peaches, in 2017 the concept was expanded the WV and VA using similar methods. Paired 5-acre blocks were used, one with the IPM-CPR approach and the other using grower standard practices. All fruit was harvested when one of the blocks was ripe. BMSB was monitored using Trécé dual baited black pyramid traps placed on the border, approximately 4 per 5 acre block. Each week, a 3-minute visual assessment of selected interior trees was conducted for presence of BMSB. If 2 or more total individuals were found, a single whole-block spray was applied. Border-based insecticide applications (border plus 1st full row) began at 170 DD_{14}, and continued weekly until harvest. Stink bug injury and severity was evaluated at harvest by peeling fruit.

After discussions with NJ growers who have experience with using IPM-CPR, we evaluated the IPM-CPR approach in larger blocks, selecting a 5, 10, and 20 acre block for IPM-CPR and comparing it to a similar 5-10 acre standard. As the size of the block increases, the percent border decreases, further reducing the managed area. All other protocols and the number of traps remained the same.

Results: In apple, the IPM-CPR approach resulted in similar, if not reduced injury, at harvest relative to grower standard management. Averaged across all four sites, IPM-CPR stink bug injury at harvest averaged 11.02% while standard management averaged 10.88%. These results are consistent with the result from 2016 that IPM-CPR is a comparable management tactic to the grower standard and/or threshold-based management. The amount of insecticide used has not yet been calculated, but generally, the border for a 5-acre block constitutes 25% of the total block area. Apple growers will manage stink bug at frequent intervals late in the season with either full block sprays or back to back alternate row middle sprays. At one site, the grower abandoned border sprays for full block sprays to manage due to high codling moth pressure.

In peach, injury from stink bugs in VA was 2.0 ± 0.7% and 0.8 ± 0.4% for IPM-CPR and standard, respectively. In WV, stink bug injury was 0.5 ± 0.3% and 1.0 ± 0.4% for IPM-CPR and standard, respectively. The data from blocks in NJ showed similar trends. The utility of the IPM-CPR tactic appears to depend largely on the harvest timing and plot layout in peaches. For instance, the plots in WV especially had multiple varieties and ripening periods, although all fruit was harvested at the same date, which was made more difficult due to the early ripening period in 2017. We hope to improve the plot selection in the upcoming project period.

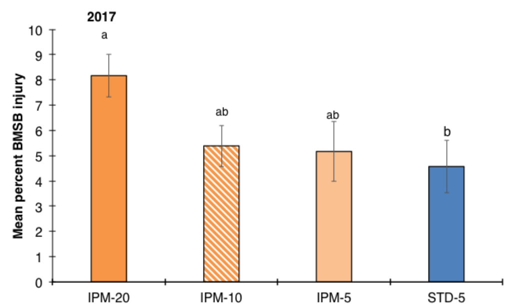


Figure 2. Efficacy of border sprays for managing stink bug injury in NJ averaged across 3 commercial orchards. Size of each block is ion the x-axis after the treatment (IPM or Standard).

There was a significant effect of block size on stink bug injury (Fig 2). At farm 1 there was no significant difference in stink bug injury at harvest between blocks (F=1.91, *P=0.13*). At farm 2, the effect was significant with the standard having significantly lower injury than the IPM-CPR block at 10 acres, however 5 and 24 acres were not significant from the standard (F=2.77, P=0.045). At the last farm, there was a significant effect of treatment and size with IPM-CPR not sufficiently managing BMSB at the 20 acre size (13% injury) (F=3.95, P=0.01), whereas the standard, 5 IPM-CPR, and 10 IPM-CPR acre had 7.5, 10.8, and 5.5% injury. This suggests that depending on stink bug pressure, IPM-CPR using border sprays for stink bug management is sufficient relative to the standard.

Key impacts:

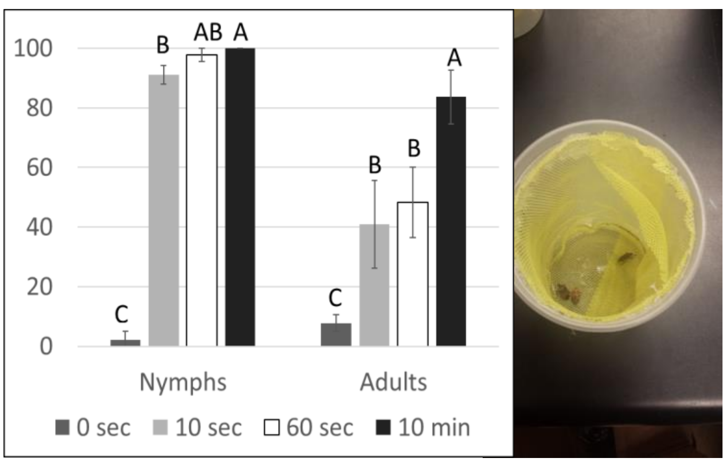
- Border sprays are a viable tactic in apples based off 2-years of data with stink bug injury at harvest similar to the grower standard.
- In peaches, the data also suggests that this is a management tactic with a maximum of 10 acres.
- We are still collecting data for the economic analysis but border-based applications manage approximately 25% of the orchard.
- The finding of the Samurai wasp, *T. japonicus*, is the first find in commercial agricultural and indicates that IPM-CPR may be a compatible tactic with biological control programs for BMSB in peach.

Objective 3. Develop management tools and strategies that are compatible with biological control and informed by risk from landscape factors.

Project: Pyrethroid-incorporated netting as a management tool

Background: Long-lasting insecticide nets, which have pyrethroids incorporated within the synthetic fibers, have been widely used for control of malaria and other insect-vectored diseases. The netting has been shown to last multiple years with only minor reductions in efficacy at killing insects. There are several commercial nets available that contain different active ingredients such as deltamethrin, alpha-cypermethrin, or permethrin, all of which have relatively low mammalian toxicity. We evaluated the effectiveness of these nets at killing stink bugs and are currently exploring potential uses of this tool in IPM strategies for BMSB.

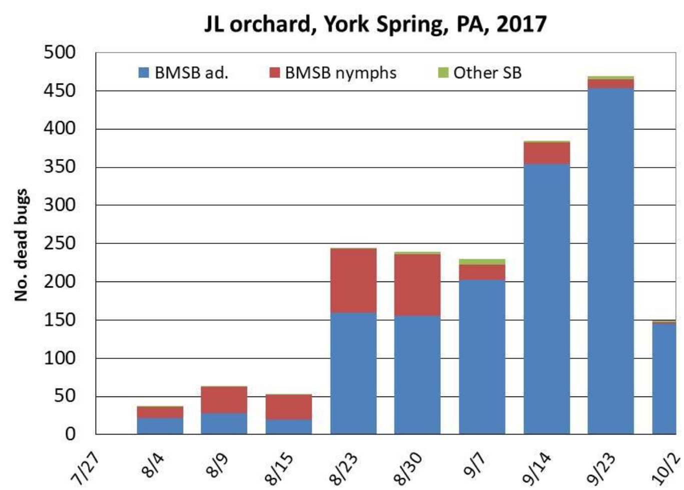
What was done: In the lab, we demonstrated that exposure to deltamethrin-incorporated netting, D-Terrance® (Vestergaard-Frandsen) for 10 s resulted in >90% mortality of BMSB nymphs and >40% mortality of adults (Kuhar et al. 2017). Longer exposure to the net resulted in higher mortality. In another experiment, a small sheet of deltamethrin net placed inside of stink bug pyramid trap tops provided long-lasting kill of BMSB adults equal to or better than the standard dichlorvos kill strips. As a result, the deltamethrin net replaced fumigant kill strips for use in all of our BMSB sampling projects involving pyramid-type traps.



Percentage mortality of BMSB after brief exposure to D-Terrance netting in a container.

Dead stink bugs at the base of D-Terrance netting surrounding an orchard in the Hudson Valley of New York.

Current and future research: Experiments by our team in Michigan, New York, Pennsylvania, Virginia, and West Virginia are exploring the use of deltamethrin-incorporated nets coupled with high dose BMSB pheromone lures into various attract-and-kill strategies. Draping the net over shepherd's hooks, or fencing surrounding orchards, or hanging the netting from apple trees have all resulted in significant kills of BMSB. Moreover, preliminary results suggest that these types of strategies also may reduce the numbers of BMSB infesting orchards. Research will continue in the coming years to further explore



A pheromone-baited D-Terrance "ghost trap" set up near Biglerville, PA (left), and the average number of dead BMSB observed per trap per week at one of the locations (Right). Data from G. Krawczyk, Penn State University.

Objective 4. Managing the economic consequences of BMSB damage

Background: During the past year two major efforts were undertaken to: 1) evaluate the cost of insecticide options for controlling BMSB for a wide range of crops and 2) development of a survey to assess the economic impact of BMSB and the potential value of biocontrols to agricultural producers.

What was done: The first effort involved updating and expanding an insecticide selection tool originally developed for assessing the cost of additional sprays to manage BMSB in Pennsylvania. The user selects an application rate (low, mid, or high based on the label rate) and inputs a pre-harvest interval (PHI) of interest. Users can either use the default insecticide prices included with the selection tool or input their own (Figure 1). Based on the user specified rate, prices, and the PHI constraint, the output for the model shows side-by-side comparisons of: 1) the least cost option, 2) the least cost option for another IRAC mode of action classification (to encourage rotation of insecticides), and 3) the least cost option with the highest efficacy (Figure 2). The model currently compares 25 insecticides for 55 crops.

The second major effort involved the development of a producer survey instrument to assess the impact of BMSB on a wide range of crops across the United States. The survey contains questions about crop damage and impact on profitability, sources of management information, management practices, and insecticide use. In particular, the survey seeks to ascertain attitudes towards biological control and potential willingness to pay (questions 18-20 in Figure 3).

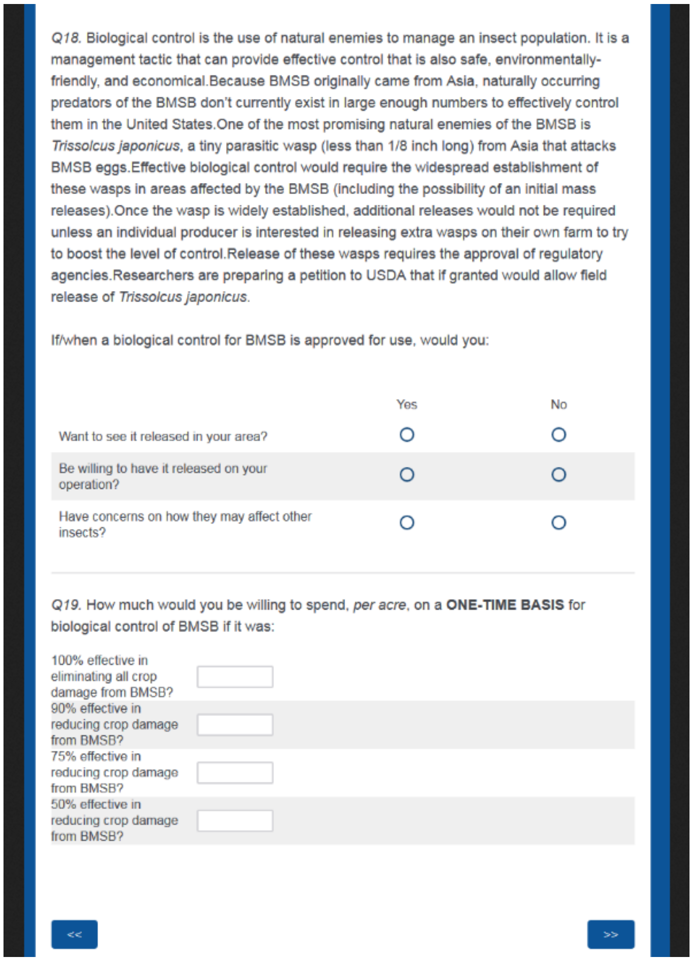
Results/impact: The plan is for the BMSB insecticide selection tool to be available on the StopBMSB.org website by mid-March 2018. The producer survey has been formatted on-line and will be available for access by survey participants by the end of February 2018. Newsletter articles and links will be made available to publicize the survey through extension channels later this winter.

Click boxes:	BMSB management scenarios evaluated:			Application Rate:	
	1) Least expensive option for PHI			Low	
Instructions	2) Least expensive option for PHI with a different IRAC			Mid	
	3) Least expensive option for PHI with highest efficacy level			High	
CALCULATE RESULTS				Pre-harvest interval:	14
			Default	Your	Price to
			Price	price	use for
Trade Name	Active ingredient	unit	per unit	per unit	per unit
Actara	thiamethoxam	oz.	$3.35	$0.00	$3.35
Admire Pro	imidacloprid	oz.	$1.08	$0.00	$1.08

Figure 1. View of the user input page for the BMSB Insecticide Selection Tool (partial)

Mid-point rate, 14 day PHI	Least expensive option					Least expensive option, different IRAC					Least expensive option, highest efficacy				
Crop	Insecticide	Cost/A	PHI	Efficacy	IRAC	Insecticide	Cost/A	PHI	Efficacy	IRAC	Insecticide	Cost/A	PHI	Efficacy	IRAC
alfalfa	Baythroid	$1.96	7	2	3	Dimethoate	$4.56	3	4	1	Lannate SP	$20.12	7	1	1
barley	Mustang	$3.64	14	3	3	Malathion 5EC	$7.44	7	4	1	Lannate SP	$10.06	1	1	1

Figure 2. View of the output page for the BMSB Insecticide selection Tool (example)



Q18. Biological control is the use of natural enemies to manage an insect population. It is a management tactic that can provide effective control that is also safe, environmentally-friendly, and economical.Because BMSB originally came from Asia, naturally occurring predators of the BMSB don't currently exist in large enough numbers to effectively control them in the United States.One of the most promising natural enemies of the BMSB is *Trissolcus japonicus*, a tiny parasitic wasp (less than 1/8 inch long) from Asia that attacks BMSB eggs.Effective biological control would require the widespread establishment of these wasps in areas affected by the BMSB (including the possibility of an initial mass releases).Once the wasp is widely established, additional releases would not be required unless an individual producer is interested in releasing extra wasps on their own farm to try to boost the level of control.Release of these wasps requires the approval of regulatory agencies.Researchers are preparing a petition to USDA that if granted would allow field release of *Trissolcus japonicus*.

If/when a biological control for BMSB is approved for use, would you:

	Yes	No
Want to see it released in your area?	○	○
Be willing to have it released on your operation?	○	○
Have concerns on how they may affect other insects?	○	○

Q19. How much would you be willing to spend, *per acre*, on a **ONE-TIME BASIS** for biological control of BMSB if it was:

100% effective in eliminating all crop damage from BMSB?	
90% effective in reducing crop damage from BMSB?	
75% effective in reducing crop damage from BMSB?	
50% effective in reducing crop damage from BMSB?	

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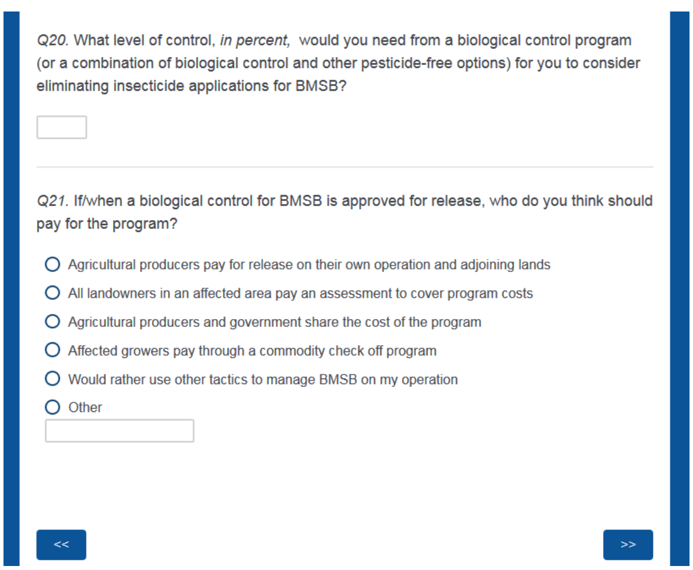

Q20. What level of control, *in percent*, would you need from a biological control program (or a combination of biological control and other pesticide-free options) for you to consider eliminating insecticide applications for BMSB?

Q21. If/when a biological control for BMSB is approved for release, who do you think should pay for the program?

- ○ Agricultural producers pay for release on their own operation and adjoining lands
- ○ All landowners in an affected area pay an assessment to cover program costs
- ○ Agricultural producers and government share the cost of the program
- ○ Affected growers pay through a commodity check off program
- ○ Would rather use other tactics to manage BMSB on my operation
- ○ Other

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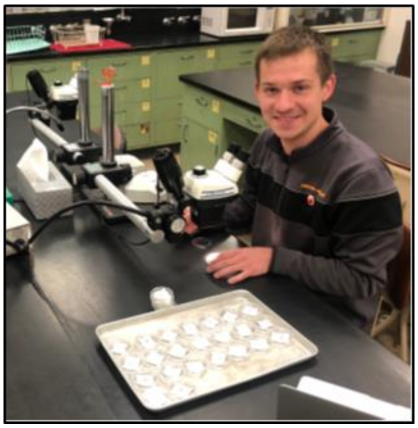
Figure 3. Survey questions relating to BMSB biological control and willingness to pay

Objective 5. Outreach – Deliver New Information on BMSB to Stakeholders

Inspire next generation of invasive pest Experts: The project is playing a key role in providing training and inspiration for the next generation of scientists in the area of invasive pests, insect behavior, and integrated pest management. Directly and indirectly, the project made available training opportunities for 13 MS students, 5 PhD students, and 14 Postdoctoral researchers. In addition, 57 undergraduate students were either directly supported or worked on research supported by the project.



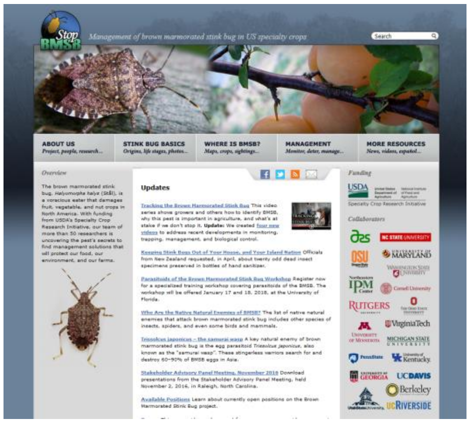
Utah State University graduate student Zachary Schumm at the microscope (left), and Virginia Tech graduate student Hayley Bush spraying peppers for BMSB (right).

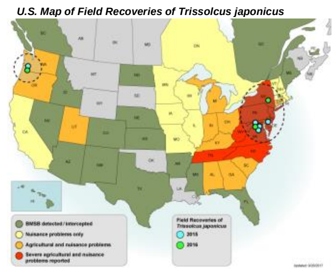
Build upon existing BMSB outreach resources, develop and maintain a knowledge repository that captures lessons, insights and success stories over time. During the past year, project participants and collaborators have provided educational training to stakeholders across the country. This training has included presentations at scientific meetings, commodity oriented meetings, master gardeners, and a diversity of general public audience.

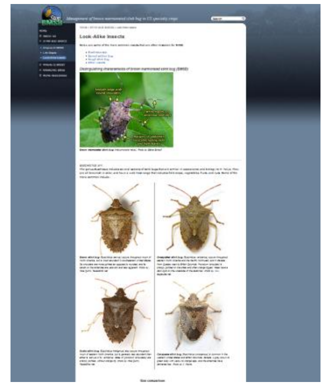
Number of BMSB publications and presentations during between November 2016 and December 2017.

Publications		Presentations	
Research journal	30	Research Conferences	104
Proceedings	12	Extension Meetings	84
Extension	23	Workshops	8
Popular articles	8		
Broadcast/Print news	21		
State Websites	16		

StopBMSB.org website is a major avenue for delivering information to a wide array of stakeholders, including the scientific community, grower and commodity organizations, and the general public. This website is maintained by the Northeastern IPM Center (Cornell University), and was originally established during the first BMSB SCRI project. The website has been updated to reflect the new focus and personnel in the current SCRI project, as well as revision of existing information and addition of several new focus articles. To guide the future development of the website, an extension committee represented by members from each of the five regions is working with NEIPM Center personnel Chris Gonzales and Kevin Judd to identify feature article topics and a series of Spotlight articles on project participants. The website is recognized as the "go to" site for BMSB information, and provides links to state sites and cooperating organizations. In the past year StopBMSB.org has had 86,000 unique visitors.







Expand the relevancy of BMSB outreach sources to all US Regions. There is a great diversity of needs among stakeholders based on their familiarity with the pest, the specialty crops grown, and region of the country. For instance, specialty crop producers in the mid-Atlantic region have experienced severe BMSB pest pressure since 2010, while it is still expanding into new areas in the southeast, Great Lakes, and western US. With expansion of the insect into new areas, come different climates, agroecosystems, specialty crops and communication strategies that may be unique to each region. Hence, the project promotes communication among participants at both the regional and national level to learn from previous experiences and adapt strategies to the local level. Both regional and national stakeholder meetings provide a mechanism for relevancy at both levels. Outreach activities are tailored for location audiences, yet listservs for PIs, all project participants, as well as the BMSB community at large, provide a mechanism for sharing new and relevant information with audiences at the local and national (and international) level.

Regional stakeholder advisory meeting at the Southeastern Apple Growers Meeting in Asheville, NC, in January 2017.

Washington State BMSB team conducting an outreach activity at the Saturday Farmer's Market in Wenatchee.

PROJECT OUTPUTS

Research publications:

*Denotes publications acknowledging current SCRI project (#2016-51181-25409). Others acknowledged the previous SCRI project (#2011-51300-20097).

*Ingels, CA, and KM Daane. 2018. Phenology of brown marmorated stink bug and trap and lure studies in a California urban landscape. Environ. Entomol. 47. In press.

*Rice, KB, RH Bedoukian, GC Hamilton, P Jentsch, A Khrimian, P Mclean, WR Morrison, BD Short, PM Shrewsbury, DC Weber, NG Wiman, and TC Leskey. 2017. Enhanced response of *Halyomorpha halys* (Hemiptera: Pentatomidae) to its aggregation pheromone with ethyl decatrieonate. J. Econ. Entomol. 110. In press. DOI: 10.1093/jee/tox316

Abram, PK, KA Hoelmer, A Acebes-Doria, H Andrews, EH Beers, JC Bergh, R Bessin, D Biddinger, P Botch, ML Buffington, ML Cornelius, E Costi, ES Delfosse, C Dieckhoff, R Dobson, Z Donais, M Grieshop, G Hamilton, T Haye, C Hedstrom, MV Herlihy, MS Hoddle, CRR Hooks, P Jentsch, NK Joshi, TP Kuhar, J Lara, JC Lee, A Legrand, TC Leskey, D Lowenstein, L Maistrello, CR Mathews, JM Milnes, WR Morrison III, AL Nielsen, EC Ogburn, CH Pickett, K Poley, J Pote, J Radl, PM Shrewsbury, E Talamas, L Tavella, JF Walgenbach, R Waterworth, DC Weber, C Welty, and NG Wiman. 2017. Indigenous arthropod natural enemies of the invasive brown marmorated stink bug in North America and Europe. J. Pest Sci. 90: 1009–1020. DOI: 10.1007/s10340-017-0891-7

Acebes-Doria, AL, TC Leskey, and JC Bergh. 2017. Temporal and directional patterns of nymphal *Halyomorpha halys* (Hemiptera: Pentatomidae) movement on the trunk of selected wild and tree fruit hosts in the mid-Atlantic region. Environ. Entomol. 46: 258–267.

Aigner, BL, TP Kuhar, DA Herbert, CC Brewster, JW Hogue, and JD Aigner. 2017. Relationship of brown marmorated stink bug, *Halyomorpha halys*, infestations in tree borders to subsequent patterns of movement into soybean fields. J. Econ. Entomol. 110(2): 487–490. DOI: 10.1093/jee/tox047

Bergh, JC, WR Morrison III, SV Joseph, and TC Leskey. 2017. Characterizing spring emergence of adult *Halyomorpha halys* using experimental overwintering shelters and commercial pheromone traps. Entomol. Exp. Appl. 162: 336–345.

Blaauw, B, C Mathews, T Leskey, RW Morrison, and AL Nielsen. 2017. Measuring host plant selection and retention of *Halyomorpha halys* (Hemiptera: Pentatomidae) by a trap crop. Entomologia Experimentalis et Applicata. DOI: 10.1111/eea.12571

Cambridge, JE, L Francouer, and GC Hamilton. Accepted. Brown marmorated stink bug (Hemiptera: Pentatomidae) attraction to different light stimuli. Florida Entomologist.

Cira, TM, EC Burkness, RL Koch, and WD Hutchison. 2017. *Halyomorpha halys* mortality and sublethal feeding effects following insecticide exposure. J. Pest Sci. (special issue) 90: 1257–1268. DOI: 10.1007/s10340-017-0871-y

Dieckhoff, C, K Tatman, and KA Hoelmer. 2017. Natural biological control of *Halyomorpha halys* (Hemiptera: Pentatomidae) by native egg parasitoids – a multi-year survey in northern Delaware. J. Pest Sci. 90: 1143-1158..

Greene, JK, EP Benson, JA Baum, CS Bundy, WA Jones, GG Kennedy, JE McPherson, FR Musser, FPF Reay-Jones, MD Toews, and JF Walgenbach. 2017. Management of invasive stink bugs and related species (Pentatomoidea). In *Bionomics of Invasive Stink Bugs and Related Species (Pentatomoidea): Higher Classification, Biology, Semiochemistry, and Management*, edited by JE McPherson, 728–755. Boca Raton: CRC Press.

Hahn, NG, C Rodriguez-Saona, and GC Hamilton. 2017. Characterizing the spatial distribution of brown marmorated stink bug, *Halyomorpha halys* (Stål) (Hemiptera: Pentatomidae), populations in peach orchards. PLoS ONE. http://dx.doi.org/10.1371/journal.pone.0170889

Hahn, NG, MC Hwang, and GC Hamilton. 2017. Circuitry and coding used in a flight mill system for the study of flight performance of *Halyomorpha halys*. Florida Entomologist 100: 195–198.

Hajek, AE, LF Solter, JV Maddox, WF Huand, AS Estep, G Krawczyk, DC Weber, ND Sanscrainte, and JJ Becnel. 2017. *Nosema maddoxi* sp. nov. (Microsporidia, Nosematidae), a widespread pathogen of green stink bug, *Chinavia hilaris* (Say), and the brown marmorated stink bug, *Halyomorpha halys* (Stål). J. Eukaryot. Microbiol. (early view online). DOI: 10.1111/jeu.12475

Hamilton, GC, JJ Ahn, WJ Bu, TC Leskey, AL Nielsen, Y-L Park, W Rabitsch, and KA Hoelmer. *Halyomorpha halys* (Stål). In *Bionomics of Invasive Stink Bugs and Related Species (Pentatomoidea): Higher Classification, Biology, Semiochemistry, and Management*, edited by JE McPherson. Boca Raton: CRC Press.

Hedstrom, C, DM Lowenstein, B Bai, H Andrews, and N Wiman. 2017. Host range and preference and discovery of an established population of *Trissolcus japonicus*. J. Pest Sci. 90: 1169–1179.

Krawczyk, G, M Zanelato Nunes, H Morin, and L Shaak. 2017. Alternative methods to manage brown marmorated stink bug, *Halyomorpha halys* (Stål). *Pennsylvania Fruit News* 97(1): 52–56.

Krawczyk, G, M Zanelato Nunes, H Morin, and L Shaak. 2017. New endeavors in monitoring and management of brown marmorated stink bug, *Halyomorpha halys* (Hemiptera: Pentatomidae), in eastern United States. *IOBC-WPRS Bulletin* 123: 50–56.

Kuhar, TP, and K Kamminga. 2017. Review of the chemical control research on *Halyomorpha halys* in the USA. J. Pest Sci. 90: 1021–1031. DOI: 10.1007/s10340-017-0859-7

Kuhar, TP, BD Short, G Krawczyk, and TC Leskey. 2017. Deltamethrin-incorporated nets as an integrated pest management tool for the invasive *Halyomorpha halys* (Hemiptera: Pentatomidae). J. Econ. Entomol. 110(2): 543–545. DOI: 10.1093/jee/tow321

Lara, JR, M Kamiyama, G Hernandez, J Nay, and M Hoddle. 2017. Assessment of feeding acceptance and injury of Kerman Pistachios, *Pistacia vera*, by brown marmorated stink bug (Hemiptera: Pentatomidae). J. Insect Sci. 17(5). DOI: 10.1093/jisesa/iex084.

Maslo, B, R Valentin, K Leu, K Kerwin, GC Hamilton, A Bevan, NF Fefferman, and DM Fonseca. 2017. Chirosurveillance: The use of native bats to detect invasive agricultural pests. PLoS ONE 12: 1–10. e0173321

Mathews, CR, B Blaauw, G Dively, J Kotcon, J Moore, D Pfeiffer, E Ogburn, JF Walgenbach, C Welty, G Zinati, and AL Nielsen. 2017. Evaluating a polyculture trap crop for organic management of *Halyomorpha halys* (Hemiptera: Pentatomidae) and native stink bugs in peppers. J. Pest Sci. 90: 217–225.

Morehead, JA, and TP Kuhar. 2017. Efficacy of organically approved insecticides against brown marmorated stink bug, *Halyomorpha halys*, and other stink bugs. J. Pest Sci. DOI: 10.1007/s10340-017-0879-3

*Morrison III, WR, C-G Park, BY Seo, Y-L Park, HG Kim, KB Rice, D-H Lee, and TC Leskey. 2017. Attraction of the invasive *Halyomorpha halys* in its native Asian range to traps baited with semiochemical stimuli. J. Pest Sci. 90(4): 1205–1217.

Morrison III, WR, A Acebes-Doria, E Ogburn, TP Kuhar, JF Walgenbach, JC Bergh, L Nottingham, A DiMeglio, P Hipkins, and TC Leskey. 2017. Behavioral response of the brown marmorated stink bug (Hemiptera: Pentatomidae) to semiochemicals deployed inside and outside anthropogenic structures during the overwintering period. J. Econ. Entomol. 110(3): 1002–1009. DOI: 10.1093/jee/tox097

Morrison III, WR, AN Bryant, B Poling, NF Quinn, and TC Leskey. 2017. Predation of *Halyomorpha halys* (Hemiptera: Pentatomidae) from web-building spiders associated with anthropogenic dwellings. Journal of Insect Behavior 30(1): 70–85.

Morrison III, WR, M Allen, and TC Leskey. 2017. Behavioral response of the invasive *Halyomorpha halys* (Hemiptera: Pentatomidae) to host plant stimuli augmented with semiochemicals in the field. Agr. Forest Entomol. 20: 62–72. DOI: 10.1111/afe.12229.

Nielsen, AL, SJ Fleischer, GC Hamilton, T Hancock, G Krawczyk, JC Lee, E Ogburn, JM Pote, A Raudenbush, A Rucker, M Saunders, VP Skillman, J Sullivan, J Timer, J Walgenbach, NG Wiman, and TC Leskey. 2017. Phenology of *Halyomorpha halys* described using female reproductive development. Ecol. Evol. 7: 6680–6690. DOI: 10.1002/ece3.3125

Nystrom, E, R Venette, C Dieckhoff, K Hoelmer, and RL Koch. 2017. Cold tolerance of *Trissolcus japonicus* and *T. cultratus*, potential biological control agents of *Halyomorpha halys*, the brown marmorated stink bug. Biol. Control 107: 11–20.

Philips, CR, TP Kuhar, GP Dively, G Hamilton, J Whalen, and K Kamminga. 2017. Seasonal abundance and phenology of the brown marmorated stink bug, *Halyomorpha halys* (Stål) on different pepper cultivars in the mid-Atlantic U.S. J. Econ. Entomol. 110: 192–200.

Rice, KB, JP Cullum, NG Wiman, R Hilton, and TC Leskey. 2017. *Halyomorpha halys* (Hemiptera: Pentatomidae) response to pyramid traps baited with attractive light and pheromonal stimuli. Florida Entomologist 100(2): 449–453.

Rijal, JP, and R Duncan. 2017. First report of an established brown marmorated stink bug (Hemiptera: Pentatomidae) population in California agricultural crops. J. Entomol. Sci. 52(4): 450–454.

Skillman, VP, and JC Lee. 2017. Evaluating impacts of brown marmorated stink bug on non-fruiting nursery crops. J. Environ. Hort. 35: 93–98.

Talamas, E, M Buffington, and K Hoelmer. Revision of Palearctic *Trissolcus* Ashmead (Hymenoptera: Scelionidae). J. Hymenoptera Res. 56: 3–185. 2017.

Tognon, R, JR Aldrich, ML Buffington, EJ Talamas, J Sant'Ana, and FG Zalom. 2017. *Halyomorpha halys* (Heteroptera: Pentatomidae) egg surface chemicals inhibit North American *Telenomus* and *Trissolcus* (Hymenoptera: Scelionidae) parasitism. Biol. Control 114: 39–44.

Valentin, R, A Nielsen, N Wiman, D-H Lee, and D Fonseca. 2017. Global invasion network of the brown marmorated stink bug, *Halyomorpha halys*. Scientific Reports 7.

Weber, DC, WR Morrison III, A Khrimian, K Rice, TC Leskey, C Rodriguez-Saona, AL Nielsen, and BR Blaauw. 2017. Chemical ecology of *Halyomorpha halys*: Discoveries and applications. J. Pest Sci. (special issue on *Halyomorpha halys*). DOI: 10.1007/s10340-017-0876-6

Woltz, JM, NG Wiman, and JC Lee. 2017. Two pests overlap: *Drosophila suzukii* (Diptera: Drosophilidae) use of fruit exposed to *Halyomorpha halys* (Hemiptera: Pentatomidae). J. Econ. Entomol. 110: 1938–1941. DOI: https://doi.org/10.1093/jee/tox156

Aigner, BL, DA Herbert, GP Dively, J Whalen, TP Kuhar, CC Brewster, JW Hogue, and E Seymore. 2016. Comparison of two sampling methods for assessing *Halyomorpha halys* (Hemiptera: Pentatomidae) numbers in soybean fields. J. Econom. 109 (6): 2586-2589. DOI: https://doi.org/10.1093/jee/tow230

Cornelius, ML, C Dieckhoff, KA Hoelmer, RT Olsen, DC Weber, MV Herlihy, EJ Talamas, BT Vinyard, MH Greenstone. 2016. Biological control of sentinel egg masses of the exotic invasive stink bug *Halyomorpha halys* (Stål) in Mid-Atlantic USA ornamental landscapes. Biol. Control. 103: 11-20.

Tognon, R, J Sant'Ana, QH Zhang, JG Millar, JR Aldrich, and FG Zalom. 2016. Volatiles mediating parasitism of *Euschistus conspersus* and *Halyomorpha halys* eggs by *Telenomus podisi* and *Trissolcus erugatus*. J. Chem. Ecol. 42: 1016. http://link.springer.com/article/10.1007/s10886-016-0754-3

Proceedings/abstracts

Chambers, BD, TP Kuhar, AR Pearce, TC Leskey, and G Reichard. 2016. Structure access and settling site preferences of overwintering brown marmorated stink bugs (*Halyomorpha halys*). Published abstract, Entomology Section. Virginia Journal of Science, 67(1). Retrieved from http://digitalcommons.odu.edu/vjs/vol67/iss1

Ingels, C. 2017. The potential threat of brown marmorated stink bugs and how to manage them. Proceedings, 31st Annual Clarksburg District Grape Day, Clarksburg, CA.

Ingles, C. 2017. BMSB in Sacramento County: Phenology, distribution, and trap comparisons. Orchard Pest & Disease Management Conference, Portland, OR. (abstract)

Krawczyk, G, R Morrison, T Leskey, M Zanelato Nunes and L Shaak. January 11-13, 2017. Management options to mitigate the impact of brown marmorated stink bug in fruit orchards. 91st Annual Orchard Pest and Disease Management Conference, Portland, OR. https://opdmc.org/wp-content/uploads/2017/01/2017-Abstract-Book-for-web.pdf

Kuhar, T. January 31-February 2, 2017. Stink bugs and aphids, what's new for controlling these pests. p. 201-202 in Proceedings for the Vegetable, Potato, Greenhouse, Small Fruit, and General Sessions of the 2017 Mid-Atlantic Fruit and Vegetable Convention. Hershey, PA.

Lara, JR, MS Hoddle, C Pickett. 2016. Biological Control of BMSB in California: Status and Prospects. International Congress of Entomology 2016. Orlando, FL

Lowenstein, D, H Andrews, C Hedstrom, and NG Wiman. January 11, 2017. *Trissolcus japonicus* arrives in Oregon: Evaluating biological control of brown marmorated stink bug. Orchard Pest and Disease Management Conference. Portland, OR.

Lowenstein, DM, and N Wiman. Feeding preferences of brown marmorated stink bug in blueberries, table grapes, and hazelnuts. Pacific Northwest Insect Management Conference. Portland, OR.

Pickett, C, C Ingels, M Stadtherr, V Popescu, J Lara-Artiga, M Hoddle, and D Lightle. 2017. Resident natural enemies of brown marmorated stink bug in California. Seaside, CA. (abstract)

Rijal, JP, and R Duncan. 2017. Detection survey of brown marmorated stink bug in peach Orchards in San Joaquin Valley. Orchard Pest and Disease Management Conference, Portland, OR. (abstract)

Skillman V, and J Lee. 2017. Feeding damage by the brown marmorated stink bugs on nursery crops. Pacific Northwest Insect Management Conference. (conference proceedings)

Wiman, NG, E Tomasino, and J Milnes. January 11, 2017. Monitoring BMSB – Which trap? Orchard Pest and Disease Management Conference. Portland, OR.

Extension publications

Cannon, C, DG Alston, C Nischwitz, LR Spears, and C Burfitt. 2016. Invasive fruit pest guide for Utah: insect and disease identification, monitoring and management. Utah State University Extension. 102 pp.

Hilton, R. Fall 2016. “Days of Wine and Stink Bugs.” Applegater.

Hoelmer, K. and K. Tatman. 2017. Samurai wasp (Trissolcus japonicus): Natural enemy of the brown marmorated stink bug. USDA-ARS factsheet. http://www.stopbmsb.org/stopBMSB/assets/File/Samurai-wasp-factsheet-5-12-17.pdf

Holthouse, MC, DG Alston, LR Spears, and E Petrizzo. 2017. Brown marmorated stink bug [*Halyomorpha halys* (Stål)]. Fact Sheet ENT-144-17. Utah Plant Pest Diagnostic Lab and Utah State University Extension, Logan, UT. 8 pp.

Jasinski, J. 2017. Brown marmorated stink bug already active. May 4, 2017. VegNet. http://u.osu.edu/vegnetnews/2017/05/04/brown-marmorated-stink-bugs-already-active.

Jentsch, P. Establishing the Samurai Wasp in NY Orchards. October 4, 2017. https://blogs.cornell.edu/jentsch/2017/10/04/establishing-the-samurai-wasp-in-ny-orchards-october-4-2017/

Kemble, J, IM Meadows, KM Jennings, and JF Walgenbach. 2017 Southeastern US Vegetable Handbook. (Insect management sections.) Farm Journal Media. 294 p.

Lowenstein, D, N Wiman, H Andrews, R Hilton, C Kaiser, J Lee, and V Walton. 2017. Samurai Wasp: promising egg parasitoid for management of brown marmorated stink bug (BMSB). Oregon State University Extension Service Publication EM 9164.

Rijal, J, and R Duncan. 2017. Brown marmorated stink bug spread to peach growing areas in the Northern San Joaquin Valley. CAPCA Adviser, 2017.

Rijal, J. 2017. Update on brown marmorated stink bug (BMSB) monitoring. University of California Agriculture and Natural Resources Field Notes. pg. 4-5.

Skillman, V, and J Lee. Stink bug stopping by nurseries. Digger Magazine, in press.

Spears, LR, and C Cannon. 2017. A review and update on the status of brown marmorated stink bug in Utah. Utah Pests News Quarterly Newsletter Vol. 11 (Fall). Utah Plant Pest Diagnostic Lab and Utah State University Extension, Logan, UT (in press).

Spears, LR, R Davis, D Alston, R Ramirez, E Brennan, and C Cannon. 2016. First detector guide to invasive insects. Utah State University Extension, Logan (53 pp).

Walgenbach, J, W Mitchem, M Parker, S Villani, and D Lockwood. 2017 Integrated Orchard Management Guide for Commercial Apples in the Southeast. NC Coop. Ext. Service. 87 p.

Welty, C. 2017. Insect observations on fruit crops. Ohio Fruit News. Edition 2, 7/4/2017. https://u.osu.edu/fruitpathology/files/2017/04/Edition2_07042017-1a05nzu.pdf

Welty, C. 2017. Lingering stink bug activity in late-season fruit crops. Ohio Fruit News. Edition 3, 10/16/2017. https://u.osu.edu/fruitpathology/files/2017/04/Edition3_10162017-1y4dldh.pdf

Welty, C. 2017. Preparing for insect pest management in 2017. Ohio Fruit News. Edition 1, 4/24/2017. https://u.osu.edu/fruitpathology/files/2017/04/Edition1_04242017_Publish-1aqiil5.pdf

Welty, C. 2017. Stink bugs in tree fruit. Ohio Fruit News. Mini edition 3, 8/15/2017. https://u.osu.edu/fruitpathology/files/2017/04/Mini_08152017-1z6goxe.pdf

Welty, C. 2017. Surge in stink bug activity. VegNet. 9/23/17. https://u.osu.edu/vegnetnews/2017/09/23/surge-in-stink-bug-activity/

Wilson, J, LJ Gut, M Haas, M Grieshop, K Poley and W Shane. 2016. Managing Brown Marmorated Stink Bug in Michigan Tree Fruits.

Wilson, J. Sept 22, 2016. Brown marmorated stink bugs are moving into Michigan homes. MSU AgNews.

Wilson, J. Aug 1, 2017. Michigan brown marmorated stink bug report for Aug. 1, 2017. MSU AgNews.

Wiman, NG, and D Lowenstein. 2017. Emerging Pests: Brown marmorated stink bug. In: Hollingsworth, C.S., editor. Pacific Northwest Insect Management Handbook [online].

Trade journal articles

Almond, peach growers on alert. Stink bug threatens high-dollar crops. Rijal, J. Field Journal article: Western Fruit Growers magazine. September 2017. pg 22-24.

Biological control research focuses on BMSB pest as insecticidal option. Cecilia Parsons. Western Farm Press. August 17, 2017. http://www.westernfarmpress.com/tree-nuts/biological-control-research-focuses-bmsb-pest-insecticidal-option

Can attract-and-kill technology protect fruit against brown marmorated stink bug? Karli Petrovic. Growing Produce. June 1, 2017.

Five ways to rid your home of stink bugs. Article in Ohio State Insights. July 2017. https://insights.osu.edu/sustainability/stink-bugs

New project targets BMSB – sustainably. Rosemary Hallberg. Growing Produce. October 30, 2016.

Seeking the Stink Bug's Natural Enemies. Press release on May 8, 2017 by OSU Marketing and Communications office. https://cfaes.osu.edu/news/articles/seeking-the-stink-bug%E2%80%99s-natural-enemies-0

Tiny wasps set to wreak havoc on stink bugs. Wisconsin State Farmer. Mar 7, 2017. https://www.wisfarmer.com/story/news/2017/03/08/tiny-wasps...stink-bugs/98889258

Wasps released to eat stink bug eggs. Good Fruit Grower. Kate Prengaman. March 15, 2017.

News/Broadcasts

Albany Times Union. Jul 24, 2017. The battle of the bugs has been launched. http://digital.olivesoftware.com/Olive/ODN/AlbanyTimesUnion/shared/ShowArticle.aspx?doc=HATU%2F2017%2F07%2F24&entity=Ar00205&sk=91EDF0AC

The Beacon-News and in the Chicago Tribune. October 11, 2017. If it's autumn, it is stink bug season in Aurora. Interview with David Sharos, reporter for The Beacon-News, and Kate Thayer of The Chicago Tribune.

The Harlem Valley News. Mar 6, 2017. The Fall of the Brown Marmorated Stink Bug in New York's Hudson Valley. https://www.theharlemvalleynews.net/?p=26341

LOHUD.com. March 13, 2017. John Ferro. Stink bug killers: Scientists to release Samurai wasps. Updated 6:06 a.m. ET March 13, 2017: Discovery of wasps in Ulster County is likely to speed process across New York. http://www.lohud.com/story/news/local/2017/03/13/stink-bug-wasps/99113182/

The Oregonian. June 3, 2017. Samurai wasps battle invasive stink bugs in Oregon. http://www.oregonlive.com/hg/index.ssf/2017/06/natural_enemy_samurai_wasp_bat.html

Rochester Democrat & Chronicle. March 16, 2017. The battle of the bugs: wasps combat upstate stink bugs. Sara Taddeo.

Syracuse.com. March 13, 2017. Ben Axelson. Scientists to release hordes of Samurai wasps to combat stink bugs in Upstate NY. http://www.syracuse.com/state/index.ssf/2017/03/scientists_to_release_hordes_of_samurai_wasps_to_combat_stink_bugs_in_upstate_ny.html

Tri-City Herald. October 22, 2016. Annette Cary. Stink bug infestation heading toward tri-cities.

USA Today. Mar 7, 2017. Tiny wasps set to wreak 'Alien'-like havoc on stink bugs. https://www.usatoday.com/story/news/nation-now/2017/03/07/stink-bug-natural-killer/98861570/

Washington Examiner. September 19, 2017. Paul Bedard. Chinese 'samurai wasp' invades to kill destructive stink bug. http://www.washingtonexaminer.com/chinese-samurai-wasp-invades-to-kill-destructive-stink-bug/article/2634671

AgInfo.net. June 22, 2017. Samurai wasps. http://www.aginfo.net/index.cfm/event/report/id/Fruit-Grower-Report-37389

KDSK. March 27, 2017. KSDK staff. 10 things to know about stink bugs. St. Louis, MO.

NCC News, Syracuse Univ. Oct. 31, 2017. Interview (by Jose Cuevas) for story on using Samurai wasp against BMSB and enlisting citizen scientists in the effort. https://nccnews.expressions.syr.edu/2017/11/06/samurai-wasps-and-citizen-scientists-make-for-a-dynamic-duo-versus-stinkbugs-in-cny/

NPR Interview: Virginia's Public Radio, All Things Considered. Robbie Harris (reporter). October 4, 2017. Stink Bug Redux; New Strategies for Controlling Them. http://wvtf.org/post/stink-bug-redux-new-strategies-controlling-them-0

Orchard People Podcast with Susan Poizner. April 25, 2017. Battling the brown marmorated stink bug. Toronto, Ontario.

Utah Public Radio. August 10, 2017. A new and bad insect in Utah: brown marmorated stink bug. DG Alston. Logan, UT.

WHCU, Cayuga Radio Group, Ithaca. October 27, 2017.Interview (by Kyle Robertson) for story on BMSB and biocontrol efforts using Samurai wasp.

WPDH, Poughkeepsie (101.5) Radio Broadcast, Boris and Robin Morning show. March 6, 2017. Scientists Plan to Kill Hudson Valley Stink Bugs by Releasing Wasps. P Jentsch. http://wpdh.com/scientists-plan-to-kill-hudson-valley-stink-bugs-by-releasing-wasps/

WRNR Talk Radio with Rob Mario. August 1, 2017. Fall invasion of the brown marmorated stink bug.

WROC Ch. 8, Rochester, March 17, 2017 Evening News. Biocontrol of BMSB using wasp parasitoids. A Agnello. Interview with Emily Noonan.

WSET Lynchburg Affiliate with Elizabeth Tyree & Annie Andersen (reporter). ABC News Interview. October 6, 2017. Invasive stinkbugs taking over Virginia, now VT is researching how to get rid of them. http://wset.com/news/local/invasive-stinkbugs-taking-over-virginia-now-vt-is-researching-how-to-get-rid-of-them

Research Conference Presentations

Akotsen-Mensah, C, AL Nielsen, R Morrison, TC Leskey, C Bergh. 2017. Re-introducing IPM post BMSB detection in apples. Entomological Society America Eastern Branch Meeting, Newport, RI.

Alston, DG. April 2-5, 2017. Latest in brown marmorated stink bug research in the West: symposium introduction. Annual Meeting of the Pacific Branch of the Entomological Society of America, Portland, OR.

Alston, DG. November 3 and 10, 2016. IPM for primary and secondary insect and mite pests of fruit trees. Utah Fruit School, Spanish Fork. UT.

Bergh, JC, A Acebes-Doria, and TC Leskey. September 25-29, 2016. Ecology and behavior of brown marmorated stink bug (*Halyomorpha halys*) at the interface between orchards and woodlands in the Mid-Atlantic, USA. XXV International Congress of Entomology. Orlando, FL.

Bergh, JC, TC Leskey, J Walgenbach, G Hamilton, M Toews, and A Acebes-Doria. December 1-2, 2016. Emergence of overwintering *Halyomorpha halys* from experimental shelters across a transect from New Jersey to Georgia. Cumberland-Shenandoah Fruit Workers Conference. Winchester, VA.

Bergh, JC, NF Quinn, and JP Engelman. 2017. Can insecticide-treated netting mitigate *H. halys* issues for homeowners? Cumberland-Shenandoah Fruit Workers Conference, November 30-December 1. Winchester, VA.

Blaauw, B, C Rodriguez-Saona, G Hamilton, A Nielsen. 2016. When stink bugs react: Host stimuli and the brown marmorated stink bug. XXV International Congress of Entomology. Orlando, FL.

Bon, M, K Hoelmer, C Dieckhoff, M Buffington, E Talamas, F Guermache, and D Weber. April 2017. Using phylogeography and population genetics to reconstruct the introduction scenario of invasive populations of *Halyomorpha halys* in the western U.S. and of its egg parasitoid *Trissolcus japonicus* unexpectedly recovered from the wild in the U.S. International Heteroptera Symposium and Workshop. Seaside, CA.

Bush, H, and T Kuhar. March 18-21, 2017. An attract and kill approach for BMSB using pheromone lures and deltamethrin-incorporated screens. 88th Annual Meeting of the Eastern Branch of the Entomological Society of America. Newport, RI.

Bush, H, TP Kuhar, R Bedoukian, K McKenzie, and M Maher. 2017. Evaluating tactile repellents for brown marmorated stink bug, *Halyomorpha halys* (Stål). Annual Meeting of the Entomological Society of America. November 5 – 8. Denver, CO.

Bush, H. 2017. Examining the Success of Food-Grade Repellents on Overwintering BMSB. Brown Marmorated Stink Bug Areawide Stakeholder Meeting & IPM Working Group Meeting, November 29. Winchester, VA

Chambers, B, T Kuhar, A Pearce, G Reichard and TC Leskey. March 18-21, 2017. Response of the brown marmorated stink bug (*Halyomorpha halys*) to thermal contrast in wall panels during winter shelter seeking. 88th Annual Meeting of the Eastern Branch of the Entomological Society of America. Newport, RI.

Chambers, B, TP Kuhar, A Pearce, T Leskey, and G Reichard. September 25-29, 2016. Structure access and settling behavior of overwintering brown marmorated stink bugs (*Halyomorpha halys*). XXV International Congress of Entomology. Orlando, FL.

Cullum, J, JC Bergh, MJ Raupp, PM Shrewsbury, PD Venugopal, H Martinson, and TC Leskey, September 25-29, 2016. Influence of elevation on dispersal behavior of brown marmorated stink bug (*Halyomorpha halys*) seeking overwintering sites. XXV International Congress of Entomology. Orlando, FL.

Daane, K. 2017. Small and large bug damage in nut crops. 8th Annual Advances in Pistachio Production Conference. Visalia, CA.

Diekhoff, C., K. Tatman, S. Boyle, and K. Hoelmer. 2016. Host choice behavior in Trissolcus japonicus, a candidate classical biological control agent of H. halys: beyond choice/no-choice host range testing. International Congress of Entomology. Sept. 2016, Orlando, FL.

Fann, L, R Bessin and RT Villanueva. 2017. Predation and parasitism of sentinel egg masses of the brown marmorated stink bug in established and more recently colonized areas of Kentucky. Annual meeting of the Entomological Society of America, Denver, CO.

Fann, L. 2017. Biological control of brown marmorated stink bug, *Halymorpha halys*, in Kentucky. Ohio Valley Entomological Association. Columbus, OH.

Fleischer, S, A Nielsen, S Chen. 2016. Phenology and dynamics of the invasive brown marmorated stink bug, *Halyomorpha halys,* as revealed in an agent-based model. XXV International Congress of Entomology. Orlando, FL.

Formella, A, T Kuhar and J Mason. March 18-21, 2017. Pyrethroid-incorporated mosquito netting as a pest management tool in vegetables. 88th Annual Meeting of the Eastern Branch of the Entomological Society of America. Newport, RI.

Formella, A, and TP Kuhar. 2017. Brown marmorated stink bug oviposition on trees within non-managed wooded borders and urban environments. Annual Meeting of the Entomological Society of America. November 5 – 8. Denver, CO.

Formella, A. 2017. Brown Marmorated Stink Bug Oviposition on Trees around Blacksburg, VA. Brown Marmorated Stink Bug Areawide Stakeholder Meeting & IPM Working Group Meeting, November 29. Winchester, VA

Fraga, DF, C Rodriguez-Saona, GC Hamilton and AL Nielsen. 2016. Eavesdropping the victim: a generalist predator utilizes an alarm pheromone to locate an invasive pest. Annual Meeting of the International Society of Chemical Ecology. Iguassu Falls, Brazil.

Hadden, W, JF Walgenbach and M Toews. 2016. Edge effects of *Halyomorpha halys* (Stäl), brown marmorated stink bug, in southeastern row crops. International Congress of Entomology. Florida. September 25-30, 2016.

Hadden, W, TC Leskey, and JC Bergh. 2017. Farm-scape factors influencing the abundance and distribution of brown marmorated stink bug among Mid-Atlantic apple orchards. Entomological Society of America. November 5-8. Denver, CO.

Hadden, W, TC Leskey, and JC Bergh. 2017. Dynamics influencing farm-scape distribution and abundance of brown marmorated stink bug in Mid-Atlantic apple orchards. Entomological Society of America. November 5-8. Denver, CO.

Hadden, W, TC Leskey, and JC Bergh. 2017. Factors driving farmscape distribution and relative abundance of brown marmorated stink bug in Mid-Atlantic apple orchards. Cumberland-Shenandoah Fruit Workers Conference. November 30-December 1. Winchester, VA.

Hajek, AE, LF Solter, J Becnel. 2017. New microsporidian species infecting invasive and native stink bugs. Brown Marmorated Stink Bug Areawide Stakeholder Meeting. November 17. Winchester, Virginia. [presented by Art Agnello]

Hajek, AE, LF Solter, J Becnel. 2017. New microsporidian species infecting invasive and native stink bugs. Entomological Society of America, National meeting. November 17. Denver, Colorado.

Hajek, AE, LF Solter, J Becnel. 2017. The new species, *Nosema maddoxi*, is a widespread pathogen of the green stink bug *Chinavia hilaris* and the brown marmorated stink bug *Halyomorpha halys* Annual meeting of the Society for Invertebrate Pathology. August 17. La Jolla, CA.

Hamilton, GC. 2016. Introduction and spread of BMSB in North America. 2016 International Conference of Entomology. Orlando, FL.

Herlihy, M, E Talamas, and D Weber. September 2016. Habitat specialization of exotic and native parasitoids: Complexity in biocontrol of a polyphagous, mobile host. International Congress of Entomology. Invited Symposium Presentation, paper 0610. Orlando, FL.

Hoelmer, K. 2017. How Biological Control Contributes to Management of Brown Marmorated Stink Bug & other Invasive Heteropteran Pests. International Heteroptera Symposium, Seaside, CA, USA, Apr.

Hoelmer, K.. 2017. Status of Halyomorpha halys as an Invasive Pest and Potential for its Biological Control. Internatl. Conference of Integrated Pest Management. July 2017 Changsha, China.

Hoelmer, K. and C. Dieckhoff. 2016. Asian Remedy for an Invasive Asian Pest? Biological Control of BMSB. International Congress of Entomology. Sept. 2016, Orlando, FL.

Ingles C. 2017. BMSB in Sacramento County: Phenology, distribution, and trap comparisons. Orchard Pest & Disease Management Conference. Portland, OR.

Ingles C. 2017. BMSB in Sacramento County: Phenology, distribution and trap comparisons. Entomological Society of America, Pacific Branch. Portland, OR.

Krawczyk, G, MZ Nunes, HD Morin and L Shaak. September 4-8, 2016. New endeavors in monitoring and management of brown marmorated stink bug *Halyomorpha halys* (Hemiptera: Pentatomidae) in eastern United States. IOBC WPRS 9th International Conference on Integrated Fruit Production. Thessaloniki, Greece. (Invited)

Krawczyk, G. June 9, 2017. Biology, ecology and control of the brown marmorated stink bug *Halyomorpha halys*. IRTA, Sustainable Plant Protection, Mas Badia Agricultural Experimental Station. Girona, Spain. (Invited)

Krawczyk, G, C Hirt, and H Peterson. 2017. Trapping *Halyomorpha halys* with insecticide treated nets- 2017 trials in PA orchards. Cumberland Shenandoah Fruit Workers Conference. December 1. Winchester, VA.

Kuhar, TP. September 25-29, 2016. Pest management impact of the brown marmorated stink bug, *Halyomorpha halys*, on field and vegetable crops in the Mid-Atlantic US. Invited Talk. Symposium: Impact of Native and Invasive Alien True Bug Species in Agro-Ecosystems: Range Expansion, Pest Status, and Control Tactics. XXV International Congress of Entomology. Orlando, FL.

Kuhar, TP, DC Weber, AK Wallingford, AS DiMeglio, J Wilson, H Bush. 2017. Current research on three major heteropteran pests attacking vegetables in the mid-Atlantic U.S. Annual Meeting of the Entomological Society of America. November 5 – 8. Denver, CO.

Kuhar, TP. 2017. Insecticide Netting: Current Research and Where We Go from Here. Brown Marmorated Stink Bug Areawide Stakeholder Meeting & IPM Working Group Meeting, November 29. Winchester, VA

Lara, JR, C Pickett and MS Hoddle. September 26, 2016. Biological control of brown marmorated stink bug in California: Status and prospects. International Congress of Entomology, symposium. Orlando, FL.

Lara, JR, C Pickett and MS Hoddle. April 2017. Developing a biological control program for BMSB. 101st Pacific Branch ESA Annual Meeting. Portland, OR.

Lee, J. January 2017. Feeding damage by the brown marmorated stink bugs on nursery crops. Pacific Northwest Insect Management Conference, Portland, OR.

Leskey, TC, BD Short, WR Morrison, A Nielsen, B Blaauw, G Krawczyk, and JC Bergh. September 25-29, 2016. Behaviorally-based management of brown marmorated stink bug. XXV International Congress of Entomology. Orlando, FL.

Leskey, TC, BD Short, R Morrison, KB Rice, and TP Kuhar. 2017. Developing sensitive and cost-effective biosurveillance and monitoring systems for the invasive brown marmorated stink bug, *Halyomorpha halys*. Annual Meeting of the Entomological Society of America. November 5 – 8. Denver, CO.

Leskey, TC. 2017. Managing the invasive BMSB in Fruit Orchards: Development of IPM Tactics. Ministry of Primary Industries and Hort New Zealand, Wellington, New Zealand.

Leskey, TC. 2016. University of Kentucky. Development of behaviorally based tools for management of the invasive brown marmorated stink bug. Lexington, KY.

Leskey, TC. 2016. West Virginia University. Development of behaviorally based tools for management of the invasive brown marmorated stink bug. Morgantown, WV.

Leskey, TC. 2017. Developing border surveillance technology for the invasive brown marmorated stink bug. JCM USA and New Zealand Invasive Species Conference, Auckland, New Zealand.

Leskey, TC. 2017. Managing the invasive BMSB in Fruit Orchards: Development of IPM Tactics. Zespri Workshop, Tauranga, New Zealand.

Leskey, TC. 2017. Integrating biological, ecological and behavioral studies to manage the invasive brown marmorated stink bug. University of Missouri.

Leskey, TC. 2017. Heteropteran pests of permanent crops in the Eastern USA with emphasis on the management of the invasive brown marmorated stink bug. International Heteropteran Conference. Monterrey, CA.

Lowenstein, DM, H Andrews, and N Wiman. 2017. Characterizing the success of an Asian egg parasitoid, *Trissolcus japonicus*, at management of Brown Marmorated Stink Bug. Entomological Society of America - Pacific Branch meeting. Portland, OR.

Lowenstein, DM, H Andrews, C Hedstrom, and N Wiman. April 4, 2017. *Trissolcus japonicus* arrives in Oregon: Evaluating Biological Control of Brown Marmorated Stink Bug. Orchard Pest and Disease Management Conference. Portland, OR.

Lowenstein, DM. 2017. Insect Pests in Vegetable gardens: Documenting damage and delivering results. Ecological Society of America. Portland, OR.

Lowenstein, DM. 2017. Public engagement as a tool to monitor the distribution of Brown Marmorated Stink Bug and its newly introduced biocontrol agent. Urban Ecology and Conservation Symposium of the Portland and Vancouver areas, Portland, OR.

Lowenstein, DM, H Andrews, and N Wiman. Establishment of *Trissolcus japonicus*, a parasitoid of *Halyomorpha halys*, in Oregon. Annual Meeting of the Entomological Society of America. 7 November. Denver, CO.

Marshall, AT, and EH Beers. 2017. Alternative effects of shade netting over apple orchards. American Society for Horticultural Science (ASHS) Annual Conference, 19-22 September, Waikoloa, HI.

Marshall, AT, and EH Beers. 2017. Direct pest control through season long enclosure of apple orchards. Entomological Society of America, 5-8 November, Denver, CO.

Morin, HD, and G Krawczyk. 2017. Potential native parasitoids of brown marmorated stink bug eggs in an organic orchard. EB ESA Annual Meeting. Newport, RI.

Morin, H, and G Krawczyk. 2017. Potential native egg parasitoid community of brown marmorated stink bug (Halyomorpha halys) in organic and conventionally managed orchards in southern Pennsylvania. ESA Annual Meeting. November 5-8. Denver, CO.

Morrison, WR, D-H Lee, B Colpitts, C Vincent, G Boiteau and TC Leskey. 2016. Using the latest generation of harmonic radar and microtags to track retention capacity of the invasive BMSB in vegetables and tree fruit augmented with semiochemicals. International Congress of Entomology. Orlando, FL.

Morrison, WR, III, and TC Leskey. 2017. Biological control of brown marmorated stink bug eggs on wild hosts over two years. 87th Annual Meeting of the Eastern Branch of the Entomological Society of America. Newport, RI.

Morrison, WR, III, and TC Leskey. 2017. Using radar to track the movement of the invasive brown marmorated stink bug on hosts augmented with varied stimuli. 87th Annual Meeting of the Eastern Branch of the Entomological Society of America. Newport, RI.

Morrison, WR, III, JC Bergh, T Kuhar, J Walgenbach, and TC Leskey. 2017. Evaluation of pheromone-baited traps for the monitoring and management of nuisance problems associated with the invasive brown marmorated stink bug. Integrated Protection of Stored Products, International Organization for Biological and Integrated Control of Noxious Animals and Plants, West Palearctic Regional Section. Ljubljana, Slovenia.

Murray, MS, LR Spears, and DG Alston. January 11-13, 2017. Status of brown marmorated stink bug in Utah. Orchard Pest and Disease Management Conference, Portland, OR.

Nielsen, AL, S Chen, S Fleischer. 2017. Factors influencing *H. halys* population development and size. New Zealand - United States Invasive Species Workshop. Auckland, New Zealand.

Nielsen, AL, S Fleischer, S Chen. 2016. Deciphering an invader's population ecology: Halyomorpha halys. XXV International Congress of Entomology. Orlando, FL.

Nielsen, AL. 2016 Invasion ecology of BMSB: A biological and behavioral perspective. Rutgers University, Department of Ecology and Evolution Seminar. New Brunswick, New Jersey.

Nielsen, AL. 2016. Applying invasion ecology to pest management of BMSB. University of Arkansas, Entomology. Fayetteville, Arkansas.

Nielsen, AL. 2016. Developing Systems-Level Management Programs for BMSB. Virginia Tech Agriculture and Environment Series. Blacksburg, Virginia.

Nielsen, AL. 2017. Biology and management of *Halyomorpha halys*. Horticulture New Zealand. Wellington, New Zealand.

Nielsen, AL, E Ogburn, and JF Walgenbach. 2017. Studies on the critical diapause termination cues in *Halyomorpha halys*. National Meeting of Entomological Society of America. Nov.8, 2015. Denver, CO.

Nielsen, AL. C. Akotsen-Mensah, T. Leskey, B. Short, B. Blaau, and D. Polk. 2017. Impact of IPM-CPR on beneficial insects. Cumberland-Shenandoah Fruit Workers Conference. Winchester, Virginia. Nov. 30, 2017. Winchester, VA.

Nielsen, AL. 2017. Integrating biological and behavioral information into management programs for *Halyomorpha halys*. Pipfruit NZ, Hawkes Bay, New Zealand.

Ogburn, EC, and JF Walgenbach. 2016. Brown marmorated stink bug post-emergence reproductive ecology. BMSB Working Group Meeting. Winchester, Virginia. November 30, 2016.

Ogburn, EC, SC Schoof, and JF Walgenbach. 2016. Association of pheromone trap captures and BMSB damage in NC apples. Cumberland-Shenandoah Fruit Workers Conference. Winchester, Virginia. December 1, 2016.

Ogburn, EC and JF Walgenbach. 2017. Non-target effects of organic insecticides on stink bug egg parasitoids. National Meeting of Entomological Society of America. Nov.7, 2015. Denver, CO.

Ogburn, EC and JF Walgenbach. 2017. Reproductive phenology of first generation BMSB in North Carolina. BMSB Working Group Meeting. November 29, 2017, Winchester, VA.

Peterson H, and G Krawczyk. 2017. An update on monitoring BMSB populations and its natural enemies during the summer 2017 in Pennsylvania. BMSB IPM Working Group Meeting. November 29. Winchester, VA.

Peterson H, C Hirt, and G Krawczyk. 2017. Potential native egg parasitoid community of brown marmorated stink bug (*Halyomorpha halys*) in organic and conventionally managed orchards in southern Pennsylvania. Cumberland Shenandoah Fruit Workers Conference, November 30. Winchester, VA.

Quinn, NF, TC Leskey, and JC Bergh. December 1-2, 2016. Monitoring brown marmorated stink bug in the tree canopy: Initial approaches. Cumberland-Shenandoah Fruit Workers Conference. Winchester, VA.

Quinn, NF, TC Leskey, and JC Bergh. March 18-21, 2017. Searching for the samurai wasp and its host: Sampling *Trissolcus japonicus* and *Halyomorpha halys* in tree of heaven (*Ailanthus altissima*). Entomological Society of America, Eastern Branch Meeting. Newport, RI.

Quinn, NF, TC Leskey, and JC Bergh. 2017. The stratification of the brown marmorated stink bug (*Halyomorpha halys*) and its natural enemies in a common wild tree host. Entomological Society of America. November 5-8. Denver, CO.

Quinn, NF, TC Leskey, and JC Bergh. 2017. Assessing the presence and distribution of *Trissolcus japonicus* using yellow sticky traps. Brown Marmorated Stink Bug Areawide Stakeholder Meeting and IPM Working Group Meeting. November 29. Winchester, VA.

Quinn, NF, TC Leskey, and JC Bergh. 2017. Assessing the presence and distribution of *Trissolcus japonicus* using yellow sticky traps. Cumberland-Shenandoah Fruit Workers Conference. November 30-December 1. Winchester, VA.

Rijal, JP and R Duncan. 2017. Detection Survey of Brown Marmorated Stink Bug in Peach Orchards in San Joaquin Valley. Orchard Pest and Disease Management Conference. Portland, OR.

Rijal, JP and R Duncan. 2017. First Evidence of Finding Brown Marmorated Stink Bug in Agricultural Area in California. International Heteroptera Conference. Monterey, CA.

Rijal, JP. 2016. Detection Survey and Monitoring of Brown Marmorated Stink Bugs in North San Joaquin Valley Peach Orchards. Poster presentation, International Congress of Entomology. Orlando, FL.

Short, BD, and TC Leskey. 2016. Refinement of perimeter-based management tactics for *Halyomorpha halys* in apple orchards. Cumberland-Shenandoah Fruit Workers Conference. Winchester VA.

Shrewsbury, P. Spring 2016. Impact of indigenous natural enemies on the exotic brown marmorated stink bug, *Halyomorpha halys*, in MD Nurseries, Department of Entomology Colloquium Series, University of Arkansas, Lafayette, AK.

Skillman, V, N Wiman, J Lee. March 2017. Nutrient profiles of brown marmorated stink bug. Pacific Branch Entomological Society of America. Portland, OR.

Skillman, V, N Wiman, J Lee. . September 2016. Nutrient profiles of brown marmorated stink bug, International Congress of Entomology. Orlando, FL (poster)

Spears, LR, MC Holthouse, and DG Alston. April 2-5, 2017. Brown marmorated stink bug host plant use and phenology in northern Utah. Annual Meeting of the Pacific Branch of the Entomological Society of America. Portland, OR.

Walgenbach, JF, and EC Obgurn. 2016. Impact of native natural enemies on brown marmorated stink bug in eastern US tree fruit and vegetable ecosystems. International Congress of Entomology. Orlando, FL.

Walgenbach, JF, S Schoof and E Ogburn. 2017. Relationship among BMSB pheromone trap captures, degree-day accumulations and damage to apples. Cumberland-Shenandoah Fruit Workers Conference. Nov. 30, 2017. Winchester, VA.

Weber, D. December 2016. An aggregation of stink bug semiochemical research for ecological understanding and pest management. Invited Seminar at 1187th meeting of the Entomological Society of Washington, Smithsonian Institution. Washington, DC.

Weber, D. November 2016. Pentatomid permutations: Semiochemical mixology for stink bug attraction. Department of Entomology Colloquium. University of Maryland.

Weber, D, and A Khrimian. March 2017. Proactive semiochemical intelligence against invasive species: Stereoisomeric chemical libraries for pheromone discovery & development. Eastern Branch Entomological Society of America meeting. Newport, Rhode Island.

Weber, D, R Morrison, A Khrimian, and T Leskey. November 2016. Have we got the right ratio? Attraction of brown marmorated stink bug to different pheromone ratios, and to different ratios of mixed pheromone and (E,E,Z)-methyl-2,4,6-decatrienoate (MDT). Brown Marmorated Stink Bug IPM Working Group. Winchester, Virginia.

Weber, D, T Leskey, WR Morrison III, and A Khrimian. April 2017. Brown marmorated stink bug pheromone: Purity, ratio and dose response, cross-attraction and synergy. International Heteroptera Symposium and Workshop, Monterey, California. (poster)

Weber, DC, A Khrimian, M Blassioli-Moraes, and JG Millar. September 2016. Pheromones of Pentatomoidea: New discoveries for application to pest management. International Congress of Entomology. Orlando, FL. Invited Symposium Presentation, paper 3391.

Wiman, NG, C Hedstrom, D Lowenstein, P Shearer, V Walton, J Lee, and H Andrews. April 4, 2017. Addressing the challenge of BMSB in Oregon. Symposium: Solutions and Challenges with invasive species, the past, present, and future. 101st Annual Meeting of the Pacific Branch of the Entomological Society of America. Portland, OR.

Wiman, NG, VM Walton, SI Rondon, and DL Lowenstein. April 5, 2017. Invasion history and status of brown marmorated stink bug in Oregon. 101st Annual Meeting of the Pacific Branch of the Entomological Society of America. Portland, OR.

Wiman, NG. September 25-30, 2016. Temperature-dependent feeding behavior of *Halyomorpha halys* and implications for crop damage. Symposium: Insect-Plant Interactions in a changing climate. ICE 2016 XXV International Congress of Entomology. Orlando, FL.

Extension presentations

Agnello, A. 2017. New York survey of Trissolcus japonicus populations in BMSB trappings. Great Lakes Fruit Workers Meeting. November. Port Huron, MI.

Bergh, JC, N Quinn, and W Hadden. August 12, 2017. BMSB display. Public Open House, AHS research station. Winchester, VA.

Bergh, JC, N Quinn, and W Hadden. September 16-17, 2017. BMSB display. Apple Harvest Festival. Winchester, VA.

Bergh, JC. February 13-17, 2017. Brown marmorated stink bug update 2017. Winter Fruit Schools for commercial tree fruit producers. Meetings at 6 locations throughout Virginia.

Bergh, JC. March -August 2017. Pest management update. Extension meetings for commercial tree fruit producers. Eleven meetings at various locations in VA and WV.

Bergh, JC. May 25, 2017. A smörgåsbord of arthropod pest issues. In-Depth meeting for commercial tree fruit producers. Winchester, VA.

Cooper, M. 2017. BMSB in Napa County - Quarterly Update. Winegrape Presentation. Napa County Winegrape Pest and Disease Control District.

Daane, K. 2017. BMSB in California's northcoast wine regions. Winegrape Presentation. Napa County Viticulture Technical Group. Napa, CA.

Gut, L. April 2017. Insect management outlook for 2017. Ridge/Belding Spring Spray Meeting. Grand Rapids, MI.

Gut, L. December 2016. Invasive species trends and outlooks for 2017. Michigan State Horticultural Society. Grand Rapids, MI.

Gut, L. February 2017. Tree fruit insect management. Southwest Michigan Horticultural Days, Benton Harbor, MI.

Gut, L. January 2017. Monitoring and management of brown marmorated stinkbug. Crop Production Services Specialty Crop Meeting. Mt. Pleasant, MI.

Gut, L. January 2017. Monitoring and management of new invasive pests of apple and cherry. Wisconsin Fresh Fruit & Vegetable Conference. Waterloo, WI.

Gut, L. June 2017.BMSB control strategies in pome fruit. Brown Marmorated Stink Bug Clinic, Grand Rapids, MI.

Gut, L. March 2017. Apple and Stone Fruit Insect Update and Recommendations for 2017. Southeast MI Spring Tree Fruit Meeting. Flint, MI.

Hilton, R. June 15, 2017. Integrated Pest Management Successes. Interpera. Wenatchee, WA.

Hilton, R. May 19, 2017. Updates on Emerging Pests. Southern Oregon Wine Institute Seminar. Roseburg, OR.

Hilton, R. November 3, 2017.Update on Invasive Pests. Roseburg Orchard and Vineyard Pest Management Seminar. Roseburg, OR.

Hoelmer, K. 2017. Challenges to Biological Control of Heteroptera (especially brown marmorated stink bug). International Heteroptera Workshop, Seaside, CA, USA, Apr. 2017.

Hoelmer, K. 2017. Biocontrol Research: Managing Spotted Wing Drosophila, Tarnished Plant Bug & Brown Marmorated Stinkbug. Penn. State Extension, Advanced Biocontrol School, Nov. 2016, Lancaster, PA.

Hoelmer, K.. 2017. Status of Halyomorpha halys (BMSB) as an Invasive Pest & Potential for its Biological Control. Presentation for New Zealand-US Invasive Species & Grower Meetings - Summerfresh, Clyde, New Zealand, 23 August 2017.

Hoelmer, K. 2017. Status of Biological Control for BMSB. Presentation at meeting of the BMSB Council. Wellington, New Zealand, 24 August 2017.

Hoelmer, K. 2017. Status of Biological Control for BMSB. Presentation for New Zealand-US Invasive Species / New Zealand Apples & Pears, Napier, new Zealand, 28 August 2017.

Hoelmer, K. 2017. Biological Control of Brown Marmorated Stink Bug. Presentation for New Zealand-US Invasive Species / Zespri. Tauranga, New Zealand, 25 August 2017.

Holthouse, MC, LR Spears, and DG Alston. September 30, 2016. Brown marmorated stink bug. First Detector Training Workshop. Kaysville, UT.

Hooks, CRR. August 10, 2017. Benefits of Marigold as a companion plant. Field crops twilight, barbeque and ice cream social tour. Upper Marlboro, MD. Note: CRRH was one of two co-organizers of this twilight tour event.

Hooks, CRR. August 17, 2017. Companion plantings for increased biocontrol. University of Maryland, AGNR, Organic vegetable field day. Upper Marlboro, MD.

Ingles, C, L Varela, and R Elkins. 2017. Phenology of brown marmorated stink bugs and distribution near California pear orchards. 2016 Calif. Pear Research Reports.

Ingles, C. February 2017. Advanced Fruit Training for Master Gardeners. Sacramento, CA.

Ingles, C. February 2017. EcoLandscape California Conference & Trade Show. Stockton, CA.

Ingles, C. February 2017. Phenology and distribution of brown marmorated stink bugs and new threats to farms. Pear Research Meetings. Walnut Grove and Lakeport, CA.

Ingles, C. July 2017. International Master Gardener Conference. Portland, OR.

Ingles, C. March 2017. The potential threat of brown marmorated stink bugs and how to manage them. Clarksburg District Grape Day. Clarksburg, CA.

Ingles, C. November 2016. Master Gardeners monthly meeting. Auburn, CA.

Krawczyk, G. February 20, 2017. Predictive strategies and best management practices for brown marmorated stink bug. President's Day Fruit Growers Educational Meeting. Biglerville, PA.

Krawczyk, G. February 21, 2017. Predictive strategies and best management practices for brown marmorated stink bug. Lancaster/York Counties Commercial Tree Fruit Growers Meeting. Lancaster, PA.

Krawczyk, G. February 22, 2017. Predictive strategies and best management practices for brown marmorated stink bug. Franklin County Winter Fruit Growers Educational Meeting. Waynesboro, PA.

Krawczyk, G. February 28, 2017. Predictive strategies and best management practices for brown marmorated stink bug. Appalachian Fruit Growers Meeting. Bedford, PA.

Krawczyk, G. March 1, 2017. Predictive strategies and best management practices for brown marmorated stink bug. Erie County Winter Educational Tree Fruit Meeting. Northeast, PA.

Krawczyk, G. March 2, 2017. Predictive strategies and best management practices for brown marmorated stink bug. Western Pennsylvania Tree Fruit Growers Meeting. Prospect, PA.

Krawczyk, G, C Hirt, M Zanelato Nunes, and H Peterson. 2017. Advances in monitoring of brown marmorated stink bug. Great Lakes Fruit, Vegetable and Farm Market Expo. December 5-7. Grand Rapids, MI.

Krawczyk, G, C Hirt, M Zanelato Nunes, and H Peterson. 2017. Brown marmorated stink bug - challenges and some solutions. Great Lakes Fruit, Vegetable and Farm Market Expo. December 5-7. Grand Rapids, MI.

Kuhar, T, and H Doughty. January 24-25, 2017. Insect Management for Snap Beans. 2017 Eastern Shore Agricultural Conference and Trade Show. Melfa, VA.

Kuhar, T, K Catron, J Mason, and H Bush. 2017. Field day presentation including BMSB discussion. On-Farm Twilight Vegetable Growers Meetings. Woodbine Farms. August 1. Winchester, VA.

Kuhar, T. Insect Management Update. March 8, 2017. Richmond Area Vegetable Growers Meeting. Henrico, VA.

Kuhar, T. January 31- February 2, 2017. Stink bugs and aphids: what's new for controlling these pests? 2017 Mid-Atlantic Fruit and Vegetable Convention. Hershey, PA.

Kuhar, TP. November 2016. Brown marmorated stink bug pest status in the Mid-Atlantic Region. BMSB SCRI Stakeholder Advisory Meeting. Raleigh, NC.

Kuhar. T. February 22, 2017. Insect Control Update. Hampton Roads Fruit and Vegetable Conference. Henrico, VA.

Lee, JC. Stink bugs, flies, and lace bugs. 2017. OktoberPest. North Willamette Research and Education Center. October 17. Aurora, OR.

Leskey, TC. 2017. Pheromone-based monitoring and management tools for BMSBMichigan State IPM Fruit School. Traverse City, MI.

Lowenstein, DM. Brown Marmorated Stink Bug Update. Oktoberpest workshop for nursery and greenhouse growers, North Willamette Research and Extension Center. 19 October. Aurora, OR.

Lowenstein, DM. 2017. Pest Management Forum (meeting with orchardists that occurs throughout the growing season to discuss pest management issues). SOREC. May 25. Central Point, OR.

Lowenstein, DM. Update on Brown Marmorated Stink Bug in the Pacific Northwest: The samurai arrives! Hermiston Farm Fair. 29 November. Hermiston, OR.

Marshall, AT, and EH Beers. 2017. Behavioral control of stink bugs. 113th Washington State Tree Fruit Association Annual Meeting, Research News Flash. 4-6 December 2017. Three Rivers Convention Center, Kennewick, WA.

Milnes, JM, and EH Beers. 2017. Biological control of invasive BMSB using an exotic egg parasite in Washington State. 113th Washington State Tree Fruit Association Annual Meeting, Research News Flash. 4-6 December 2017. Kennewick, WA.

Milnes, JM, and EH Beers. 2017. An update on the distribution of the Brown Marmorated Stink Bug in WA and potential biocontrol options. 31st Pacific Northwest Vegetable Association. 15-16 November 2017. Kennewick, WA.

Milnes, JM, and EH Beers. 2017. 2017 update on the brown marmorated stink bug. Washington State Grape Society. 16-17 November 2017. Grandview, WA.

Milnes, JM, AT Marshall, EH Beers, C Sater. 2017. BMSB information/outreach booth. Wenatchee Farmer's Market. 28 October. Wenatchee, WA.

Rijal, JP, and R Duncan. 2017. Report submitted to CA Cling Peach Board for their BMSB research funding for the year 2016.

Rijal. JP. February 2017. San Joaquin Valley Ag Commissioners' meeting. Modesto, CA.

Shield, D. 2017. BMSB - how to recognize this invasive pest. Master Gardeners Presentation: Napa, CA.

Short, BD, and TC Leskey. 2017. Insecticide-based management of the brown marmorated stink bug. Syngenta Northeastern Invitation to Innovation. Philadelphia PA.

Short, BD, and TC Leskey. 2017. Pheromone-based monitoring and management of BMSB in tree fruit. Bay Area Fruit School. Queenstown, MD.

Short, BD, and TC Leskey. 2017. Updates and the future of monitoring and management of BMSB. Western MD Fruit School. Keedysville, MD.

Shrewsbury, P. Jan. 2017. Biological Control Approaches. Advanced Landscape IPM Shortcourse. Department of Entomology, University of Maryland. College Park, MD.

Shrewsbury, P. June 13, 2017. Stinkers beware! Project Stink-be-Gone with Maryland's Master Gardeners. Monthly meeting of Anne Arundel County MGs. Glen Burnie, MD.

Shrewsbury, P. June 29, 2017. Making a habitat for benefical insects. Maryland Nursery, Landscape, and Greenhouse Association annual Field Day. Ruppert Nursery, Laytonsville, MD.

Shrewsbury, P. May 4, 2017. Stinkers beware! Project Stink-be-Gone with Maryland's Master Gardeners (MGs). Monthly meeting of Montgomery County MGs. Gaithersburg, MD.

Shrewsbury, P. May 9, 2017. Stinkers beware! Project Stink-be-Gone with Maryland's Master Gardeners. Monthly meeting of Frederick County MGs. Frederick, MD.

Spears, LF and MC Holthouse. June 29, 2017. Effective monitoring of brown marmorated stink bug and spotted wing drosophila in Utah. Utah Tree Fruit Field Day. Payson, UT.

Spears, LR, E Brennan, and MC Holthouse. 2017. Invasive species awareness booth. Farmers' Markets and Community Events (9 markets/events: Lehi, April 21 and 28; Logan, June 10, August 19; Ogden, June 24; Kaysville, July 6; Salt Lake City, July 8-9, and 30). UT.

Spears, LR. February 28, 2017. Updates on invasive pests in Utah. Utah Pests In-service Training, Utah State University Extension Conference. Logan, UT.

Spears, LR. January 20, 2017. Updates on invasive fruit pests. Utah State Horticultural Association. Spanish Fork, UT.

Spears, LR. March 18, 2017. Brown marmorated stink bug. First Detector Training Workshop for Master Gardeners. Midvale, UT

Spears, LR. September 22, 2017. Brown marmorated stink bug. First Detector Training Workshop for Master Gardeners. Midvale, UT.

Spears, LR. September 22, 2017. Invasive pest update. First Detector Training, State Master Gardener Conference. West Jordan, UT.

Villani, S, M Parker, and JF Walgenbach. 2016. Bugs, Diseases, and Bountiful Trees: Managing Tree Fruits in North Carolina. Workshop at NC Cooperative Extension Annual Conference. Raleigh, NC. November 16, 2016.

Walgenbach, J, and H Burrack. 2016. Managing Arthropods in Vegetables and Small Fruits. Workshop at NC Cooperative Extension Annual Conference. Raleigh, NC. November 16, 2016.

Walgenbach, JF. 2016. Insect management in vegetable crops. NC Tomato Growers Winter Vegetable Conference. Asheville, NC. February 10-11, 2016.

Walgenbach, JF. 2016. Managing pests and protecting pollinators. Southeastern Apple Growers Meeting. Asheville, NC. February 9-10, 2016.

Walgenbach, JF. 2017. Chemigation for management of tomato insect pests. South Mountain Vegetable Growers Assn. Meeting, March 7, 2017. Lincolnton, NC.

Walgenbach, JF. 2017. Vegetable insect management. Henderson County Vegetable Growers. Nov 2, 2017.

Walgenbach, JF. 2017. Management strategies for BMSB. Southeastern Apple Growers Meeting. Jan. 10, 2017. Asheville, NC.

Walgenbach, JF. 2017. Apple insect management update. Blue Ridge Apple Growers Meeting. Feb. 9, 2017. Hendersonville, NC

Walgenbach, JF. 2018. Apple insect management update. Brush Mountain Apple Growers Meeting. March 7, 2017. Wilkesboro, NC.

Wiman, NG. December 8, 2016. New and old hazelnut pests. Pratum Co-op Grower Workshop. Salem, OR.

Wiman, NG. January 26, 2017. Brown marmorated stink bug- a new pest of concern in small fruits? Horticulture Short course, Pacific Agriculture Show. Abbotsford, BC.

Wiman, NG. March 2, 2017. Biological control of brown marmorated stink bug. Biocontrols USA West Conference and Expo. Reno, NV.

Wiman, NG. 2017. Pest management research update for hazelnuts. Wilbur Ellis Hazelnut Grower Day. 7 December. Salem, OR.

Wiman, NG. 2017. Brown marmorated stink bug in orchard crops: what have we learned and where are we now? Washington State Tree Fruit Association Annual Meeting. 6 December. Kennewick, WA.

Workshops

Daane, K. 2017. Update: brown marmorated stink bug in California. Almond Workgroup Presentation. UC Cooperative Extension Almond Workgroup. Davis, CA.

Gut, L. June 2017. Brown Marmorated Stink Bug Clinic. Grand Rapids, MI.

Holthouse, MC, Z Schumm, DG Alston, and LR Spears. September 21, 2017. Brown marmorated stink bug in Utah: biology, host range, and biological control. Utah Pests In-service Training. Kaysville, UT.

Shrewsbury, P. 2017. Three training workshops for Project Stink-be-Gone (citizen science). One each in Montgomery, Frederick, and Anne Arundel Counties, Maryland. June 7, 14, 28, 2017, respectively.

Walgenbach, J, and H Burrack. 2016. Managing Arthropods in Vegetables and Small Fruits. Workshop at NC Cooperative Extension Annual Conference. Raleigh, NC. November 16, 2016.

Walgenbach, J. 2017. Brown Marmorated Stink Bug: Threat to southeastern apples and survey of stakeholder knowledge. January 10, 2017. Southeastern Apple Growers Meeting, Asheville, NC.

Wiman, NG. 2017. Hazelnut IPM workshop. North Willamette Research and Extension Center. Workshop included info on BMSB and *Trissolcus japonicus* presented by D Lowenstein. August 23, Aurora, OR. (68 attendees)

Leskey T, and G. Hamilton. 2017. BMSB IPM Working Group Meeting. November 29, 2017. Winchester, VA.

Leveraged Funding

Alston, DG, and LR Spears. 2017-2020. Brown marmorated stink bug: new invasive pest in Utah's fruit industry. Utah Department of Agriculture and Food USDA Specialty Crop Block Grant. $34,137 (funded, but award amount pending).

Alston, DG, and LR Spears. 2016-2018. A new invasive insect pest of specialty crops in Utah, the brown marmorated stink bug: plant host utilization in diverse urban-agricultural landscapes and promoting biological control. Utah Agricultural Experiment Station Seed Grant Program. $55,000.

Krawczyk, G. Alternative methods to manage brown marmorated stink bug *Halyomorpha halys* (Stal). State Horticultural Association of Pennsylvania. Research Committee. 2017. $24,000

Bergh, JC, and N Quinn. Development of a reliable monitoring and detection procedure for *Trissolcus japonicus*, an adventive egg parasitoid of brown marmorated stink bug. Southern SARE Graduate Student Grant Program, $14,813

Bergh, JC. Sampling for *Trissolcus japonicus*, a new Asian egg parasitoid of brown marmorated stink bug. Virginia Department of Agriculture and Consumer Services, Specialty Crop Block Grant, $37,601

Zalom, F. California Cling Peach Board (for field studies related to fruit damage on peaches) (Davis)

Hoddle, M. California Pistachio Research Board (Riverside)

Hoddle, M. Consolidated Central Valley Table Grape Pest & Disease Control District (riverside)

Kuhar, T. Contract research on the evaluation of repellents for BMSB. Bedoukian Research Inc., Danbury, CT $5,000 (VT).

Jentsch, P. and A. Agnello. Ag & Markets Apple Research and Development Program Grant funding for "Biological Control of the Brown Marmorated Stink Bug in New York State" $43,745.70 (NY)

Jentsch, P. Dow AgroSciences: "Assessing The Neonicotinoid Closer Against The Brown Marmorated Stink Bug For Mortality And Feeding Repeliency". $3,000 (NY)

Kuhar, TP. 2017. Contracted research on the evaluation of new insecticides on BMSB. United Phosphorous Inc. $3000

Gut, L. Michigan Apple Research Committee: - Managing invasive pests to maintain fruit quality and profitability. $22,000

Gut, L. Michigan Apple Research Committee: - Manipulating symbiotic bacteria to manage brown marmorated stink bug. $11,798

Leskey, T. Ministry of Primary Industries New Zealand. BMSB Surveillance Project: Trap Improvement and Lure Attractiveness. (PD). $180,664. (USDA)

Spears L.R. and D.G. Alston. 2017-2018. Finding the best traps and lures for brown marmorated stink bug (Halyomorpha halys). Utah Extension IPM and Sustainable Agriculture Mini-Grant Program. $10,000.

Spears L.R., R. Davis, J. Gunnell, K. Wagner, D. Alston and R.A. Ramirez. 2017-2018. Expanding the invasive insect detection and prevention outreach program in Utah. USU Extension Grant Program. $30,000.

Spears, L.R. and C. Nischwitz. 2017-2018. Orchard commodity survey. USDA-APHIS-PPQ (Farm Bill). $17,000.

Spears, L.R., J. Gunnell, K. Wagner, L. Millard, R. Davis, D.G. Alston, and R.A. Ramirez. 2017-2018. Invasive pest outreach. USDA-APHIS-PPQ (Farm Bill). $49,995.

USDA-ARS Areawide. An Areawide Biointensive Management Plan for Brown Marmorated Stink Bug (BMSB), Halyomorpha halys (Stål), to Reduce Impacts Throughout the Agro-Urban Interface. $371,278 annually for up to 5 years. (USDA)