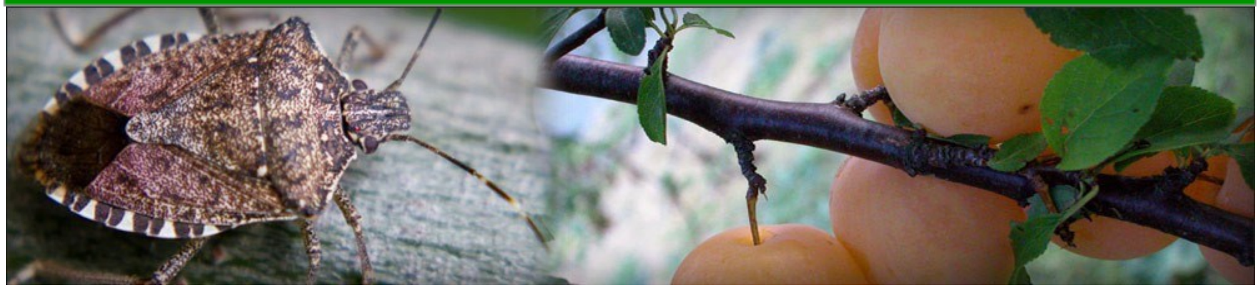
Biology, Ecology, and Management of Brown Marmorated Stink Bug in Orchard Crops, Small Fruit, Grapes, Vegetables, and Ornamentals



Our long-term goals for this project are to develop economically and environmentally sustainable pest management practices for the brown marmorated stink bug (BMSB), Halyomorpha halys (Stål), in specialty crops and to implement a coordinated, rapid delivery system to disseminate critical information generated from this project to specialty crop end-users. USDA-NIFA SCRI # 2011-51181-30937

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OBJECTIVES

Objective 1. Establish biology and phenology of BMSB in specialty crops.

Objective 2. Develop monitoring and management tools for BMSB.

Objective 3. Establish effective management programs for BMSB in specialty crops.

Objective 4. Integrate stakeholder input and research findings

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Rapid transcriptome sequencing of an invasive pest, the brown marmorated stink bug, *Halyomorpha halys* by Leslie Pick and Julie Dunning-Hotopp

Understanding the biology of the brown marmorated stink bug requires investigations at all levels, from population and behavioral measures to dissection of the genetic and genomic information that provides instructions for all developmental and physiological processes of the organism. In a study published this summer in BMC Genomics, investigators at the Institute for Genome Sciences at the University of Maryland School of Medicine and the University of Maryland Department of Entomology used state-of-the-art next generation sequencing methods to identify the sequences of all of the genes active in BMSB, the so-called transcriptome of BMSB. These researchers utilized new strategies to rapidly sequence the full transcriptome that allowed them to skip the time-consuming first step of breeding genetically identical individual animals in the laboratory, which is normally a first step in analysis of new genomes. Instead, the researchers were able to sequence and analyze all of the genetic variants that arose in their population of stink bugs, and to do so at all points in the insects' life cycle, from the egg stage through late adulthood, including animals in diapause. This type of rapid sequencing provides a wealth of information about the biology of BMSB that is now available to the entire research community. In addition, it sets a precedent for an approach to sequencing that can provide a rapid response to other pest invasions similar to that already described for human disease epidemiology.

Figure 1. Life stages of BMSB starting with eggs followed by 1st, 2nd, 3rd, 4th, and 5th instar nymphs, and an adult in a counter-clockwise spiral outwards and from largest to smallest. The bar in the low left represents 1 cm.

The genome of each organism, present in each and every cell, is the information center that harbors the code for virtually every process carried out by the organism over its entire life cycle. This code is in the form of genes - DNA sequences with unique combinations of 4 different bases (A,T,C,G) in unique orders and of unique length. To be active, genes must be copied by cellular machinery into RNA that can then act on its own to execute cellular functions, or which, more often, is translated into proteins that function as enzymes, structural molecules, hormones, etc., responsible for everything from fertility, to embryonic development to homeostasis and aging. The differential expression of genes at different times during development and in different cells of the animal is the key step in making cells and processes different from one another. For example, cells destined to become wing cells express a particular set of genes while cells destined to become parts of the brain express a different and unique complement of genes. Thus,

This research project supports Objective 1. Establish biology and phenology of BMSB in specialty crops the key step required for a gene to be active in a cell or organism is the copying or transcription into RNA. Identifying all of the different RNA molecules in an organism tells us which genes are active in that organism.

The goal of the study published in BMS Genomics was to - in one fell swoop - identify as many genes as possible that are transcribed by BMSB at any stage of the life cycle of BMSB. This approach would provide an overview of virtually all the genes that are active in this species. To achieve this, RNA was extracted from BMSB eggs, 1st instar nymphs, 2nd instar nymphs, 3rd instar nymphs, 4th instar nymphs, 5th instar nymphs, an active adult male, an active adult female, an adult male in diapause, and an adult female in diapause (Figure 1). The RNA was divided into two pools: pre-adult stages and adult stages in order to get a first glimpse at the differential expression of genes between developing animals and adults. From this RNA, strand-specific libraries were constructed and Illumina HiSeq was used to gather the sequences of these transcripts. Bioinformatic analysis, using the program Trinity, as well as a novel method that analyzed the strand-specificity of the data, led to the identification of 53,071 putative transcripts from 18,573 components (Figure 2). By integrating other data, such as comparison to known genes from other insects, this number was further narrowed to 13,211 representative transcripts (Table 1). For comparison, *Drosophila*

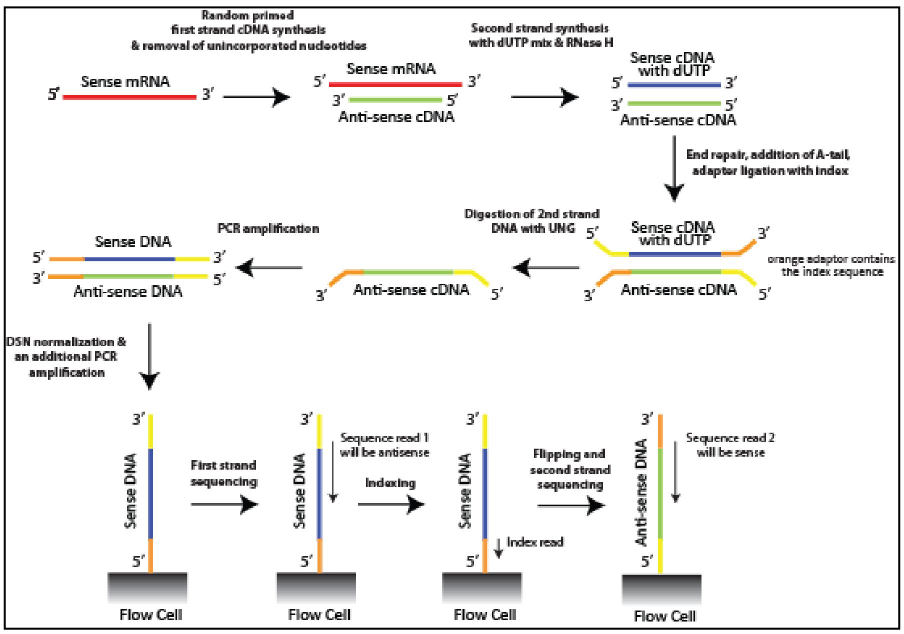

Figure 2. Strand-specific Sequencing Method. An overview of the steps involved in strand specific sequencing. The final sequencing reads can be assigned to a particular strand of DNA. The methods and steps undertaken in generating the libraries are illustrated including how the sequences are loaded on the flow cell.

melanogaster, the insect best-studied at the molecular level, is estimated to express ~ 14,000 genes (http://www.nature.com/scitable/topicpage/eukaryotic-genome-complexity-437), suggesting that this single sequencing approach likely identified the majority of the genes active in BMSB.

To begin to determine the different functions carried out by the transcripts identified, their sequences were compared to genes from other insects and the transcripts were assigned to putative functional categories based upon the types of proteins they likely encode (Figure 3). Approximately 5,000 of the sequenced transcripts could be assigned to functions based on this sequence comparison. They fall into the following major categories: information storage and processing, cellular processes and signaling, and metabolism. The top five sub-categories were general function prediction only (22.2%); DNA replication, recombination and repair (8.2%); posttranslational modification, protein turnover, and chaperones (7.9%); transcription (7.5%); and amino acid transport and metabolism (7.1%). Overall, this is very similar to the distribution of gene categories in other transcriptomes of eukaryotes, including insects. However, now that the BMSB-specific sequences are available for these genes, they can be used for monitoring and tracking pest populations and for designer gene targeting using approaches such as RNA interference (RNAi).

Table 1. Summary of Assembly and Annotation

Characteristic	Before filtering	After filtering
Number of reads (both pools)	366,689,206	N/A
Number of putative transcripts (both pools)	194,729	13,211
Average length (bp)	1,005	2,026
Standard deviation (bp)	1,474	1,592
Median length (bp)	439	1,649
Maximum length (bp)	27,655	24,046
Length >1000 bp	50,599	9,657
With a Uniref100 hit (e-value < 1e-10)	80,536	11,513
Matching unique Uniref100 proteins	37,160	9,993
With a NR hit (e-value < 1e-10)	80,262	11,497
Matching unique NR proteins	37,346	10,007
Number of Trinity components	123,175	13,211
Number of ORFs	89,684	13,210
>450 bp	61,569	11,141
With a function assigned	57,197	9,811

The mass-sequence information obtained is publically available and accessible to the scientific community for use by researchers in many different ways, dependent upon their individual research programs. Here we suggest several immediate applications that the transcriptome data will support: (1) Population tracking. The assembled transcriptome sequences will have heterogeneity that reflects some of the genetic heterogeneity of the US BMSB population. Such heterogeneity at the sequence level was identified in 11,462 different putative transcripts, 86.8% of the total number of putative transcripts identified. These polymorphisms can be used to examine the future spread of BMSB in the US, as well as for a retrospective tracking of current populations from the original invasion in Allentown. (2) Monitoring of insecticide resistance. Transcripts with functions related to pesticide detoxification were identified in both the juvenile and adult RNA pools. Interestingly, there were 25 genes encoding proteins related to cytochrome P450 and glutathione S-transferase that were more abundant in adults. There were nine such proteins that were more abundant in the pre-adult RNA pool. Differential expression of these and other detoxification genes under field conditions may occur, providing an early warning signal for the emergence of pesticide-resistance in a population. (3) Monitoring Symbionts and lateral gene transfers. A recent report by others members of the USDA-SCRI group suggests that, like many other insects, BMSB is dependent upon symbionts that are likely necessary to supplement dietary needs (Taylor et al, PLoS One.2014;9:e90312). The BMC Genomics paper reported that, in addition to gut symbionts, evidence was found for lateral gene transfer between bacteria and BMSB. This suggests that, as in other animals, direct transfer of DNA into the genome of BMSB has occurred and been maintained in insect lineages, likely because of the benefits conferred to the insect from these bacterial genes. Transcriptome sequencing identified putative lateral gene transfers between bacteria and BMSB of genes encoding ankyrin-repeat related proteins, lysozyme, and mannanase. Some of these appear to have occurred in hemipteran stem groups while other may be BMSB-specific. While further research at the genomic level is necessary to verify lateral gene transfer, these Hemiptera- and BMSB-specific transfers provide novel targets for the development of genome based methods to control them. (4) Development of gene-specific pest control strategies. The advent of RNAi technology has opened up the possibility of generating gene

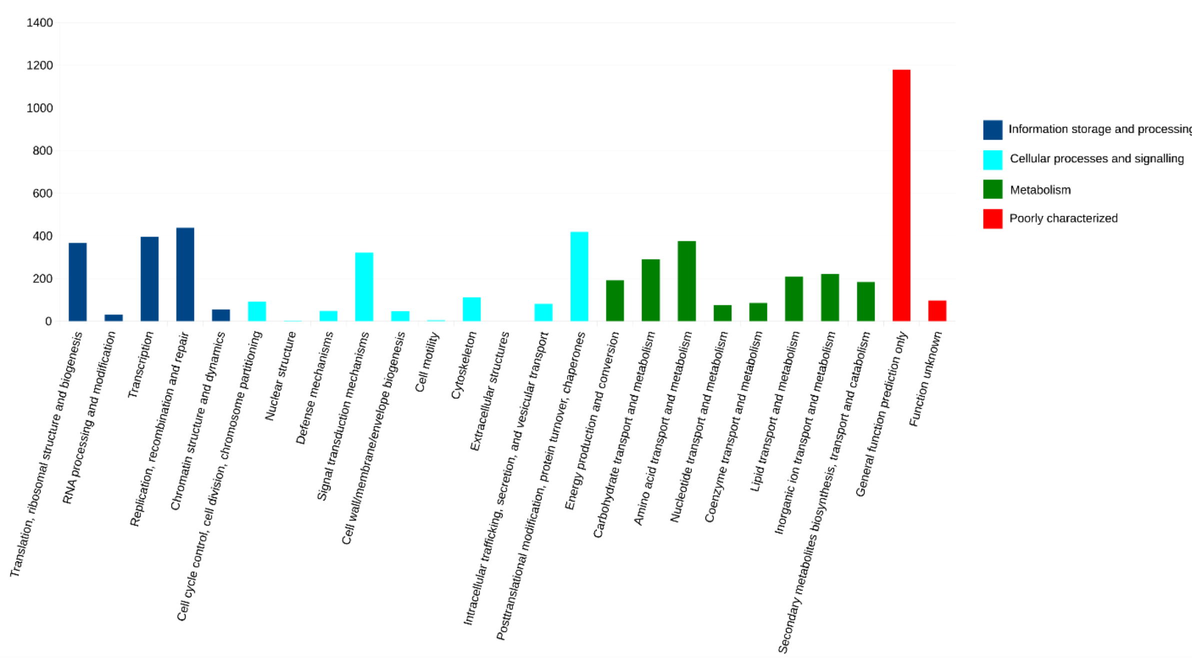

Figure 3. Transcript functional categories. The NCBI Cluster of Orthologous Groups (COG) database was used to classify the predicted proteins in the 13,211 representative transcripts. Assignment of COG categories showed that a large number of ORFs belonged to categories of proteins whose functions are poorly characterized, namely those that have general function prediction only and those with unknown function.

specific agents that will abolish the expression of a gene of choice, thereby impacting the viability or fertility of the treated animals. Preliminary data suggests that RNAi is effective in BMSB (Lu and Pick, unpublished). The transcriptome sequence makes available to the research community numerous potential targets for these types of gene-based pest control.

In sum, the complete transcriptome of BMSB was assembled using novel methods that are likely to be useful for rapid genomic analysis of invasive species. The sequence information is publically available and will provide resources for researchers throughout the world interested in BMSB. The overall complement of BMSB genes appears to be similar to other related insects, as expected. However, specific BMSB gene sequences identified will be broadly useful for understanding the fundamental biology of BMSB, for monitoring pest populations and insecticide resistance, and for gene-based targeting techniques to control BMSB populations.

Classical biological control of brown marmorated stink bug, *Halyomorpha halys* by Christine Dieckhoff and Kim Hoelmer

Scientists at the USDA-ARS Beneficial Insects Introduction Research Unit in Newark, DE, continue to work towards a classical biological control solution for brown marmorated stink bug. A classical (importation) biological control program became warranted when our initial surveys showed that the impact of native stink bug parasitoids on BMSB in the Mid-Atlantic states was very low and not sufficient to significantly suppress BMSB populations. We've continued these surveys but there is no indication that native parasitoids are adapting to BMSB (figs. 1a and 1b). In contrast, egg masses of BMSB are routinely parasitized in Asia at much higher rates of 60-90%.

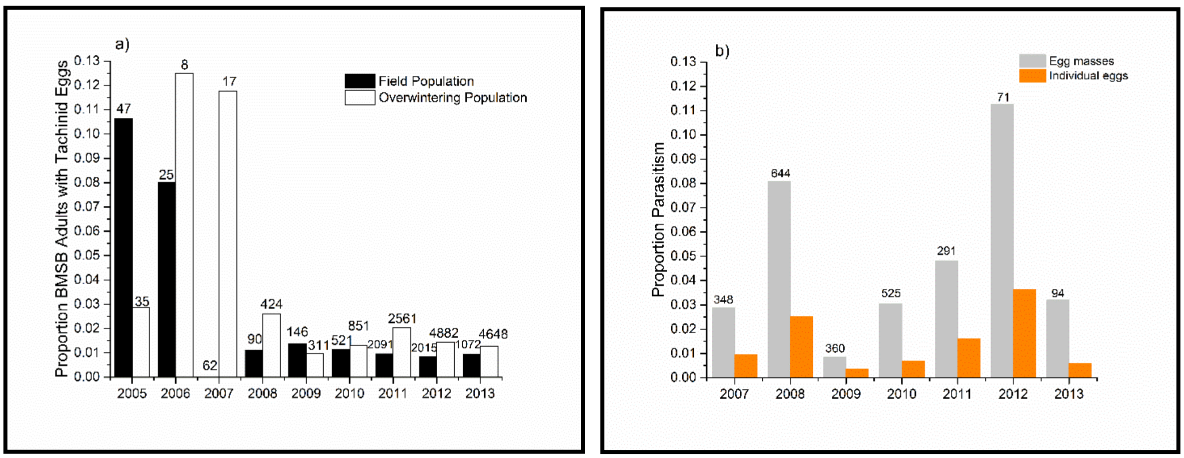

Figure 1. Impact of indigenous parasitoids on BMSB in the Delmarva area. a) proportion of adult BMSB containing egg deposited by tachinid flies (Diptera: Tachinidae), 2005-2013; b) proportion of parasitized sentinel egg masses placed around Newark, DE, 2007-2013. Egg mass columns indicate those clusters of eggs with at least one or more eggs attacked. Usually only a few of the available eggs in the cluster were attacked. Numbers above columns indicate the respective sample sizes (BMSB egg masses typically contain 28 individual eggs).

Foreign exploration in Asia was begun in 2005, focusing on the native range of BMSB in China, Japan, and South Korea. These exploratory trips identified several species in the genus *Trissolcus* (Hymenoptera: Scelionidae) that frequently attack and kill BMSB eggs. *Trissolcus* are tiny parasitic wasps, 1-2 mm in length as adults, that attack eggs of various species of stink bugs, and members of this genus have been used as biological agents of other stink bug pests (Orr 1988, Corrêa-Ferreira & Moscardi 1996). Several *Trissolcus* species from different Asian locations have been recovered over the course of the explorations and a total of 32 populations comprising 4 species is currently maintained in the Newark, DE quarantine facility. The most abundant and widespread of these species in Asia are *T. japonicus* (originally described as *T. halyomorphae* by Yang et al. 2009, and synonymized as *T. japonicus* by Talamas et al. 2013) and *T. cultratus*. Other species occur less frequently (Fig. 2). The identities of the Asian parasitoids have been confirmed with the cooperation of ARS scientists at the Systematic Entomology Laboratory (Matt Buffington and Elijah Talamas) and the European Biological Control Laboratory (Marie-Claude Bon).

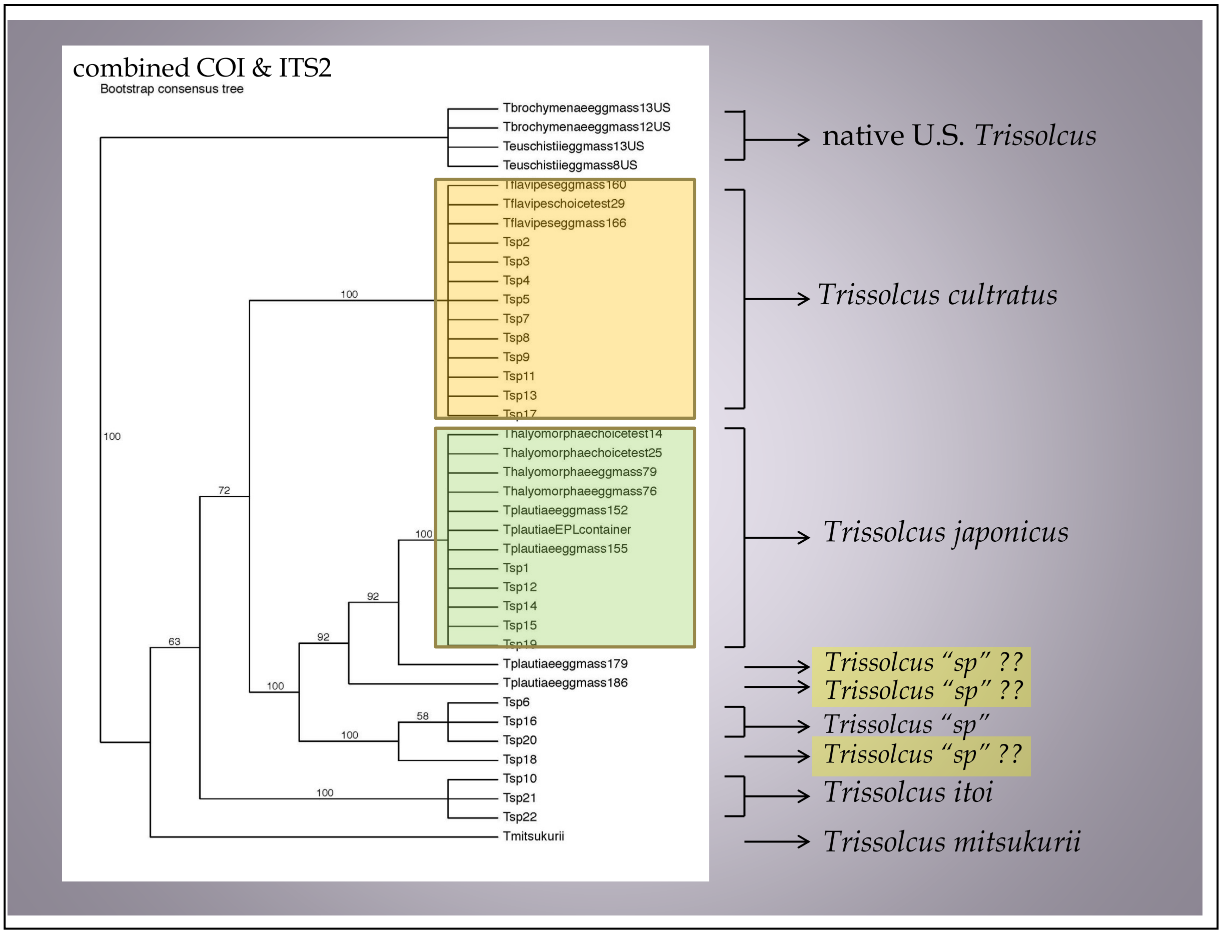

Figure 2. Taxonomic tree showing the relationships and identifications of Asian *Trissolcus* imported to the U.S. for host specificity tests as candidate biological control agents.

To fast-track the host range evaluations needed to assess the safety and suitability of Asian *Trissolcus* for field release, the Newark ARS laboratory is coordinating regional tests by state and university cooperators in other parts of the U.S. (Florida Dept. Food & Consumer Services; Michigan State Univ.; Oregon Dept. Agric.; Univ. California (Riverside); and California Dept. Food & Agriculture) with supplemental funding from APHIS Farm Bill funds. Currently the focus of these host range evaluations is on a Chinese populations of *Trissolcus japonicus* collected in the Beijing area (fig. 3). In addition, evaluations of a second species, *T. cultratus*, were initiated during 2014 in cooperation with FDACS to support the research with this species already begun in Newark, DE.

To date, sixty-two species and/or geographic populations of non-target stink bug species have been tested within the framework of host range tests using standardized protocols for no-choice (only the non-target species offered to the parasitoid) and choice (BMSB and non-target offered simultaneously) tests. Testing of the *Trissolcus japonicus* (Beijing) population is nearing completion. Tests conducted so far have shown an inability to develop in twenty of these species. No-choice testing of 18 additional species is currently underway or planned. Thirty-two species of non-targets

Figure 3. **Female *Trissolcus japonicus*** parasitizing BMSB eggs in the ARS Newark, DE quarantine facility. (photo credit: Christine Dieckhoff)

were attacked to some degree in no-choice tests (ranging from minor to significant levels); these species have been subjected to choice testing. Fourteen of the non-targets exhibited varying levels of attack in choice tests and tests of other species are still pending. In many cases, parasitoids that attack some non-target species in no-choice tests show a preference for the BMSB target when a choice is presented. Because no-choice and choice tests are deliberately designed to give every possible opportunity to attack a non-target, they are very conservative tests and often overestimate the impact on non-target species under actual field conditions. Non-target species which are attacked under choice test conditions are therefore being studied further to determine the influence the laboratory conditions of exposure and how these may change under more natural conditions. Particular emphasis is given in these additional studies to the spined soldier bug, *Podisus maculiventris* (figure 4), which is a predator of other pest insects in natural and agricultural settings.

a)  b) 

Figure 4. *Podisus maculiventris* adult (a) and its egg mass (b) used in host range evaluations of *Trissolcus japonicus*. (photo credit: a) Brian T. Cutting, b) Ashley M. Colavecchio)

Additional tests with both BMSB and *P. maculiventris* egg masses have been started or are planned to test the influence of the test arena size, length of time exposure, order of egg mass exposure, and plant structure on attack rates under choice condition to better understand how these factors may change the behavior of *Trissolcus* under actual field conditions. If these studies show that the impact on non-target species is likely to be insignificant in nature, we will then be able to submit a petition for field release.

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Working Toward Commercialization and Application of Pheromone-Based Tools by Tracy C. Leskey

As reported last year, the BMSB pheromone has been identified as a two-component mixture of (3*S*,6*S*,7*R*,10*S*)-10,11-epoxy-1-bisabolen-3-ol and (3*R*,6*S*,7*R*,10*S*)-10,11-epoxy-1-bisabolen-3-ol (Khrimian et al. 2014). In addition, this pheromone is synergized when deployed in combination with (*E,E,Z*)-2,4,6-decatrienoate **(**MDT), the pheromone of another Asian stink bug species, *Plautia stali* (Weber et al. 2014). In combination (Fig. 1), these stimuli can be used as a sensitive lure for deployment in traps for season-long monitoring of presence, abundance and activity of BMSB.

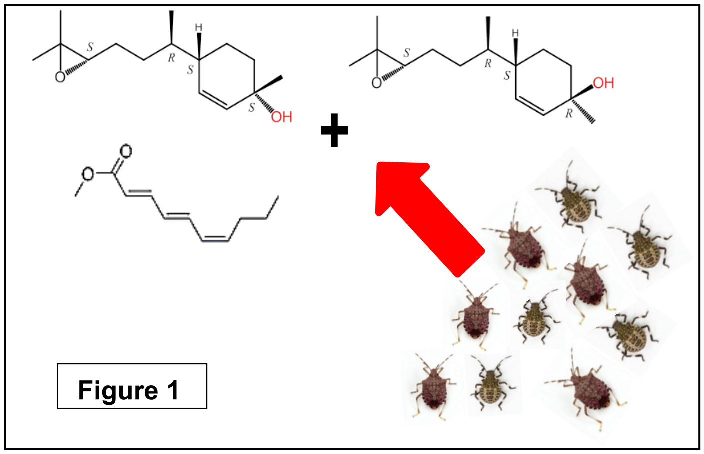


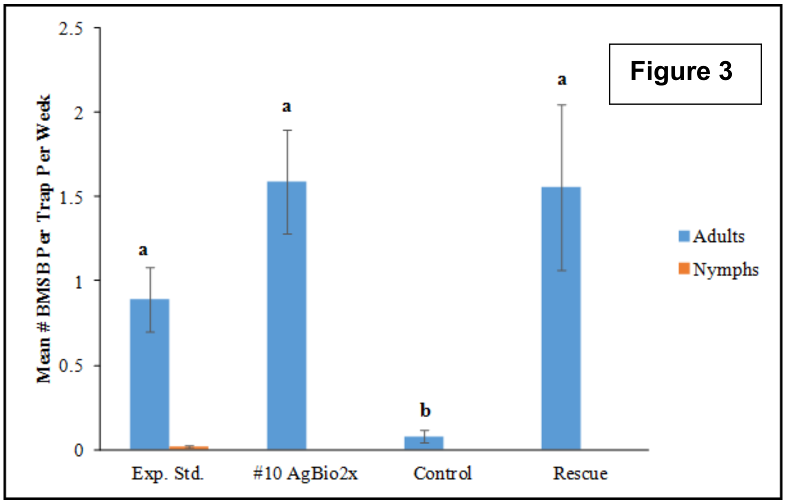
Figure 1

Figure 2

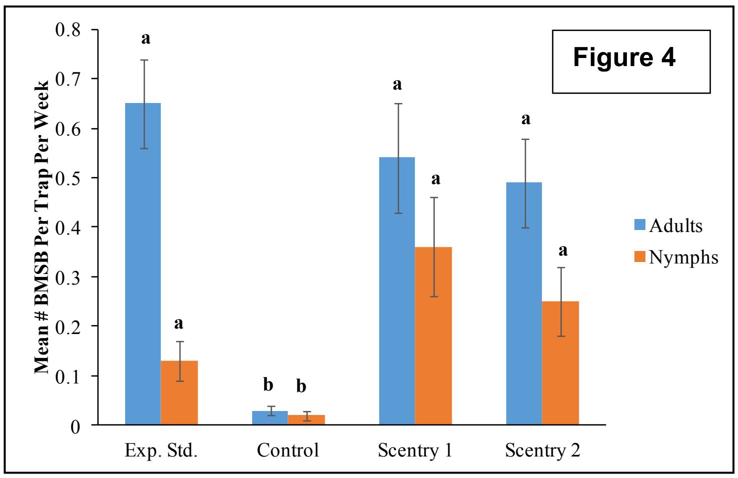
Commercialization*.* However, there still is much work needed to ultimately commercialize pheromone-based products. Therefore, a series of coordinated multi-state trials were conducted throughout the season to provide commercial companies with information regarding overall lure performance. Lures evaluated included those from AgBio/ChemTica, Rescue/Sterling, Alpha Scents, Scentry and Trece. Standard black pyramid traps (Fig. 2) were baited with treatments provided by commercial companies and compared with traps baited with our experimental standard of 10mg lures of the BMSB aggregation pheromone + 66mg MDT (AgBio) and an unbaited control. Trials were conducted throughout the season. Thus, population pressure was variable. However, because we included our experimental standard during each interval, we can make some baseline inferences. Trials were conducted in, DE, MD, NC, NY, PA, NJ, OR, VA, WA, and WV and from May – November 2014.

This research project supports Objective 3. Establish effective management programs for BMSB in specialty crops.

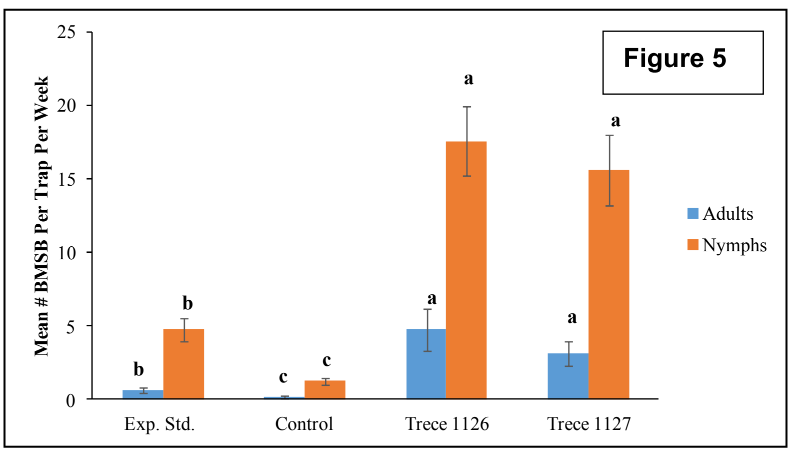
Trial one was conducted throughout May 2014 and compared our experimental standard with: 1) #10 mg BMSB pheromone + 2X AgBio MDT; 2) standard Rescue/ Sterling combination lure and 3) an unbaited control. This early season trial clearly demonstrated that BMSB adults were responding to baited traps. However, there were no significant differences among our experimental standard, #10+ 2X AgBio MDT or the Sterling/Rescue lure (Fig. 3). Very few nymphs were present in the field at this time.



Our second trial was conducted in June 2014. Treatments included: 1) experimental standard; 2) Scentry #1; 3) Scentry #2; and 4) and an unbaited control. For adults and for nymphs, significantly greater numbers were captured in traps baited with our experimental standard and both Scentry treatments compared with the unbaited control (Fig. 4).



In July, Trece provided us with two experimental formulations. We evaluated four treatments: 1) experimental standard; 2) Trece 1126; 3) Trece 1127; and 4) an unbaited control. At this point in the season, nymphal populations were higher than adults. However, for both adults and for nymphs, both Trece treatments yield captures significantly greater than our experimental standard and control (Fig. 5).



In late July-early August, we evaluated three treatments from AlphaScents. These included the following treatments: 1) 80/11; 2) 80/13; and 3) 80/31. These

This research project supports Objective 3. Establish effective management programs for BMSB in specialty crops.

treatments were compared with our experimental standard and with an unbaited trap as a control. Adult and nymphal captures were significantly higher in traps baited with our experimental standard and with AlphaScents treatments compared with the unbaited control (Fig. 6).

Finally, in the late-season, we compared captures in traps baited with our experimental standard and with three commercial treatments; Trece 1126, AgBio, and Rescue and with an unbaited control. Among all treatments, only Trece 1126 performed as well as experimental standard with significantly greater adult captures compared with AgBio, Rescue and the unbaited control. Captures of nymphs, however, were low but were significantly greater in baited traps compared with the unbaited control (Fig. 7).

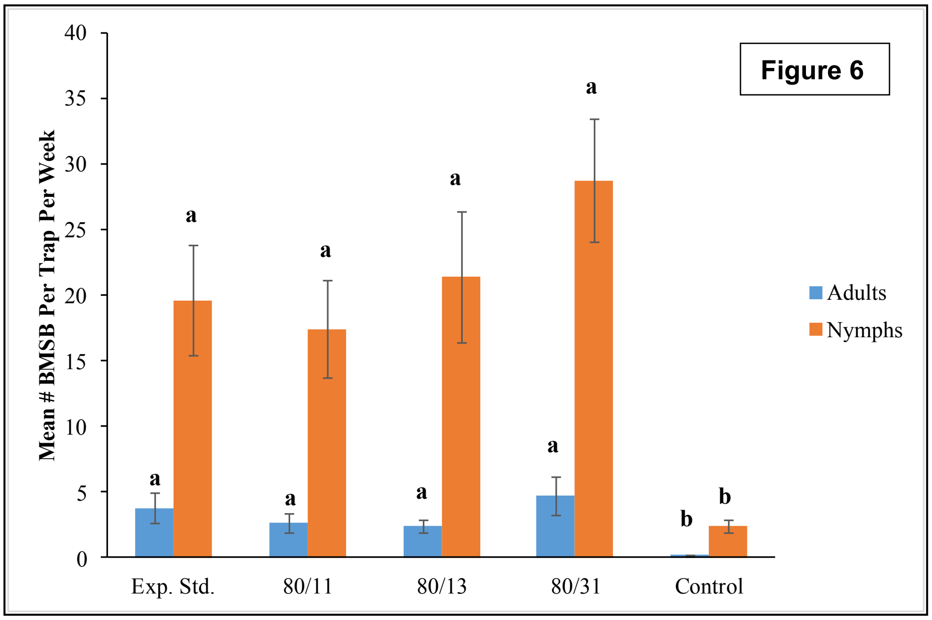


Figure 6

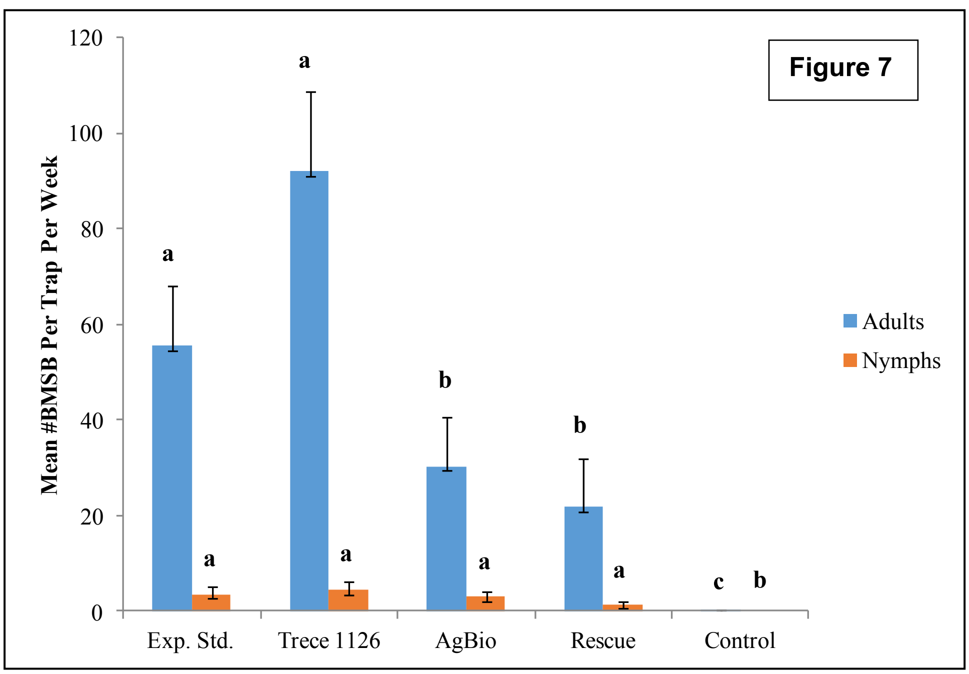
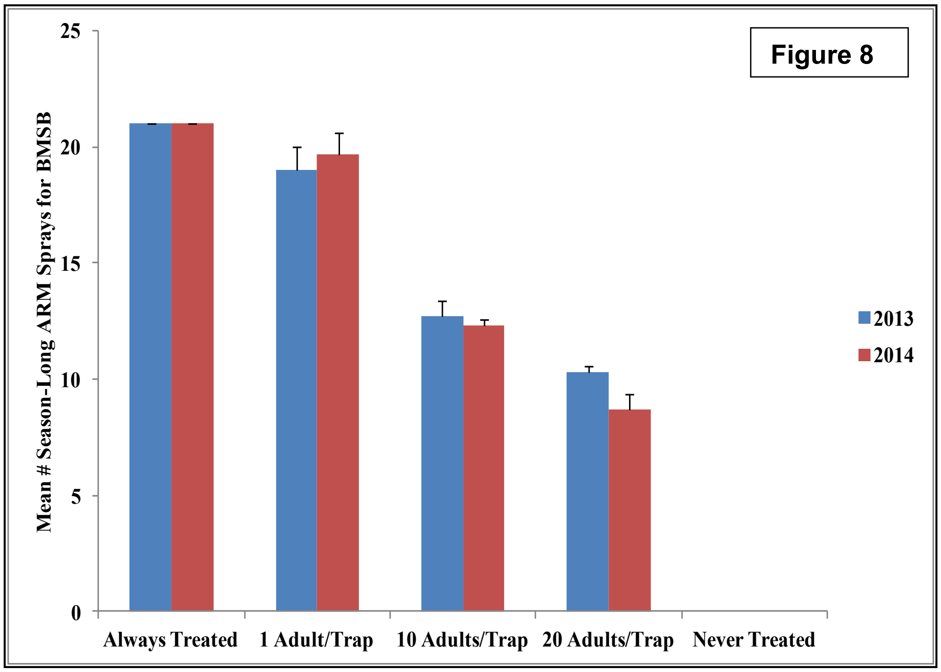
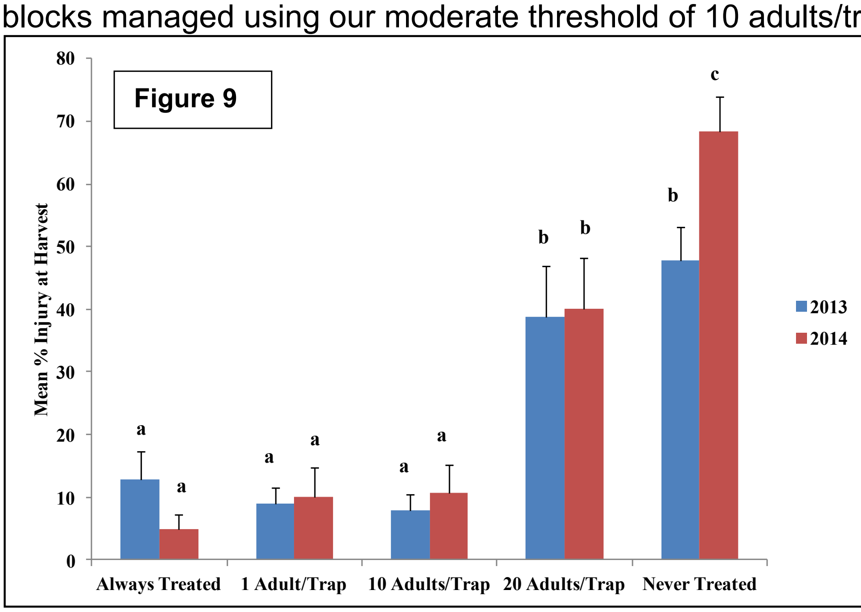


Figure 7

Application. Based on our results, it appears that commercial companies have products that can be used to detect the presence, abundance, and seasonal activity of BMSB in specialty crops. To further determine if we can utilize the biological



information generated by baited traps to guide BMSB management, we conducted a two-year study aimed at determining if pre-set trap-based treatment thresholds could be used to successfully manage BMSB in apple. In this study, apple blocks were monitored with two traps baited with the pheromone and synergist; one in the center of the block and one in the perimeter row. When captures in either trap reached one of our pre-set thresholds, the block was treated with an insecticide considered to be effective against BMSB using an alternate-row-middle (ARM) spray pattern. The block was treated again seven days later and the threshold was then reset. Trap-based threshold evaluated in this study were: 1) 1 adult/trap; 2) 10 adults/trap; and 3) 20 adults/per trap. Blocks under these management regimes were compared with blocks treated weekly and those that were never treated. In both years of the study, our moderate threshold of 10 adults/trap reduced spray applications by ~40% from 21 to ~12 applications (Fig. 8) whereas blocks managed using 1 adult / trap saw reductions of only ~10%. More importantly, blocks managed using our moderate threshold of 10 adults/trap to trigger sprays



resulted in statistically identical levels of injury compared with blocks treated weekly during both years of the study (Fig. 9). Blocks managed using a higher threshold of 20 adults/ trap resulted in overall spray reduction of about 50% compared with blocks treated weekly. However, it appears that some key sprays were missed as injury was significantly higher during both years of the study.

Our results indicate that the biological information generated by baited pheromone traps can be used to guide management of BMSB in apple orchards. It seems likely that this same approach could be useful in other specialty crops such as peaches (Fig. 10) as well. In 2014, five commercial growers evaluated this provisional threshold for guiding BMSB management in an apple block on their farms. Although we are still in the process of receiving and evaluating spray records, we found that there was no statistical difference in the amount of injury in apple blocks managed using this provisional threshold and under standard management tactics used by each grower. Although these results are promising, we likely will need to continue to recalibrate these threshold-based management tactics as commercial companies refine and tweak their pheromone-based products. Furthermore, trap styles and deployment strategies may also be improved. However, we now have the ability to reliably monitor BMSB season-long and develop more sustainable approaches for their management.


Fig. 10

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BMSB Stakeholder Survey Yields Directions for Future Outreach Efforts by Keoki Hansen and Tracy C. Leskey

Led by The Northeastern IPM Center and Eric Day at Virginia Tech, the stakeholder community has been surveyed since the inception of the BMSB SCRI CAP. The goal of this survey effort was to first quantify baseline knowledge of BMSB biology and management tactics, level of specialty crop damage being inflicted, and outreach needs.

The survey efforts were extremely successful with 776 individuals completing in-person, paper surveys at grower-oriented meetings and 360 individual completing an online version based on Qualtrics.

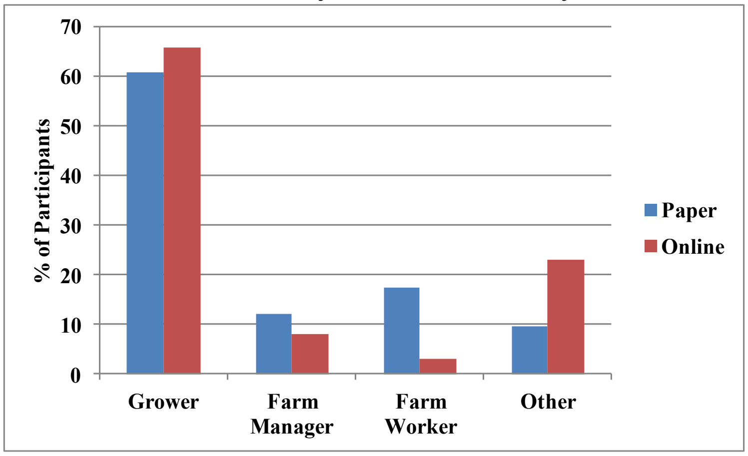

Figure 1. Participants in online and paper surveys.

Over 60% of all participants characterized themselves as growers (Fig. 1). Data were generated from participants from a total of 35 states (9 using the in-person, paper surveys).

A key issue identified by this survey was the need for simple identification tools for BMSB and other stink bugs. In the online survey we asked respondents if they knew how to scout for BMSB; only 24% responded yes, while 37% responded maybe. However, 64% reported scouting for BMSB on their farm. In response to this need, the Northeastern IPM Center has led an effort to update the Field Guide to Stink Bugs put together by researchers from Virginia Tech and Clemson and funded by the Virginia Agricultural Council and Southern Center (Fig. 2). The newly updated guide has been expanded by Ames Herbert and Tom Kuhar at Virginia Tech. to provide a national scope for both pest and beneficial stink bugs. The Northeastern IPM

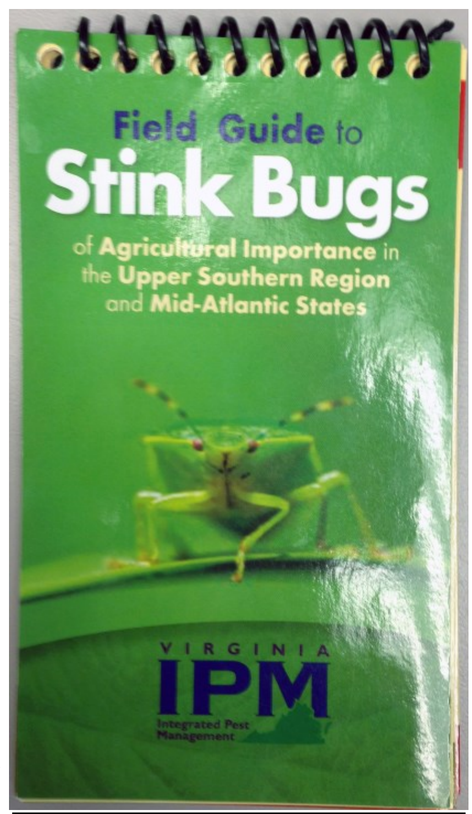

Figure 2. Field Guide to Stink

This research project supports Objective 4: Integrate stakeholder input and research findings to form and deliver practical outcomes

Center has also developed BMSB ID tools using small bottles of clear hand sanitizer, which allows full view of the stink bug.

Figure 3. Big-eyed bug. *Courtesy of USDA.*

Another revealing question from the online survey asked respondents to identify which natural enemy of BMSB eggs have shown promise. Most respondents identified parasitic wasps as being a promising biological control agent. However, the correct answer was all of the above as generalist predators such as big-eyed bugs, *Geocoris spp.* (Fig. 3), have also been identified as consuming BMSB eggs.

Among respondents who grew specialty crops, tree fruit was the most frequently damaged with nearly 60% reporting damage in 2012 and 2013. Damage to peppers and tomatoes for both years was reported by 40% of the survey participants (Fig. 4).

Among respondents, 45% of growers reported losses from BMSB and 79% of growers said they thought it was likely or very likely they would be threatened by this invasive pest. The majority of the growers participating in the survey practiced IPM but those dealing with BMSB did make changes in their management practices. For those taking the online survey, 57% reported increases in the use of insecticides though 56% also reported an increase in scouting.

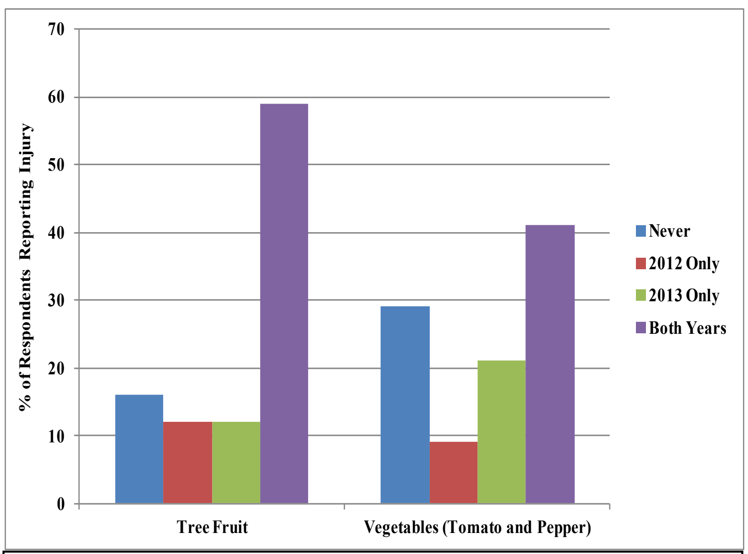

Figure 4. Damage estimates from BMSB on tree fruit and vegetables.

In addition to questions regarding identification, damage and management tactics, we asked participants what types of BMSB information would be most helpful. They indicated that scouting, sprays, trapping and BMSB biology and behavior were the most important. In-person delivery of information was still considered very important by our participants, though Extension publications, websites and email were also favored. All of this information can be used by our BMSB SCRI CAP team to further refine outreach efforts.

Project Outputs

Research Talks

Acebes, A., T.C. Leskey and J.C. Bergh. 2013. Comparison of trunk traps for brown marmorated stink bug nymphs on tree hosts. Cumberland-Shenandoah Fruit Workers annual conference. Winchester, VA. December 5-6.

Acebes, A., T.C. Leskey and J.C. Bergh. 2013. Effects of single and mixed diets of selected fruit trees and wild hosts on brown marmorated stink bug, *Halyomorpha halys* (Hemiptera: Pentatomidae) development and survival. Annual meeting of the Entomological Society of America, Austin, TX. November 10-13.

Acebes, A., T.C. Leskey and J.C. Bergh. 2014. Development and comparison of traps to monitor movement of *Halyomorpha halys* Stål (Hemiptera: Pentatomidae) nymphs on trees. Annual meeting of the Eastern Branch of the Entomological Society of America , Williamsburg, VA. March 15-18.

Aigner J. and T. Kuhar. 2013. Evaluating neonicotinoid insecticides for systemic control of brown marmorated stink bug (*Halyomorpha halys*) in fruiting vegetables. Annual meeting of the Entomological Society of America. Austin, TX. November 10-13.

Bai, B., C.S. Hedstrom, and H.W. Rogg, 2014 Oregon host range testing for *Trissolcus japonicus* –a potential biological control agent for brown marmorated stink bug. Annual Meeting of the Pacific Branch of the Entomological Society of America, Tucson, AZ. April 6-9.

Bakken, A.J., and J.F. Walgenbach. 2013. BMSB damage to apples at different growth stages. BMSB Winter IPM Working group Meeting. Winchester, VA. December 3.

Basnet S., D. Pfeiffer, T. Kuhar, and C. Laub. 2013. Stink bug species composition, seasonal abundance, varietal preference, and feeding injury in Virginia raspberry. Annual meeting of the Entomological Society of America. Austin, TX. November 10-13.

Basnet S., D. Pfeiffer, T. Kuhar, C. Laub. December 2013. Seasonal phenology and feeding preference of brown marmorated stink bug (BMSB) in Virginia vineyards. Cumberland-Shenandoah Fruit Workers annual conference, Winchester, VA. December 5-6.

Bergh, J.C. and T.C. Leskey. 2013. Emergence of adult brown marmorated stink bug from overwintering shelters. Brown Marmorated Stink Bug Working Group meeting, Winchester, VA. December 3.

Bergh, J.C. and T.C. Leskey. 2013. Emergence of brown marmorated stink bug from artificial overwintering shelters and response to pheromone traps. Annual meeting of the Entomological Society of America, Austin, TX. November 10-13.

Bergh, J.C. and T.C. Leskey. 2013. Use of overwintering shelters deployed against exterior and interior walls of buildings by adult brown marmorated stink bug. Cumberland-Shenandoah Fruit Workers annual conference, Winchester, VA. December 5-6.

Bergmann, E., H. Martinson, and P. Shrewsbury, 2014. Patterns of host use by

Halyomorpha halys in woody plant nurseries. Annual meeting of the Eastern Branch of the Entomological Society of America. Williamsburg. VA. March 16.

Biddinger, D., N. Joshi, C. Mullin, E. Rajotte, J. Robertson, J. Frazier, M. Otieno, and M. Frazier. 2014. Modifying Pennsylvania apple IPM programs to include pollinators. Annual meeting of the Eastern Branch of the Entomological Society of America, Williamsburg, VA. March 15-18.

Cambridge, J. and G.C. Hamilton. 2013. Brown marmorated stink bug diel sampling variance in peaches. Annual meeting of the Entomological Society of America . Austin, TX. November 9-14.

Cambridge, J. and G.C. Hamilton. 2014. Standardization of visual sampling techniques for *Halyomorpha halys* in New Jersey peaches. Annual meeting of the Eastern Branch of the Entomological Society of America. Williamsburg, VA. March 15-18.

Colavecchio, A.M, C. Dieckhoff and K. Hoelmer. 2013. Classical biological control of brown marmorated stink bug (*Halyomorpha halys*): an update. Annual meeting of the Entomological Society of America, Austin, TX. November 9-14.

Creary, S., A. Szczepaniec, and C. Riley. 2013. Effects of systemic applications of imidacloprid on boxwood spider mite abundance, fecundity, feeding damage and the mobility, feeding rates, and survival of associated predators. Annual Meeting of the Entomological Society of America. Austin, TX. November 10.

Day, E., T. Dellinger, and C. Koplinka-Loehr. 2014. Brown marmorated stink bug impact survey: Longitudinal data, Brown Marmorated Stink Bug Working Group, Georgetown, DE. June 16.

Dieckhoff, C. 2014. Brown marmorated stink bug, *Halyomorpha halys*: Biology and biological control - invited presentation - presented in Dr. Hough-Goldstein's Biological Control class - May 2.

Dieckhoff C. and Hoelmer, K. 2014. BMSB and the potential for biological control with Asian parasitoids - FL Dept. Agric. & Consumer Services, Gainesville FL. August 5.

Dieckhoff, C. and K. Hoelmer. 2014. Decisions, decisions, decisions ... oviposition behavior in *Trissolcus japonicus*, an egg parasitoid of *Halyomorpha halys*. Annual meeting of the Eastern Branch of the Entomological Society of America. March 15-18.

Dieckhoff, C. and K. Hoelmer. 2014. BMSB and the potential for biological control with Asian parasitoids. FL Dept. Agric. & Consumer Services, Gainesville FL. August 5.

Fleischer 2014 Developing a phenological model for the invasive brown marmorated stink bug in peaches IOBC WPRS. Vienna, Austria.

Hahn, N., C. Rodriguez-Saona and G.C. Hamilton. 2013. Factors affecting spatial patterns of brown marmorated stink bug, *Halyomorpha halys*, in peach orchards. Annual meeting of the Entomological Society of America. Austin, TX. November 9-14.

Hahn, N., G.C. Hamilton and C. Rodriguez-Saona. 2014. Landscape features associated with brown marmorated stink bug (*Halyomorpha halys*) clustering in peach orchards. Annual meeting of the Eastern Branch of the Entomological Society of America. Williamsburg, VA. March 15-18.

Hedstrom C.S., P.W. Shearer, J.C. Miller, J. Olsen, and V.M. Walton. 2013. Feeding damage by brown marmorated stinkbug, *Halyomorpha halys*, on commercial hazelnuts. Annual Meeting of the Entomological Society of America. Austin, TX. November 9-14.

Hedstrom C.S., V. Walton, P. Shearer, J. Miller and J. Olsen. 2014. Feeding Damage by Brown Marmorated Stink Bug (*Halyomorpha halys*) on Commercial Hazelnuts. Abstracts of the 88th Annual Orchard Pest and Disease Management Conference. Portland, OR. January 8-10.

Hoelmer, K.A. 2013. Searching for solutions to invasive pests at their origins: Overseas research programs. Annual meeting of the Entomological Society of America, Austin, TX. November 9-14.

Jentsch, P. 2013. Overview of Three Years of ARDP Funded Research in brown marmorated stink bug, *Halyomorpha halys* (Stål) Management in NY Tree Fruit. Apple Research & Development Program NYSAES, Jordan Hall, Geneva, NY November 12.

Jones, A.L., C.R.R. Hooks and P. M. Shrewsbury. 2013. Indigenous natural enemies of the brown marmorated stink bug in ornamental nurseries. Annual meeting of the Entomological Society of America. Austin, TX. November 10-13.

Jones, A.L., Shrewsbury, P. M., and Hooks, C.R.R. 2013. Natural enemies associated with the brown marmorated stink bug in ornamental nurseries. Annual meeting of the Eastern Branch of the Entomological Society of America, Eden Resort and Suite. Lancaster, PA. March 16- 19.

Khrimian, A, A. Zhang, H-Y Yo, J.R. Aldrich, K.E. Vermillion, S. Shirali, F. Guzman and T.C. Leskey. 2013. Use of stereoisomeric libraries for discovery of bug aggregation pheromones: a case study with 1,10-bisaboladien-3-ols. Annual Meeting of the Entomological Society of America. Austin, TX. November 10-13.

Krawczyk, G. 2014. Economic impact, monitoring and management of brown marmorated stink bug *Halyomorpha halys*, a new exotic pest in United States. San Michelle all'Adige Instituto Agrario, Italy, May 30.

Krawczyk, G. and L. A Hull. 2014. Is there a place for mating disruption in orchards affected by invasive pests? Annual meeting of the Eastern Branch of the Entomological Society of America. Williamsburg, VA. March 18.

Krawczyk, G., T. Enyeart and B. Lehman. 2013. Monitoring BMSB in Pennsylvania orchards – traps, lures and…. Cumberland-Shenandoah Fruit Workers annual conference. Winchester, VA. December 3-4.

Krawczyk, G., T. R. Enyeart, B. Lehman and L. A. Hull. 2014. Brown marmorated stink bug – lures, traps and… . 88th Orchard Pests and Diseases Management Conference. Portland, OR. January 8-10.

Kuhar, T., and D. Herbert. 2013. Brown marmorated stink bug Virginia research update. Brown Marmorated Stink Bug Working Group meeting, Winchester, VA. December 3.

Kuhar, T.P., and G. Dively. 2014. Injury diagnostics for vegetables, soybean and field crops. Brown Marmorated Stink Bug Working Group, Georgetown, DE. June 16.

Lee, D-H, T.C. Leskey, L. Beckettt and J. Daugherty. 2013. Confirmation of brown marmorated stink bug overwintering in natural landscapes using human and canine surveyors. Annual meeting of the Entomological Society of America. Austin, TX. November 10-13.

Lee, D-H, T.C. Leskey, L. Beckettt and J. Daugherty. 2013. Exploring overwintering ecology of brown marmorated stink bug using detector dogs. Korean Young Entomologist Symposium. Annual meeting of the Entomological Society of America. Austin, TX. November 10-13.

Lee, D-H., B.D. Short and T.C. Leskey. 2014. Development of pheromone-based attract and kill systems for brown marmorated stink bug. Annual meeting of the Eastern Branch of the Entomological Society of America. Williamsburg, VA. March 15-18.

Lee, J., A. Cave, A. Lake. 2014. Brown marmorated stink bug in ornamentals. 73rd Annual Pacific Northwest Insect Management Conference, Portland, OR. January 6-7.

Leskey, T.C. 2014. Developing monitoring and management tools for the invasive brown marmorated stink bug. Rural Development Agency of South Korea. Seoul, South Korea.

Leskey, T.C. 2014. Developing monitoring and management tools for the invasive brown marmorated stink bug. Gachon University. Seoul, South Korea.

Leskey, T.C. 2014. Developing monitoring and management tools for the invasive brown marmorated stink bug. Plant and Food Research Center, Auckland, NZ.

Leskey, T.C. 2014. Developing pheromone-based monitoring tools for the brown marmorated stink bug. Annual meeting of the Southeastern Branch of the Entomological Society of America. Greenville, SC.

Leskey, T.C. 2014. Potential risks posted by the brown marmorated stink bug. Better Border Biosecurity Conference, Wellington, NZ.

Lu, Y. and L. Pick. 2013. Evolution and Function of ftz and ftz-f1 in Hemipteroid Assemblage Insects. Annual MOCB Concentration Area Retreat, College Park, MD.

Lu, Y. and L. Pick. 2013. Genetic studies of brown marmorated stink bug. USDA NIFA SCRI CAP Project, Stakeholder Advisory Panel Meeting, Kearneysville, WV

Martinson, H., P. Shrewsbury, and E. Bergmann. 2013. The hosts you know or ones you don't: Patterns of host use by *Halyomorpha halys* in woody plant nurseries. Annual meeting of the Entomological Society of America. Austin, TX. November 10-13.

Mathews, C.M., T.C. Leskey and H. Hallack. 2014. Biological control of Hemipteran pests in organic vegetable crops with an integrated trap crop and pheromone trap system. Annual meeting of the Eastern Branch of the Entomological Society of America. Williamsburg, VA. March 15-18.

Mehl, H. and D.A. Herbert. 2014. Brown marmorated stink bug injury to field corn kernels and associated fungi and metabolites. Annual meeting of the Eastern Branch of the Entomological Society of America. Williamsburg, VA. March 15-18.

Mohekar, P., N.G. Wiman, J. Osborne, C.H. Hedstrom, V.M. Walton, and E. Tomasino. 2014. Postharvest impact of brown marmorated stink bug in wine. 88th Annual Orchard Pest and Disease Management Conference, Portland, OR. January 9.

Morrison, III W.R., Z. Szendrei and T. Leskey. 2014. Steps leading to the identification and application of semiochemicals in agriculture. Annual Macadamia Workshop, South African Macadamia Growers' Association (SAMAC), Tzaneen, South Africa. June 7.

Morrison, III W.R., Z. Szendrei, and T. Leskey. 2014. Field and landscape distribution of insects in agriculture: Prospects for their management through the use of semiochemicals. Annual Macadamia Research Symposium, South African Macadamia Growers' Association (SAMAC), Tzaneen, South Africa. June 6.

Nielsen A.L. 2014 Bringing IPM Back to Fruit Systems post-BMSB Rutgers University Departmental Seminar. New Brunswick, NJ.

Nielsen A.L. 2014 Deciphering the population ecology and behavior for the invasive BMSB in fruit. MSU Departmental Seminar. East Lansing, MI.

Nielsen A.L., 2013. Refining the pre-oviposition period for *Halyomorpha halys* and incorporation into phenological models Annual meeting of the Entomological Society of America. Austin, TX. November 10-13.

Nielsen A.L., and A. Rucker. 2013. Selecting insecticides for season-long brown marmorated stink bug management in peach. Cumberland-Shenandoah Fruit Workers Conference. Winchester, VA. December 5-6.

Pick, L. 2013. Variation and constraint in Hox gene evolution. Society for Molecular Biology and Evolution Meeting. Chicago, Illinois.

Rice, K.B., M. Gish, S.J. Fleischer, and J.F. Tooker. 2014. Insights on brown marmorated stink bug behavior from a mark recapture field experiment. Organized symposium: Leaving a mark: marking technologies for tracking insect movement. Annual meeting of the Pacific Branch of the Entomological Society of America, Tucson, AZ. April 6-9.

Rice, K.B., R. Troyer, L. Kime, J. Harper, J. F. Tooker and S.J. Fleischer. 2014. Economics of BMSB in processing tomato: Influence of landscape and management. Organized symposium: Are we winning the battle against invasive pests? The brown marmorated stink bug and spotted wing drosophila. Annual meeting of the Eastern Branch of the Entomological Society of America. Williamsburg, VA. March 15-18.

Shrewsbury, P., A.L. Jones, M.J. Raupp, C.R.R. Hooks, and D.E. Jennings. 2014. Survey. Impact of indigenous natural enemies of the invasive brown marmorated stink bug, *Halyomorpha halys*, in the United States. Pentatomid pests and associated microbes Symposium at the Xth European Congress of Entomology, University of York, York, UK. August 3-8.

Shrewsbury, P., C. Dieckhoff, K. Hoelmer, C. Hooks, L. Hunt, A. Jones, A. Rosario-Lebron, and J. Walgenbach. 2014. The who, where, and what for indigenous natural enemies attacking brown marmorated stink bug. Are we winning the battle against invasive pests? The brown marmorated stink bug and spotted wing drosophila Symposium at the Annual meeting of the Eastern Branch of the Entomological Society of America. Williamsburg, VA. March 15-18.

Shrewsbury, P.M., A.L. Jones, M.J. Raupp, C.R.R. Hooks and D.E. Jennings. 2014. Symposium title: Pentatomid pests and associated microbes. Talk title: Survey and impact of indigenous natural enemies of the invasive brown marmorated stink bug, *Halyomorpha halys*, in the United States. Symposium at the Xth

European Congress of Entomology. University of York, York, UK. August 3-8.

Suits, R., and J.F. Walgenbach. 2013. Impact of natural enemy populations on *Halyomorpha halys* in organic and conventional vegetables in western North Carolina. Annual meeting of the Entomological Society of America. Austin, TX. November 10-13.

Trope T., D. Pfeiffer, T. Kuhar. 2013. Monitoring brown marmorated stink bug, *Halyomorpha halys*, movement in organic crop systems for proper management. Annual meeting of the Entomological Society of America. Austin, TX. November 10-13.

Venugopal, D.P., G. Dively, D.A. Herbert, J. Whalen, and W.O. Lamp. 2014. Landscape factors influencing brown marmorated stink bug abundance and distribution vary with special scale. Annual meeting of the Eastern Branch of the Entomological Society of America. Williamsburg, VA. March 15-18.

Venugopal, P.D., G. Dively, D.A. Herbert, and W.O. Lamp. 2013. Environmental and spatial factors influencing patterns in stink bug communities in soybean. Annual meeting of the Eastern Branch of the Entomological Society of America. Lancaster, PA. March.

Walgenbach, J.F. 2013. BMSB spread and impact in frontier states. USDA-SCRI BMSB Advisory Committee Meeting. Kearneysville, WV. December 4.

Walgenbach, J.F., A.J. Bakken, and R. Suits. 2013. Fate of BMSB sentinel egg masses in NC agroecosystems. BMSB Winter IPM Working Group Meeting. Winchester, VA. December 3.

Weber, D.C., A. Khrimian, T.C. Leskey, J. R. Aldrich and J.G. Millar. 2013. Aggregation pheromones of stink bugs and their use in pest management. Annual meeting of the Entomological Society of America. Austin, TX. November 10-13.

Wiman, N.G., and S.I. Rondon. 2013. Brown marmorated stink bug: current status and research in the PNW. Farm Fair. Hermiston, OR. December 4-6.

Wiman, N.G. and E. Tomasino. 2014. Impact of brown marmorated stink bug on Oregon's vines and wines. Oregon Wine Research Institute Annual Grape Day. Corvallis, OR. April 1.

Wiman, N.G., P. Shearer, V. Walton, and S. Rondon. 2014. Feeding patterns of BMSB: Implications for sampling and management. 88th Annual Orchard Pest and Disease Management Conference, Portland, OR. January 9.

Wiman, N.G., P.W. Shearer, V.M. Walton S.I. Rondon. 2014. Synergy and antagonism between reporting, sampling and the media in the search for BMSB in Oregon. Symposium: Invasive Pests in the Landscape: Biology, ecology and management. Annual meeting of the Pacific Branch of the Entomological Society of America. Tucson, AZ. April 9.

Wiman, N.G., P.W. Shearer, V.M. Walton, S.I. Rondon. 2014. Factors affecting flight capacity of *Halyomorpha halys* in Oregon. Annual meeting of the Pacific Branch of the Entomological Society of America. Tucson, AZ. April 9.

Zobel, E., C.R.R. Hooks and G. Dively. 2013. The feeding habits of the brown marmorated stink bug, *Halyomorpha halys* (Heteroptera) on select vegetable crops. Annual meeting of the Entomological Society of America , Austin, TX. November 10-13.

Research Posters

Acebes-Doria, A., T.C. Leskey and J.C. Bergh. 2014. Development and comparison of traps to monitor movement of *Halyomorpha halys* nymphs on trees. Annual meeting of the Eastern Branch of the Entomological Society of America. Williamsburg, VA. March 15-18.

Colavecchio, A.M, C. Dieckhoff, and K. A. Hoelmer. 2013. Classical biological control of brown marmorated stink bug (*Halyomorpha halys*): an update. Annual meeting of the Entomological Society of America. Austin, TX, November 9-14.

Kuhar, T.P., J.W. Hogue, C.E. Blank, D.A. Herbert and J.D. Aigner. 2014. Population dynamics of brown marmorated stink bug on wooded borders and their movement into soybean fields in Virginia. Annual meeting of the Eastern Branch of the Entomological Society of America. Williamsburg, VA. March 15 – 18.

Lee, D-H and T.C. Leskey. 2013. Evaluation of flight capacity of foraging and overwintering brown marmorated stink bug using flight mill studies. Annual meeting of the Entomological Society of America. Austin, TX. November 10-13.

Pike, T., R. St. Leger and P.M. Shrewsbury. 2013. Effects of entomopathogenic fungi on brown marmorated stink bug, *Halyomorpha halys*. Annual meeting of the Entomological Society of America. Austin, TX. November 10-13.

Rice, K.B., S.J. Fleischer, J.F, K. Waltrous, and J.F. Tooker. 2013. Damage rates from brown marmorated stink bug in processing tomatoes: Influence of farm management, cultivar, and landscape. Annual meeting of the Entomological Society of America. Austin, Texas. November 10-13.

Research Workshops/Meetings/Symposia

Hoelmer, K., C. Dieckhoff, and M. Buffington. 2014. Parasitoids of the brown marmorated stink bug: A specialized training workshop, June 17-18 in conjunction with the BMSB IPM working group meeting. Georgetown, DE. June 16-18.

Research-Oriented Websites and Digital Products

Hedstrom C., Wiman N., Walton V., Shearer P., Rondon S. and J., Lee 2013. Brown Marmorated Stink bug, Halyomorpha halys, Oregon State University Extension Service, EM9054. (Also available in Spanish EM 9054 S). http://horticulture.oregonstate.edu/system/files/em9054.pdf

Hudson Valley Research Laboratory, Use of pheromone trapping data to determine the presence of BMSB in NYS agricultural production systems. Provide historical urban tracking of BMSB throughout NYS. http://www.eddmaps.org/bmsbny/

Leskey, T.C., G. C. Hamilton, D. J. Biddinger, M.L.. Buffington, C. Dieckhoff, G. P. Dively, H. Fraser, T. Gariepy, C. Hedstrom, D. A. Herbert, K. A. Hoelmer, C.R.R. Hooks, D. Inkley, G. Krawczyk, T.P. Kuhar, D-H. Lee, A.L. Nielsen, D.G. Pfeiffer, C. Rodriguez-Saona, P. W. Shearer, E. Talamas, E. Tomasino, J.

Tooker, P. D. Venugopal, J. Whalen, V. Walton, and N. Wiman. 2014. Datasheet for *Halyomorpha halys* (Stål), (Hemiptera: Pentatomidae). CABI Invasive Species Compendium. http://www.cabi.org/isc/datasheet/27377

New York Invasive Species Public Map. Use of Citizen Science-based data to track BMSB throughout NYS. http://imapinvasives.org/nyimi/map/

Oregon State University, Department of Horticulture. Brown Marmorated Stink Bug in Oregon. http://horticulture.oregonstate.edu/group/brown-marmorated-stink-bug-oregon

Stop Brown Marmorated Stink Bug. Website. www.StopBMSB.org .

Tracking the Brown Marmorated Stink Bug. DVD. Also available at www.StopBMSB.org/video .

Research Publications

Aigner, J.D, and T.P. Kuhar. 2014. Using citizen scientists to evaluate light traps for catching brown marmorated stink bugs in homes in Virginia. Research In Brief. J. Extension. August 2014, Volume 52, Number 4, Article # 4RIB5. Online open-access journal publication. www.joe.org.

Aigner, J.D., T.P. Kuhar, A.K. Lohr and C.R. Philips. 2014. Temperature extremes of the brown marmorated stink bug (*Halyomorpha halys*). Published Abstract. Virginia Journal of Science. Vol. 64 (1 & 2): 37 – 38.

Basnet, S., L.M. Maxey, C. Laub, T.P. Kuhar and D.G. Pfeiffer. 2014. The stink bug (Hemiptera: Pentatomidae) community in primocane-bearing raspberries in southwestern Virginia. Journal of Entomological Science 49: 304-312.

Bergmann, E.J. and M.J. Raupp. 2014. Efficacy of common ready to use insecticides against *Halyomorpha halys* (Hemiptera: Pentatomidae). Florida Entomologist. 97(2): 791 – 800.

Haye, T., K. Hoelmer, J.P. Rossi, J.C. Streito, 2014 (March). Analyse de Risque Phytosanitaire Express: *Halyomorpha halys* – la punaise diabolique. Rapport d'expertise collective. ANSES (French Agen. Nat'l. Sécurité Sani. Alim. Environ.), 2012-SA-0093. 76 pp.

Hedstrom C.S., Shearer P. W., Miller J. C., and V.M. Walton 2014. The effects of kernel feeding by *Halyomorpha halys* (Hemiptera: Pentatomidae) on Commercial Hazelnuts. Journal of Economic Entomology 107, 5: 1858-1865

Hull, L A., G. Krawczyk, and D. Biddinger. 2013. Evaluations of products for internal Lepidoptera and brown marmorated stink bug control, 2012. Arthropod Management Tests, 38: A7.

Hull, L.A., D. Biddinger, and G. Krawczyk. 2013. Large plot evaluations of various lepidopteran and brown marmorated stink bug tactics, 2012. Arthropod Management Tests, 38: A9.

Ioannidis, P., Y. Lu, N. Kumar, T. Creasy, S. Daugherty, M.C. Chibucos, J. Orvis, A. Shetty, S. Ott, M. Flowers, N. Sengamalay, L.J. Tallon, L. Pick, and J.C. Dunning Hotopp,. (2014) Rapid transcriptome sequencing of an invasive pest, the brown marmorated stink bug *Halyomorpha halys*, BMC Genomics, 15:738 doi:10.1186/1471-2164-15-738

Jones, A.L., D.E. Jennings, C.R.R. Hooks, and P.M. Shrewsbury. 2014. Sentinel eggs underestimate rates of parasitism of the exotic brown marmorated stink bug, *Halyomorpha halys*. Biol. Control. DOI: 10.1016/j.biocontrol.2014.07.011.

Joseph, S.V., J.W. Stallings, T.C. Leskey, G. Krawczyk, D. Polk, B. Butler and J.C. Bergh. 2014. Spatial distribution of brown marmorated stink bug (Hemiptera: Pentatomidae) injury at harvest in mid-Atlantic apple orchards. Journal of Economic Entomology 107(5): 1839-1848.

Kamminga, K., D.A. Herbert, M.D. Toews, S. Malone, and T. Kuhar. 2014. *Halyomorpha halys* (Hemiptera: Pentatomidae) feeding injury on cotton bolls. Journal of Cotton Science 18:68-74, http://www.cotton.org/journal/2014-18/1/

Khrimian A., A. Zhang, D.C. Weber, H.Y. Ho, J.R. Aldrich, K.E. Vermillion, M.A. Siegler, S. Shirali, F. Guzman, and T.C. Leskey. 2014. Discovery of the aggregation pheromone of the brown marmorated stink bug (*Halyomorpha halys*) through the creation of stereoisomeric libraries of 1-bisabolen-3-ols. Journal of Natural Products, 77:1708-1717.

Kuhar, T.P, H. Doughty, C. Philips, J. Aigner, L. Nottingham, and J. Wilson. 2014. Evaluation of foliar insecticides for the control of brown marmorated stink bugs in bell peppers in Virginia – 2013. Arthropod Management Tests. 39: in press.

Kuhar, T.P., H. Doughty, K. Kamminga, A. Wallingford, C. Philips, and J. Aigner. 2012. Evaluation of foliar insecticides for the control of brown marmorated stink bugs in bell peppers in Virginia – 2012 Test 1. Arthropod Management Tests 2013, 38: E39. Online publication. doi: 10.4182/amt.2013.E39

Kuhar, T.P., H. Doughty, K. Kamminga, A. Wallingford, C. Philips, and J. Aigner. 2012. Evaluation of foliar insecticides for the control of brown marmorated stink bugs in bell peppers in Virginia – 2012 test 2. Arthropod Management Tests 2013, 38: E40. Online publication. doi: 10.4182/amt.2013.E40

Kuhar, T.P., H. Doughty, K. Kamminga, A. Wallingford, C. Philips, and J. Aigner. 2013. Evaluation of foliar insecticides for the control of brown marmorated stink bugs in bell peppers in Virginia – 2012 test 3. Arthropod Management Tests 2013, 38: E41. Online publication. doi: 10.4182/amt.2013.E41.

Lee, D-H, B.D. Short, A.L. Nielsen, T.C. Leskey. Impact of organic insecticides on the survivorship and mobility of *Halyomorpha halys* (Stål) in the laboratory. Florida Entomologist. 97: 414-421.

Lee, D-H, C-G. Park, S. Boyun, G. Boiteau, C. Vincent, and T.C. Leskey. 2014. Detectability of *Halyomorpha halys* (Hemiptera: Pentatomidae) by portable harmonic radar. Florida Entomologist 97: 1131-1138.

Lee, D-H, S.E. Wright, G. Boiteau, C. Vincent, and T.C. Leskey. 2013. Effectiveness of glues for harmonic radar attachment on *Halyomorpha halys* (Hemiptera: Pentatomidae) and their impact on adult survival and mobility. Journal of Environmental Entomology. 42:515-523.

Leskey, T., G.C. Hamilton, D.J. Biddinger, M. Buffington, C. Dieckhoff, G.P. Dively, H. Fraser, T. Gariepy, C. Hedstrom, D.A. Herbert, K. Hoelmer, C.R.R. Hooks, D. Inkley, G. Krawczyk, T. Kuhar, D. Lee, A.L. Nielsen, D.G. Pfeiffer, C. Rodriguez-Saona, P.W. Shearer. E. Talamas, E. Tomasino, J. Tooker. P.D. Venugopal, J. Whalen, V. Walton, and N. Wiman. 2014. Datasheet for *Halyomorpha halys* (Stål), (Hemiptera: Pentatomidae). In Crop Protection Compendium. CABI International, Wallingford, United Kingdom.

Owens, D.R., D.A. Herbert, Jr., G. Dively, D.D. Reissig, T.P. Kuhar. 2013. Does feeding by *Halyomorpha halys* Stål (Hemiptera: Pentatomidae) reduce soybean seed quality and yield? Journal of Economic Entomology. 106: 1317-1323. ISSN 0022-0493, Online ISSN: 1938-291X

Peiffer M. and G.W. Felton. 2014. Insights into the saliva of the brown marmorated stink bug *Halyomorpha halys* (Hemiptera: Pentatomidae). PLOS ONE 9(2): e88483. doi:10.1371/journal.pone.0088483

Rice, K., C. Bergh, E. Bergman, D. Biddinger, C. Dieckhoff , G. Dively, H. Fraser, G. Tara, G. Hamilton, T. Haye, A. Herbert, K. Hoelmer, C. Hooks, A. Jones, G. Krawczyk, T. Kuhar, W. Mitchell, A. Nielsen, D. Pfeiffer, M. Raupp, C. Rodriguez -Saona, P. Shearer, P. Shrewsbury, P. Venugopal, J. Whalen, N. Wiman, T. Leskey, and J. Tooker 2014. Biology, ecology, and management of brown marmorated stink bug (*Halyomorpha halys*). Journal of Integrated Pest Management. 5: A1-A13. DOI: http://dx.doi.org/10.1603/IPM14002

Sargent, C.S., H. Martinson, and M.J. Raupp. 2014. Effects of traps and trap placement on abundance of *Halyomorpha halys* (Hemiptera: Pentatomidae) and their associated injury to tomato fruits in home gardens. Journal of Environmental Entomology. 43(2):432-438. DOI: http://dx.doi.org/10.1603/EN13237

Taylor, C.M, P.L. Coffey and G.P. Dively. 2014. The importance of gut symbionts in the development of the brown marmorated stink bug, *Halyomorpha halys* (Stål). PLOS One 9(3): e90312. doi:10.1371/journal.pone.0090312.

Timer, J.H., and M.C. Saunders. 2014. Meridic diet for *Halyomorpha halys* (Heteroptera: Pentatomidae. Journal of Entomological Science 49(2): 195-199.

Wallner A.M., G. Hamilton, A. Nielsen, N. Hahn, E. Green, and C. Rodriguez-Saona. 2014. Landscape factors facilitating the invasive dynamics and distribution of the brown marmorated stink bug, *Halyomorpha halys* (Hemiptera: Pentatomidae), after arrival in the United States. PLoS ONE 9(5): e95691. DOI:10.1371/journal.pone.0095691

Weber, D.W., T.C. Leskey, G.J. Cabrera Walsh and A. Khrimian. 2014. Synergy of aggregation pheromone with methyl decatrienoate in attraction of brown marmorated stink bug. Journal of Economic Entomology. 107: 1061-1068

Wiman, N., V.M. Walton, P.W. Shearer, and S.I. Rondon. 2014. Electronically monitored feeding behavior in the brown marmorated stink bug, *Halyomorpha halys*, in simulated environments. PLOS One. (Accepted)

Wiman, N., V.M. Walton, S.I. Rondon, P.W. Shearer, and J.C. Lee. 2014. Factors affecting flight capacity of brown marmorated stink bug, *Halyomorpha halys* (Hemiptera: Pentatomidae). Journal Pest Science DOI:10.1007/s10340-014-0582-6.

Extension Talks and Meetings

2013 CCE Suffolk Annual Meeting: The Entomology Program at CCE: 20 November. 70 attended.

2013 Ecological Entomology. Eastern Shore Master Gardeners. Queenstown, MD. October 3.
2013 Effects of global change on insect biodiversity and community function. Montgomery County Master Gardeners. Gaithersburg, MD. November 7.
2013 Entomology update. Community Forestry Workshop. Westminster, MD. October 4.
2013 Insect Pest IPM of Hudson Valley Pome Fruit: Early Season Management. Hudson, NY. May 21. 40 attended.
2013 Insect Pest IPM of Hudson Valley Pome Fruit: Early Season Management. Milton, NY. May 21. 40 attended.
2013 Insect Pest IPM of Hudson Valley Pome Fruit: Early Season Management. Lake George, NY. May 24. 40 attended.
2013 Insect Pest IPM of Hudson Valley Pome Fruit: Early Season Management., Lake Champlain, NY. May 24. 40 attended.
2013 Introduction to insects. Master Naturalist Training, Baltimore County. Cockeysville, MD. September 26.
2013 Introduction to insects. Master Naturalist Training, Montgomery County. Chevy Chase, MD. October 8.
2013 IPM Working Group Meeting. December.
2013 Long Island Arboricultural Association: Cornell Entomology Update: Notes and Noteworthy Landscape Pests. November 12. 45 attended.
2013 Management of the Brown Marmorated Stink Bug. New England Vegetable and Fruit Conference in Manchester, NH. December 18. 110 attended.
2013 Monitoring and Management of the BMSB in Urban and Agricultural Environments in New York State. New England, New York, Canadian Fruit Pest Management Workshop. Burlington, VT. October 23. 65 attended.
2013 Monitoring the BMSB in Urban and Agricultural Environments in New York State. Agricultural Invasive Species session. Annual CCE Agriculture and Food System In-service, Ithaca, NY, November 13. 20 attended.
2013 Port Jeff. High School Environmental Science class: Entomology at Cornell on Long Island: November. 26 attended.
2013 Stakeholder Advisory Panel Meeting, December.
2013 Updates on the Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål) and Spotted Wing Drosophila, Drosophila suzukii in NY State. Fruit & Vegetable Expo, Oncenter, Syracuse NY. January 22. 85 attended.
2014 Insect Management in Processing Lima Beans, including BMSB management - Processing Vegetable Session. Delaware Ag Week. January 15.
2014 Insect Management in Sweet Corn, including BMSB. NJ Ag Convention and Trade Show. February 5.
2014 Mid-Atlantic Fruit and Vegetable Meetings, Hershey, PA Over 300 attended.
2014 BMSB control in organic vegetable systems. MOFFA Meeting. February.
2014 BMSB in vegetable high tunnel production systems. Delaware Ag Week. Harrington, DE. January.
2014 New pests and some old ones to watch for in 2014. Central MD Fruit and Vegetable
2014 Biological Control Approaches. Advanced Landscape IPM Shortcourse.

Department of Entomology, University of Maryland. College Park, MD. January.
2014 BMSB and other sucking bugs to watch for. Beginning Farmer Presentation. Germantown, MD. March.
2014 Brown Marmorated Stink Bug Management Update, Seneca Produce Auction Growers Meeting, 2295 Yerkes Road, Romulus, NY. January 10.
2014 Brown Marmorated Stink Bug Management Update. Finger Lakes Produce Auction Growers Meeting, 3691 State Route 14A, Penn Yan Yan, NY. January 9.
2014 Bugs, Aphids, Adelgids, Thrips. Advanced Landscape IPM Shortcourse. Department of Entomology, University of Maryland. College Park, MD. January.
2014 CCE Master Gardener training; Pests in the Home Garden and Landscape. April 29. 29 attended.
2014 Conserving beneficials through wise use of pesticides and management practices. Winter Ornamental & Turf Conference, Pennsylvania Cooperative Extension. Harrisburg, PA. January.
2014 Cornell Gardeners: The Entomology Program at LIHREC. April 4. 24 attended.
2014 Creating sustainable residential landscapes. Maryland Native Plant Society. Frostburg, MD. April 15.
2014 Cub Scout Pack 189 Melville Meeting: Insects in Our World: June 12. 26 attended.
2014 Ecological Entomology. Baltimore City Master Gardeners. Baltimore, MD. February 20.
2014 Ecological Entomology. Baltimore County Master Gardeners. Cockeysville, MD. February 21.
2014 Ecological Entomology. Howard County Master Gardeners. Ellicott City, MD. March 10.
2014 Ecological Entomology. Prince George's County Master Gardeners. College Park, MD. March 10.
2014 Ecological Entomology. St. Mary's Master Gardeners. Leonardtown, MD. February 27.
2014 Ecological Entomology. University of the District of Columbia Master Gardeners. Washington, DC. February 18.
2014 Ecological IPM. Part 1. Advanced master gardener training. Baltimore County Agriculture Center, MD. June 2.
2014 Ecological IPM. Part 2. Advanced master gardener training. Baltimore County Agriculture Center, MD. June 9.
2014 Ecosystem services provided by insects. Montgomery County Public Schools. Environmental Education Center. Derwood, MD. April 1.
2014 Gloucester/Cumberland/Salem County Twilight Meeting. April 2. 26 attended.
2014 Gloucester/Cumberland/Salem County Twilight Meeting. May 8. 25 attended.
2014 Hands on field training for field guides. Oregon Ridge Park, Cockeysville, MD. September 4.
2014 Home Invaders. National Park Service. Vienna, VA. September 23.
2014 Hudson Valley Nursery and Greenhouse Conference: Prescriptions for Pestilence. January 29. 63 attended.
2014 Hunterdon, Mercer, Morris, Warren, Monmouth County Twilight Meeting. Insect

Control Update with a Focus on Early Season Pests. April 8. 41 attended.

2014 Hunterdon, Mercer, Morris, Warren, Monmouth County Twilight Meeting. Insect Pest Update for North jersey Orchards. May 6. 39 attended.

2014 Hunterdon, Mercer, Morris, Warren, Monmouth County Twilight Meeting. BMSB Monitoring and Treatment Options. June 10. 35 attended.

2014 Introduction to insects and ecosystem services. Master Naturalists of Montgomery County. Brookside Gardens. Wheaton, MD. April 11.

2014 Introduction to insects and ecosystem services. Master Naturalists of Montgomery County. Brookside Gardens. Wheaton, MD. April 21.

2014 Introduction to insects and ecosystem services. Master Naturalists of Calvert County. Prince Frederick, MD. April 28.

2014 Introduction to insects and ecosystem services. Master Naturalists of Baltimore County. R.E. Lee Park, Baltimore, MD. April 28.

2014 Introduction to insects and ecosystem services. Master Naturalists of Baltimore County. Eden Mill Nature Center, Pylesville, MD. August 28.

2014 Introduction to insects and ecosystem services. Science Teachers of Baltimore County. Oregon Ridge Park, Cockeysville, MD. May 5.

2014 IPM Working Group Meeting, June.

2014 LIHREC Plant Science Day: Entomology Program Projects at LIHREC: September 4. 135 attended.

2014 LIHREC Plant Science Day: Updates on spotted wing drosophila and brown marmorated stink bug, Plant Science Day, LIHREC, Riverhead, NY. September 4. 135 attended.

2014 Long Island Arboricultural Association: New and Invasive Pests. April 4. 63 attended.

2014 Long Island Horticulture Conference: No Shutdown for Pests: January 23. 180 attended.

2014 Management of the Stink Bug Complex in Commercial Tree Fruit. Hudson Valley Commercial Fruit Growers School, Garden Plaza Hotel, Kingston, NY. February 12.

2014 Management of the Stink Bug Complex in Commercial Vegetable Production. Hudson Valley Commercial Vegetable School, Falcon, Marlboro, NY. February 24.

2014 Managing Sweet Corn Insects and Resistance with New Insecticides. Northern Commercial Vegetable Growers' School, Plattsburgh City Recreation Department, Plattsburgh, NY. February 25.

2014 Migration and Population Increase of the BMSB in NYS., Agr. Assistance Mtg; Studebakers Restaurant, Lyons, NY. March 7.

2014 NPDN First Detector Workshop: Enhanced First Detector Training: Brown Marmorated Stink Bug, Emerald Ash Borer, Spotted wing Drosophila: June 19. 26 attended.

2014 NSLGA N&S Chapters monthly: Entomology Update: Pests to Watch for in 2014. April 21. 64 attended.

2014 Onion Bulb Mite & Brown Marmorated Stink Bug in Hudson Valley Vegetable Crops. Onion School, Cornell Cooperative Extension Orange County, Middletown, NY. March 7.

2014 Organic Insect Tree Fruit Pest Management. NOFA-NY Winter Conference, Saratoga Hilton, Saratoga Springs, NY. January 26.

2014 Organic Pesticide Applicator Training for Fruit and Vegetable Growers; 'IPM in Organic Pest Management Programs' Cornell Cooperative Extension, Hudson Valley Laboratory, Highland, NY. April 3-4. 29 attended.

2014 PCA of Long Island: Out with the old, in with the new: Past and predicted problems. January 30. 116 attended.

2014 Review of the 2014 Pest Management Season in ENY.Cornell Cooperative Extension Eastern NY Commercial Horticulture Program, Upper Hudson / Champlain Commercial Tree Fruit School, Fort William Henry Hotel and Conference Center, Lake George, NY. February 10.

2014 What a warming world means for pest outbreaks. Advanced Master Gardener Training. College Park, MD. May 29.

2014 Whole Orchard Pest Management Programs for 2014, North Jersey Fruit Meeting. March 7. 75 attended.

2014 Whole Season Tree Fruit Insecticide Programs in Light of BMSB. February 13. 28 attended.

2014. Insect Management in Sweet Corn, including BMSB - Fresh Market Vegetable Session. Delaware Ag Week. January 14.

2014. Insect Management in Sweet Corn, including BMSB. Mid-Atlantic Fruit and Vegetable Meeting. January 30.

2014. Insect Management in Sweet Corn, including BMSB. New Holland, PA Vegetable Day. January 20.

Aigner, J. and E.R. Day. 2014. Impact Survey of the New Stink Bug. Eastern Shore Agricultural Conference. 2014, Melfa, VA. January 8.

Aigner, J.D. 2014. Developing monitoring strategies and economic thresholds for brown marmorated stink bug using pheromone traps in vegetable cropping systems. YMCA Twilight Grower Meeting. Blacksburg, VA. July 6.

Bergh, J.C. 2013. Diagnosing and managing injury from arthropod pests of tree fruit. In -Service Extension agent training. Blackstone, VA. December 11.

Bergh, J.C. 2013. Orchard crops update. SCRI Stakeholder Advisory panel meeting. Kearneysville, WV. December 4.

Bergh, J.C. 2014. Brown marmorated stink bug research update. In-Depth meeting for commercial tree fruit producers. Winchester, VA. May 22.

Bergmann, E., K.M. Bernhard, G. Bernon, M. Bickerton, S. Gill, C. Gonzales, G.C. Hamilton, C. Hedstrom, K. Kamminga, C. Koplinka-Loehr, G. Krawczyk, T.P. Kuhar, B. Kunkel, J. Lee, T.C. Leskey, H. Martinson, A.L. Nielsen, M. Raupp, P. Shearer, P. Shrewsbury, J. Walgenbach, J. Whalen, N. Wiman. 2013. Host plants of the Brown Marmorated Stink Bug in the U.S. www.stopbmsb.org/where-is-bmsb/host-plants

Brunner, J.F. 2014. Pest Watch: Brown Marmorated Stink Bug. G. S. Long Grower Meeting, Yakima, WA.

Butler, Sr., B.R. 2014. Brown marmorated stink bug on tree fruit. Bay Area Fruit School, Queenstown, MD. 47 attended. http://origin.peg.tv/player/index/affiliate1?video=17953

Butler, Sr., B.R. 2014. Brown marmorated stink bug on tree fruit. Western Maryland

Fruit Meeting, Queenstown, MD. 46 attended.

Butler, Sr., B.R. 2014. Brown marmorated stink bug orchard monitoring. Pennsylvania Summer Orchard Meeting, Smithsburg, MD. 92 attended.

Krawczyk, G. 2014. Revisiting IPM in the world of BMSB and SWD. President Day Fruit Growers Educational Meeting, Biglerville, PA, February 17. 220 attended.

Krawczyk, G. 2013. The impact of BMSB management on IPM systems in fruit orchards. Erie County Tree Fruit Growers Meeting. North East, PA, March 7. 52 attended.

Krawczyk, G. 2014. BMSB and seasonal orchard IPM updates. Adams County Twilight IPM meeting. Aspers, PA, May 7. 65 attended.

Krawczyk, G. 2014. BMSB and seasonal orchard IPM updates. Appalachian Fruit Growers Twilight IPM meeting. Port Matilda, PA, May 20. 40 attended.

Krawczyk, G. 2014. BMSB and seasonal orchard IPM updates. Central Susquehanna Twilight IPM meeting. Berwick, PA, May 22. 55 attended.

Krawczyk, G. 2014. BMSB and seasonal orchard IPM updates. Erie County Tree fruit IPM meeting. North East, PA, May 15. 30 attended.

Krawczyk, G. 2014. BMSB and seasonal orchard IPM updates. Franklin County Twilight IPM meeting. Chambersburg, PA, May 8. 35 attended.

Krawczyk, G. 2014. BMSB and seasonal orchard IPM updates. Southeast Region Orchard Twilight IPM meeting. New Hope, PA, May 21. 55 attended.

Krawczyk, G. 2014. BMSB and seasonal orchard IPM updates. Western PA Twilight IPM meeting. Wexford, PA, May 14. 35 attended.

Krawczyk, G. 2014. BMSB and seasonal orchard IPM updates. Multi-State Fruit Growers twilight educational meeting. Smithsburg, M. June 30. 60 attended.

Krawczyk, G. 2014. Brown marmorated stink bug management and monitoring update. PSU FREC Plant Protection Day, Biglerville, PA, September 11. 60 attended.

Krawczyk, G. 2014. Integrated fruit production update for the new season. Regional IPM meeting, Biglerville, PA, April 10. 55 attended.

Krawczyk, G. 2014. New challenges and opportunities in managing insect pests. Western PA Tree Fruit Growers Meeting. Wexford, PA, March 5. 45 attended.

Krawczyk, G. 2014. Revisiting IPM in the world of BMSB and SWD. Appalachian Fruit Growers Meeting. Bedford, PA, March 4. 37 attended.

Krawczyk, G. 2014. Revisiting IPM in the world of BMSB and SWD. Erie County Tree Fruit Growers Meeting. North East, PA, March 6. 20 attended.

Krawczyk, G. 2014. Revisiting IPM in the world of BMSB and SWD. Franklin County Fruit Growers Educational Meeting, Waynesboro, PA. February 19. 35 attended.

Krawczyk, G. 2014. Revisiting IPM in the world of BMSB and SWD. Lancaster County Fruit Growers Educational Meeting, Lancaster, PA. May 6. 45 participants

Krawczyk, G. 2014. Revisiting IPM in the world of BMSB and SWD. Northeast PA Tree Fruit Meeting. Avoca, PA, February 27. 50 attended.

Krawczyk, G. 2014. Revisiting IPM in the world of BMSB and SWD. Western PA Tree Fruit Growers Meeting. Wexford, PA, March 5. 45 attended.

Krawczyk, G. and T. Leskey. 2014. Brown marmorated stink bug-what's next? Mid-Atlantic Fruit and Vegetable Convention. Hershey, PA, January 29. 320 attended.

Kuhar T. 2013. Emerging row crop pests - stink bugs, kudzu bugs, and others, Private

Applicators Recertification Category 91. Madison, VA. December.
Kuhar T. 2013. Emerging row crop pests - stink bugs, kudzu bugs, and others, Private Applicators Recertification Category 91. Aldie, VA. December.
Kuhar T. 2013. Emerging row crop pests - stink bugs, kudzu bugs, and others, Private Applicators Recertification Category 91. Syria, VA. December.
Kuhar T. 2013. Emerging row crop pests - stink bugs, kudzu bugs, and others, Private Applicators Recertification Category 91. Culpeper, VA. December.
Kuhar T. 2013. Stink bugs, spotted wing drosophila and other insect pests of fruits and vegetables, Private Applicators Re-certification Category 90. Madison, VA. December.
Kuhar T. 2013. Stink bugs, spotted wing drosophila and other insect pests of fruits and vegetables, Private Applicators Re-certification Category 90. Aldie, VA. December.
Kuhar T. 2013. Stink bugs, spotted wing drosophila and other insect pests of fruits and vegetables, Private Applicators Re-certification Category 90. Syria, VA. December.
Kuhar T. 2014. Update on insect management for vegetables and brown marmorated stink bug, Spotted wing drosophila and kudzu bug, 9th Annual Meeting of the Appalachian Regional Horticulture Conference, Abingdon, VA. February 21.
Kuhar T. 2014. Update on insecticides for pepper/eggplant and pest problems in 2013, 2014 Mid-Atlantic fruit and Vegetable convention, Hershey, PA. January 30.
Kuhar, T.P. 2014. The story of the invasive brown marmorated stink bug. Biology Dept. Seminar, Towson University, Towson, MD. April 11.
Kuhar, T.P. 2014. Managing brown marmorated stink bug in tomatoes. New Hope, MD. January.
Murray, T. 2013. The Bugs that ate the Pacific Northwest: Exotic pests. Washington State University Master Gardener. Annual Meeting. September 27. 80 attended.
Murray, T. 2013. The Bugs that ate the Pacific Northwest: Exotic pests. Washington State University Master Gardener. Annual Meeting. Clark County. November 6. 40 attended.
Murray, T. 2014. Exotic Pests in the Columbia River Gorge. Stevenson WA. March 20. 125 attended.
Murray, T. 2014. Spotted Winged Drosophila and Brown Marmorated Stink Bug Update. GS Long Oregon Annual Grower Meeting. Hood River OR. January 8. 90 attended.
Murray, T. 2014. The Bugs that ate the Pacific Northwest: Exotic pests. Washington State University Master Gardener. Annual Meeting. Hood River County. March 5. 45 attended.
Murray, T. 2014. The Bugs that ate the Pacific Northwest: Exotic pests. Washington State University Master Gardener. Annual Meeting. Cowlitz County. May 9. 25 attended.
Nielsen A.L. 2014. Managing BMSB and OFM with Less Insecticides (and Less Money). South Jersey Fruit Meeting. February. 40 attended.
Nielsen A.L. 2014. Managing BMSB and secondary pest outbreaks. South Jersey Fruit Twilight. April. 31 attended.
Nielsen A.L. 2014. Managing BMSB. North Jersey Fruit Twilight. April. 55 attended.

Nielsen A.L. 2014. Impact of New Pests Throughout the Growing Season in NJ Wine Grapes Effective IPM Programs for BMSB in Peach: Better and Less Spraying. Mid-Atlantic Fruit and Vegetable Convention, Hershey, PA. January. 150 attended.

Nielsen A.L. 2014. Impact of New Pests Throughout the Growing Season in NJ Wine Grapes. Grape Expectations. Monroe, NJ. February. 94 attended.

Nielsen A.L. 2014. Management of BMSB and New Insecticides for Key Fruit Pests. North Jersey Fruit Meeting. March. 55 attended.

Nielsen A.L., T.C. Leskey, C. Rodriguez-Saona. 2014. Identifying BMSB injury in fruit. BMSB June Working Group Meeting.

Pfeiffer, D.G. 2013. Organic pest management for caneberries and blueberries: Old friends and new. Organic and Sustainable Berry Growers Conference. Eastern Mennonite Univ. Harrisonburg. Oct 21-22. http://www.emu.edu/berryconference/

Rondon, S.I. 2014. Brown marmorated stink bug: biology and impacts. North Willamette Valley Horticulture Society. Calby, OR. (55 participants).

Shearer, P.W. 2014. BMSB update. Oregon Hort Society, Orchard fruit section. Portland Expo Center. January 28.

Streito J.C., Rossi J.P., Haye T., Hoelmer K., and Tassus X. 2014. La Punaise diabolique (*Halyomorpha halys*): nouveau ravageur à la conquête de la France. Phytoma no. 677 : 26-29.

The 46th annual Meeting of the NC Tomato Growers Association and Winter Vegetable Conference and Trade Show, February 19-20. Asheville, NC.

Walgenbach, J.F. 2014. Biology and management of brown marmorated stink bug. Organic Growers School, Asheville, NC. March 8-9.

Walgenbach, J.F. 2014. Damage potential and management of brown marmorated stink bug. Wilkes County Apple Growers Meeting. February 24.

Walgenbach, J.F. 2014. Good bugs, bad bugs, and BMSB. Burke County Master Gardners. Morganton, NC. July 27.

Walgenbach, J.F. 2014. Managing Spider Mites and Stink Bugs. NC Tomato Growers Annual Winter Vegetable Conference. Asheville, NC. February 18.

Walton et al. 2013. Oregon Wine Research Institute seminar. Brown Marmorated Stink Bug in wine grapes. December. 120 attended.

Walton et al. 2013. Annual Blueberry field day. Brown Marmorated Stink Bug update. July. 60 attended.

Walton et al. 2013. Annual Caneberry Field Day. Brown Marmorated Stink Bug update. July. 40 attended.

Walton et al. 2014. Annual Master Gardener Mini conference. Spotted Wing Drosophila and Brown Marmorated Stink Bug in home gardens. June. 20 attended.

Walton et al. 2014. Integrated Plant Protection Conference. How to identify and manage two invasive pests, Spotted Wing Drosophila and Brown Marmorated Stink Bug in commercial agriculture. January. 300 attended.

Walton et al. 2014. Nut Grower Society Winter Meeting. Brown Marmorated Stink Bug in Hazelnuts, Current Status. January. 750 attended.

Wiman, N.G. 2014. Brown marmorated stink bug, a new invasive pest in Oregon. Developing solutions. Umpqua Valley Grape Day Seminar. Roseburg, OR. June

3.
Wiman, N.G., and V.M. Walton. 2014. Damage and impacts of BMSB on blueberries and blackberries. Annual Meeting of the Oregon Horticultural Society (Berry Day). Canby, OR. January 16.
Wiman, N.G., P.W. Shearer, V.M. Walton, S.I. Rondon, J. Lee, and J. Miller. 2014. Status of BMSB in Oregon with focus on ornamental host plants. Oregon Association of Nurseries. NW Ag Show. Portland, OR, January 28.
Wiman, N.G., P.W. Shearer, V.M. Walton, S.I. Rondon, J. Lee, J. Miller, J.F. Brunner and T. Murray. 2014. Current status of brown marmorated stink bug in the PNW. Annual Meeting of the Oregon Horticultural Society (Organic Day). Canby, OR, 16 January.
Wiman, N.G., P.W. Shearer, V.M. Walton, S.I. Rondon, J. Lee, J. Miller, J.F. Brunner and T. Murray. 2014. Update for BMSB in the PNW. Ann. Meet. Cherry Inst. Of WA. Yakima, WA. January 10.

Extension Workshops

2014 Certified Nursery and Landscape Professional Training: Pests of Ornamental Nursery and Landscape Plants: March 3. 15 attended.

2014. Man the Watch: Lookout for non-natives. Delaware Cooperative Extension Invasive Workshop. March 6.

Gill S., B. Kunkel, E. Day, P. Shrewsbury, M. Raupp, J. Brust, B. Butler, and S. Klick. 2013 A day-long workshop Brown marmorated stink bug research and practical use that combined lecture with hands-examination of the BMSB and the predators and parasites that are helping reduce populations of this bug. Landscape and grounds maintenance professionals, 51 people from green industry and Master Gardener program registered. Westminster, MD.

Wiman, N.G., and D.T. Dalton. 2014. Scouting for vineyard pests. Oregon Wine Research Institute Scouting. Woodhall Vineyard. Monroe, OR. May 20.

Extension Oriented Websites and Digital Products

2013 Death of a stink bug, Part 1: A curious reunion between the Brown Marmorated Stink Bug, *Halyomorpha halys*, and the Chinese Praying Mantis, Tenodera. September 20. http://bugoftheweek.com/blog/2013/9/20/death-of-a-stink-bug-part-1-a-curious-reunion-between-the-brown-marmorated-stink-bug-ihaylomorpha-halysi-and-the-chinese-praying-mantis-itenodera-sinensisi

2013 Death of a stink bug, Part 2: Bug vs. Bug - Brown Marmorated Stink Bug, *Halyomorpha halys*, meets the wheel bug, *Arilus cristatus*. September 30. http://bugoftheweek.com/blog/2013/9/30/death-of-a-stink-bug-part-2-bug-vs-bug-brown-marmorated-stink-bug-ihalyomorpha-halysi-meets-the-wheel-bug-iarilus-cristatusi

2013 Death of a stink bug, Part 3: Homegrown hospitality - Brown Marmorated Stink Bug, *Halyomorpha halys*, meets the black and yellow garden spider, *Argiope aurantia*. October 7 https://bugoftheweek.squarespace.com/blog/2013/10/4/

death-of-a-stink-bug-part-3-homegrown-hospitality-brown-marmorated-stink-bug-halyomorpha-halys-meets-the-black-and-yellow-garden-spider-iargiope-aurantia

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Stakeholder Advisory Panel

More than 30 independent growers, association directors, and business leaders from across the United States are working in our Stakeholder Advisory Panel. This group reviews project accomplishments, provides feedback on research plans, and guides the execution of objectives.

Member Name, Affiliations, and State

Current Members

George Behling, Tree Fruit Grower and Owner, Nob Hill Orchards, WV
Robert Black, Fruit and Vegetable Grower, Catoctin Mt. Orchards, MD
Steve Black, Nursery Owner, Raemelton Farm, MD
Susan Futrell, Director of Marketing, Red Tomato, MA
Tom Green, President, IPM Institute of North America, WI
Ken Gauen, Lima Bean Processor, Pictsweet, DE/MD
Tom Haas, Tree Fruit Grower and Owner, Cherry Hill Orchards, PA
Brad Hollabaugh, Tree Fruit Grower, General Manager and Co-Owner, Hollabaugh Bros, Inc., PA
Doug Inkley, Senior Scientist, National Wildlife Federation, MD/DC
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Nathan Milburn, Fruit and Vegetable Grower, Milburn Orchards, MD
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Rob Shenot, Fruit and Vegetable Grower, Shenot Farms, PA
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Chad Vargas, Vineyard Manager, Adelsheim Vineyards, OR
John Wise, Associate Professor, Michigan State University, MI

New Members

Sam Doane, Production Horticulturist, J.S. Schmidt, OR
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Jennie Schmidt, Vineyard Manager & Jane of all trades, Schmidt Farms, MD
Michael Rozyne, Executive Director, Red Tomato, MA
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Outgoing Members

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