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7. Title Determining the Roles and Limiting Factors Facing Native Pollinators in Assuring Quality Apple Production in Pennsylvania; a Model for the Mid-Atlantic Tree Fruit Industry			
12. Investigator Name(s) (Last Name and Initials) Biddinger, D. J.; Rajotte, E. G.; Mortensen, D. A.; Frazier, J. L.; Frazier, M.; Mullin, C. A.; Schupp, J. R.; Harper, J. K.			
20. Termination Date 08/31/2013		40. Period Covered (mo/da/year): 09/01/2010 TO 08/31/2011	
Outputs: PSU Pest Control Field Day (9/15/10)- presentation to 70 industry R&D reps on pesticide impacts on bees. PSU/NRCS/Xerces Pollinator Planting Pollinator Planting No-Till Drill Demo/Training (9/28/10) to 20 fruit growers with NRCS CSP pollinator plantings on 150 acres. Cumberland-Shenandoah Fruit Workers Conference (11/18-19/10)- Biddinger-orchard survey of pollinators and pesticide impacts presentation to 80 university/ARS scientists and crop consultants. PA Dept of Agric IPM Advisory Panel (12/3/10)- Biddinger presentation on alternative fruit pollinators and the impacts of toxic pesticides for stink bug control. PSU/Xerce/PA NRCS Meeting on Pollinator Issues (3/9/11) - Discussion of pollinator conservation issues and research in specialty crops at NRCS headquarters in Harrisburg. Biddinger meeting (6/22/11)with PA and MD NRCS at Coctoctin Mtn Orchards to discuss pollinator/IPM programs in PA and adoption in MD. PA NRCS State Technical Meetings (6/15 & 9/19, 2011)- Biddinger/Rajotte representation of IPM/Pollinator interests in conservation programs in agriculture. Millersville, PA Native Plants in the Landscape Conference (6/2/11) - Xerces Society presentation to 350 people that included description of preliminary results from PA Apple studies looking at native bees, habitat and apple pollination. Xerces Pollinator Conservation Planning Short Course, Beltsville, MD (6/ 21-22/11) - Two day short courses. One for MD NRCS staff and partners(approx 60 participants) and one for Federal agency staff (approx 45 participants). Ongoing research conducted by Penn State in PA Apples as an example of the role of habitat and wild bees in crop pollination, and the need for reduced risk pesticide practices that minimize non-target impacts to pollinators and other beneficial insects. PSU/Xerces Field day with NRCS and PA Dept of Ag (6/23/11) - tour with the PA NRCS State Conservationist, the Eastern Region Conservationist, the Secretary of the PA Dept of AG and the PSU Dean of Research and Field Stations to look at pollinator habitat projects on the ground at PSU Biglerville Field station. Xerces Pollinator Conservation Short Course at the USDA-NRCS Cape May Plant Materials Center (9/30/11). This was a New Jersey/PA sponsored event which attracted about 70 growers and conservation professionals. Xerces - IPM Twilight Meeting sponsored by New Jersey NOFA (Northeast Organic Farming Organization)(9/14/11). Attended by about 15 growers and focused on pollinator conservation within the IPM framework. (e.g., importance of following labels, recognizing that bee-safe does not necessary mean all native bees-safe). Xerces - Rutgers Snyder Research Farm Twilight Meeting (9/13/2011). Attended by about 60 growers. Explained options for putting pollinator habitat in and around orchards using PSU trials as examples. Xerces-Land and Wildlife Expo in Nashville, TN (8/11-14/11). Discussion of Xerces/NRCS/PSU pollinator research/demonstration collaboration. Products: Native Pollinators Video by Biddinger & Rajotte-Penn State, and M. Vaughn-Xerces Society. http://extension.psu.edu/ipm/resources/native-pollinators .			
Outcomes/Impacts: Change in Knowledge - Development of an ELISA method for marking bees (<i>Osmia</i> and <i>Bombus</i>) with egg white proteins is a revolutionary way to determine the foraging ranges of solitary bees and hence a better understanding of the reliability of wild bees to pollinate apple crops and where to place managed nests of HB, <i>Osmia</i> , and <i>Bombus</i> . Bioassays with <i>Osmia</i> and HB determined that the HB is not a good surrogate to measure the toxicity of specific insecticides to solitary bees, that formulated insecticides dissolved in water as applied in the field are much safer to bees than the current EPA method of using technical products in acetone, and that combinations of certain fungicides with insecticides can make them up to 1,800 fold more toxic than alone and the combinations should not be used during bloom. In the current USDA-NRCS pollinator strip plantings, the bee species present have little overlap with the bee communities found in apples during bloom and need to be modified to include more early season blooming species as supplemental food prior to apple bloom. We have identified over 50 species of bees associated with apple bloom in PA and NY. Initial evaluations of apple fruit size and seed set do not correlated well as thought initially and another measure of pollination effectiveness is being researched. Other accepted conceptions of the dominance of king bloom and the fidelity of some solitary bee species to only fruit crops is now called into question and will be further evaluated next season, before changes in orchard management practices are recommended. Presentations of preliminary data from this project have already caused some fruit growers to question the wisdom of completely relying on either HB or wild bees and the benefits of supplementing pollination needs with both. our participation in USDA-NRCS state technical meetings and the			

presentation of of field data on pollinator plot establishment, bee species diversity, and grower difficulties in maintaining the plots, has changed the current recommendations from NRCS in PA to: 1) a higher rate of seed at planting, 2) only planting in the fall to give seed time to cold stratify during the winter, 3) better site preparation with multiple applications of glyphosate followed by multiple mowings the first season to provide better stand establishment, 4) and a shift in the seed mix to include some annuals and to tailor the seed mix to the crop depending on the effective pollinators of that crop.

Publications:

Biddinger, D., E. Rajotte, N. Joshi, and A. Ritz. 2011. Wild bees as alternative pollinators. *Fruit Times*. September 2011. <http://extension.psu.edu/fruit-times/news/2011/wild-bees-as-alternative-pollinators>

Biddinger, D. 2011. Biological control of pest mites in apple. *Fruit Times*. June 2011. <http://extension.psu.edu/fruit-times/news/2011/biological-control-of-pest-mites-in-apple-1>

Jones, J. P., S. A. Steffan, L. A. Hull, and D. J. Biddinger. 2010. Effects of the loss of organophosphate pesticides in the U.S.: opportunities and needs to improve IPM programs. *Outlooks on Pest Management*. 2010: 161-6.

Frazier, J.L. M.T. Frazier, C.A. Mullin, S. Ashcraft. 2011. Pesticides and their involvement in Colony Collapse Disorder. *Amer. Bee J.* August: 779-784.

Biddinger, D. J., C. Mullin, J. Frazier, M. Frazier, S. Ashcraft, & E. Rajotte. 2011. Assessing the pesticide susceptibility of native bees in Pennsylvania orchards. *Penn Fruit News*, vol. 91 (1): 49-55.

Hull, L. A., G. Krawczyk, D. J. Biddinger. 2011. Maintaining the integrity of IPM in Pennsylvania while battling the brown marmorated stink bug. *Pennsylvania Fruit News* 91(4): 9-10.

Biddinger, D. J. 2011. Investigating alternative pollinators. *Penn State Ag Science Magazine*, Winter/Spring 2011, p. 5. <http://agsci.psu.edu/magazine/articles/2011/winter-spring/investigating-alternative-pollinators?searchterm=Biddinger>

Biddinger, D. J. 2011. A Is for Apple, B Is for Bee, C Is for Complex.. *Good Fruit Grower Magazine*, March 2011. (in press). Biddinger, D. J., H. Ngugi, J. Frazier, M. Frazier, T. Leslie, and L. R. Donovall. 2010. Development of the mason bee, *Osmia cornifrons*, as an alternative pollinator to honey bees and as a targeted delivery system for biological control agents in the management of fire blight. *Penn Fruit News*, vol. 90 (2): 35-44.

Pennsylvania Tree Fruit Production Guide 2010-2011 edition. Edited by G. Krawczyk. Co-author of entomology section with L. Hull and G. Krawczyk, co-author of pollinator section with M. Frazier, author of biological control section. Penn State Cooperative Extension. AGRS-45. 333 p. <http://tffpg.cas.psu.edu/>

D. Biddinger and E. Rajotte. 2010. Strategies to Improve Native Pollinator Biodiversity and Ecosystem Services in Pennsylvania Orchards. Invited Speaker. International Conference on Pollinator Biology, Health, and Policy. Penn State University, July 24-28, 2010. Abstract: <http://ento.psu.edu/pollinators/public-outreach/2010-conference/abstract/view>

D. Biddinger and T. Leslie. Reduced Risk Pesticides: Challenges and Opportunities in Achieving Healthy Ecosystem Goods and Services. Invited Speaker. Are We Moving Toward Ecologically Base IPM in Apple Orchards? 6th International IPM Symposium in Portland, OR, March 2009. http://www.ipmcenters.org/ipmsymposium09/Final_Presentation_Abstracts.pdf

vanEngelsdorp D, N. Speybroeck, J. D. Evans, B. K. Nguyen, C. Mullin, M. Frazier, J. Frazier, D. Cox-Foster, Y. Chen, D. R. Tarpy, E. Haubruge, J. S. Pettis, and C. Saegerman. 2010. Weighing risk factors associated with bee Colony Collapse Disorder by Classification and Regression Tree Analysis. *J. Econ. Entomol.* 103(5):1517-1523.

Ciarlo, T., J. L. Frazier and C. Mullin. 2010. Inert ingredients in pesticides may impair foraging behavior in honey bees (*Apis mellifera ligustica*). In: *Entomology 2010, 58th Annual Meeting of the Entomological Society of America*, San Diego, CA. (D0230). Also presented In: North American Beekeeping Conference & Tradeshow, Galveston, TX. (Poster Abstract)

Cox-Foster, D. L., M. Frazier, J. Frazier and C. Mullin. 2011. Loss of honey bee colonies: Unraveling the interactions between pathogens and pesticides. In: North American Beekeeping Conference & Tradeshow, Galveston, TX. (Abstract)

Frazier, J. L., M. T. Frazier, C. A. Mullin and W. Zhu. 2011. Does the reproductive ground plan hypothesis offer a mechanistic basis for understanding honey bee health? In: American Bee Research Conference, Galveston, TX. *Amer. Bee J.* 151(5): 510. (Abstract)

Frazier, M. T., S. Ashcraft, W. Zhu, and J. Frazier. 2011. Assessing the reduction of field populations in honey bee colonies pollinating nine different crops. In: American Bee Research Conference, Galveston, TX. *Amer. Bee J.* 151(5): 510. (Abstract)

Mullin, C. A., M. Frazier, J. L. Frazier, S. Ashcraft, R. Simonds, D. vanEngelsdorp, and J. S. Pettis. 2010. High levels of miticides and systemic agrochemicals in North American beehives: Implications for honey bee health. In: *Assessing Exposure of Pollinators to Systemic Pesticides Symposium*, AGRO 338, 239th ACS National Meeting, San Francisco, CA. *Picogram* 78:150. (Abstract)

Mullin, C. A., J. L. Frazier, and M. Frazier. 2010. Pesticides and pollinators: Assessing residues and multiple interactions in honey bees. In: 1st International Conference on Pollinator Biology, Health and Policy, Center for Pollination Research, Penn State University, University Park, PA. p. 31. (Abstract)

Mullin, C. A., J. L. Frazier, M. T. Frazier and T. J. Ciarlo. 2011. A primer on inerts and honey bees. In: American Bee Research Conference, Galveston, TX. Amer. Bee J. 151(5): 513. (Abstract)

Zhu, W., D. Schmehl and J. Frazier. 2011. Are we underestimating pesticide impacts? Measuring and predicting honey bee larval survival after chronic pesticide exposure. In: American Bee Research Conference, Galveston, TX. Amer. Bee J. 151(5): 518. (Abstract)

Participants:

D. Biddinger - co-PD - experimental design, plot setup, evaluation and analysis of 720 trees in 6 apple orchards whose owners were not renting honey bees, but relied on solitary bees for pollination. Biodiversity and abundance assessments of all bees in these orchards and 7 USDA-NRCS pollinator strips using pan traps and net collections. Outreach and extension to growers, the public (school & 4H tours) through special field trips, field day presentations, fruit grower publications, and development of a video. Training of MS student and post-doc, summer student workers, H. Rice, Jin Li, and N. Ellis that took summer bees and fruit samples. E. Rajotte - co-PD - Same as above. Less on field work and more on outreach and extension, to the public and USDA-NRCS on pollinator strips. Lead on developing the bee video. D. Mortensen - PI - Evaluation of landscape and plant diversity surrounding the orchards being evaluated and in the NRCS pollinator strips. Supervision of a MS student, M. Kameron which worked most of the summer at the field station. J. Schupp - PI - Horticultural evaluation of apple orchards including bloom counts, multiple summer counts of fruit, and harvest evaluations looking at seed count, and fruit size as a measure of pollination effectiveness to quantify the economic gain or loss of using only wild bees. Supervision of technician, E. Winzler, that set GPS coordinates and maps of all trees in all sites. J. and M. Frazier, C. Mullin - analysis of pollen and honey for pesticide detections in HB and solitary bees, and in charge of tech, S. Ashcraft, who conducted pesticide bioassays on both HB and *Osmia*. J. Robertson - analysis of bee bioassay data to determine variable pesticide toxicity between HB and solitary bees and synergism of insecticides with fungicides. N. Joshi - Post-doc overseeing field trial data collection, analysis and publications. T. Leslie - Long Island State University - principal component analysis of bee biodiversity and abundance data and setting baselines for determining bee declines. M. Vaughn - Xerces Society - overseeing outreach and extension presentations, publications and the bee video. N. Halbrendt - technician developing and running ELISA tests for protein marking of bees to determine foraging ranges of *Osmia* and *Bombus*, rDNA virus and fireblight detection in field collected bees. J. Harper - economic analysis of fruit data and cost of HB vs *Osmia* managed colonies. New collaboration with M. Park Ph.D student with B. Danforth at Cornell Dept. of Entomology in developing a pictorial guide to apple pollinators of the Northeast through their funding from the NE IPM Center. New collaboration with J. Robertson, an expert on pesticide bioassay analysis who has written two books by CRC Press and the specialized computer programs POLO and POLO2, who is helping with the pesticide bioassay comparisons between bee species and analysis of synergism with fungicides mixtures.

Target Audiences:

Target audiences include fruit growers, peer scientists, government officials, policy makers, industry and the general public. Pollinator preservation in the face of honey bee declines requires the cooperation of all levels of society. Most audiences recognize the problem and are willing to act, but they are unsure of the proper course. As we gain knowledge of the role of wild bee species in fruit pollination, we will be able to inform these audiences about their responsibilities to improve wild pollinator effectiveness. The project's advisory panel will have members from all of these audience groups. As research results are brought to the panel, education, publicity and policy recommendations will be constructed and forward through proper channels. Since the plight of pollinators has become a concern of the general public, the project has concentrated efforts to keep the public informed. Press releases, web sites and other means of mass communication are constantly updated. An informational video was placed on Youtube (<http://www.youtube.com/watch?v=IYKVI8ayzsw>) for this purpose.

Project Modifications:

Nothing significant to report during this reporting period.

Approved (Signature)	Title	Date

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