

Report and Recommendations

NORTHEAST MULTISTATE ACTIVITIES COMMITTEE

July 7, 2025 (virtual)

Members: Puneet Srivastava (Maryland-Chair), Jason White (CT-New Haven), Beth Gugino (Pennsylvania), Chris Smart (NY-Geneva), Bill Miller (MA/NEED), Ali Dunigan (NEED) [Non-voting, ex officio: Rick Rhodes (NERA), David Leibovitz (NERA)]

Discussion Items

- Discussion of the process for making changes to fully approved multistate activities related to Executive Branch compliance (Preparing for / responding to NIFA deferrals)
 - Requests have been coming in to change language on multistate activities in NIMSS
 - NE1 (Rural Development Center) and NE2401 (Urban Agriculture) have both gone through edits to the objectives and project language
 - Other regions are making changes on an as-needed basis
 - Changes have been driven by USDA comments (NE1) and requests from project technical teams (e.g., NE1 and NE2401)
 - The NE2401 changes in title and objectives were made after receiving approval from the Administrative Adviser and project technical committee
 - NE1962 (Outdoor Recreation) may be interested in changing one of its objectives
 - **Kal Kalavacharla (Northeast USDA NIFA Liaison) is a great resource for questions – all are encouraged to reach out to Kal**
 - Rick asked Kal: If there are problematic objectives, do those objectives need to be changed? Or, is it OK to initiate a project in NIFA NRS without selecting one of the problematic objectives? (currently awaiting response)
 - **For questions about specific project deferrals or problematic language, contact the pertinent NIFA National Program Leader related to the topic (preferably by telephone).**
 - Historically, project deferrals have not been consistent across USDA NIFA National Program Leaders so individual conversations with NPLs can be productive.
 - **The Northeast, similar to other regions, will not proactively make wholesale changes to multistate projects and will examine language on an as-needed basis.**

Recommendation on Peer Reviewed Multistate Activities

- NE_TEMP2501: *Harnessing Chemical Ecology to Address Agricultural Pest and Pollinator Priorities*, 10/01/2025-09/30/2030 [AA: Blair Siegfried, Pennsylvania]

- Peer reviews are generally supportive (good to excellent, one fair) and all recommend continuation of the project. All reviewer comments were addressed by the technical team and revisions were made accordingly.
 - The MAC encourages the group to increase its participation beyond CA, MA, NJ, and NY.
 - **After electronic deliberation, the MAC unanimously recommends the approval of NE_TEMP2501 to agInnovation Northeast.**
- NECC_TEMP2501: *Sustainable Farm Energy Production and Use*, 10/01/2025-09/30/2030 [AA: Puneet Srivastava, Maryland]
 - Peer reviews are generally supportive (good to excellent), one reviewer called for some revisions to which the committee responded and revised the proposal accordingly.
 - The shared farm energy teaching curriculum for ag professionals is a strength of this coordinating committee.
 - The group is encouraged to convert this coordinating committee effort into a multistate research project either in the upcoming year, or in a future iteration.
 - **NEASDA (Regional State Departments of Ag) approved a regional working group on creating a bioeconomy corridor in the Northeast, and all directors are encouraged to engage with their respective state agencies to advance this initiative.**
 - **Ali Dunigan introduced a motion to recommend approval of NECC_TEMP2501 to agInnovation Northeast. The motion was seconded by Bill Miller and approved unanimously. The motion was approved unanimously.**

Administrative Adviser Nominations for Multistate Activities

- NE2220: Multi-state Coordinated Evaluation of Grape Cultivars and Clones (Margaret Smith) – **Anna Katharine Mansfield has been nominated**
- NE2231: Collaborative Potato Breeding and Variety Development Activities to Enhance Farm Sustainability in the Eastern US (Margaret Smith) – **Anton Bekkerman has been nominated**
- NE2201: Mycobacterial Diseases of Animals (Rick Rhodes)
- **The MAC unanimously recommends to agInnovation Northeast, the approval of the three aforementioned Administrative Adviser assignments.**

Multistate Activities Seeking Administrative Adviser Assignments

- NE2334: Genetic Bases for Resistance and Immunity to Avian Diseases (Robert Taylor)
- NRSP8: Genomic Capacity: Building Applied Genomic Capacity for Animal Industries (John Kirby)
- NECC2202: Formal Structure for the Minor Use Animal Drug Program (Margaret Smith)
- NECC29: Corn Improvement Conference (Margaret Smith)

NE_TEMP2501: Harnessing Chemical Ecology to Address Agricultural Pest and Pollinator Priorities

Status: Submitted As Final

Duration

10/01/2025 to 09/30/2030

Admin Advisors:

[\[Blair Siegfried\]](#)

NIFA Reps:

Non-Technical Summary

A major societal issue, in particular related to our food system, is that current agricultural practices rely heavily on pesticides, which have negative impacts on the environment, human health, and beneficial insects. This project aims to develop sustainable pest control strategies by studying the chemical interactions between crops, pests, and beneficial organisms. The goal is to reduce pesticide use and promote sustainable agriculture in the Northeastern USA. Our objectives are to develop chemical ecology tools for pest management, understand how chemical interactions vary across different landscapes, find ways to minimize pesticide impacts, improve crop resilience, explore the role of microorganisms in pest control, expand the use of analytical facilities, and conduct outreach to promote the adoption of sustainable practices. Our target audiences are farmers, agricultural professionals, researchers, and the general public. Farmers will benefit from new pest management strategies that reduce reliance on pesticides and improve crop yields. Researchers will gain access to new tools and knowledge in chemical ecology. The public will benefit from a more sustainable and healthy food system. Our activities will include field experiments, chemical analyses, and the development of new pest control products. These activities will lead to a better understanding of chemical interactions in agriculture and the development of sustainable pest management strategies. This multistate project will also provide training and outreach to promote the adoption of these practices.

Statement of Issues and Justification

The need, as indicated by stakeholders:

Agriculture is both culturally important and an economic driver in the Northeast, and both culture and economics are driving us towards a strong need for new practices in agroecosystems. The significant financial burden of bringing new pesticides to market, combined with the well-documented economic, environmental, and human costs associated with their use, underscores the need to develop alternative pest control strategies. Methods that leverage the natural chemical signaling and interactions between crops, pests, and natural enemies offer promising opportunities to enhance integrated pest management (IPM) through limiting the need for synthetic, broad-spectrum insecticides, while supporting pollinator health and efficiency in agricultural systems. This proposal addresses these challenges by advancing chemical ecology's role in agriculture. Furthermore, it emphasizes the critical role of microbes in plant-arthropod interactions. Additionally, the proposal includes development of chemical ecology analytical infrastructure and extension activities.

Food security is of growing importance for the large segment of the population living in large cities which rely on imported food and also for the rural population, so maintaining agricultural productivity is essential for the well-being of many in the region. For example, New York alone ranked 5th in the nation for vegetable production (NASS 2023). Organic agriculture is an economically important element in the region contributing to \$ 1 billion in organic sales and 7,100 jobs in Pennsylvania alone (ESI 2024). Acreage of food crops grown under glass or other protective structures in the United States increased 8% from 2017-2022 with New York ranked 4th in the nation in terms of acreage of vegetables and fresh herbs grown under controlled environment agriculture yielding over \$66 million in approximated sales in 2022. In addition, agriculture in the eastern United States is focused on many crops that require insect pollination. Pollination benefits over 70% of the major food crops across the globe (Klein et al., 2007), contributing more than \$170 billion and \$15 billion to the global and US economies annually, respectively (Gallai et al., 2009; Calderone, 2012). We estimate that pollination services to New York's crops are worth approximately \$439 million annually (Grout et al. 2020), highlighting the economic importance of both the crops and the beneficial insects that support them.

Agriculture in the Northeast is comprised on a mix of growing practices that range from heavy reliance on pesticides to integrated pest management and organic practices. To support this diverse base of food production, innovations are needed that reduce the risks of pesticides in conventional agriculture and enhance the productivity in organic systems. Legislation, including the New York "Birds and Bees Protection Act" that bans the use of certain neonicotinoid pesticides, drives us to develop new pest management strategies and products. The Northeast IPM Center states "IPM and organic systems share many of the same goals and challenges, and we support collaboration between these two communities to build a more sustainable agricultural system." The Center highlights the importance of "efforts to identify alternative pesticides and alternative or new IPM practices, such as biological pesticides or cultural methods, are critical to long-term effective pest management". They add "the decline of wild and managed pollinators is one of the most critical issues facing our food systems" and "we will continue to give this issue priority and encourage efforts to develop IPM practices protective of and with lower risk to wild and managed pollinators". Northeast regional priorities for fruit, vegetable and specialty crops are replete with calls for research and sustainable practices to reduce the impacts of insect pests and to protect valuable pollinators. This multi-state project seeks to harness innate properties of crops and agroecosystems to address pest and pollinator priorities across important cropping systems in the northeast.

The importance of the work, and what the consequences are if it is not done:

As the discipline of chemical ecology matures, knowledge gained in ecological, behavioral and evolutionary studies is being combined with chemistry and engineering and increasingly translated into practical and applied pest management. This blending of fundamental and applied research enhances the likelihood of sustainable pest management and a reduction in pesticides released into our environment. The consequence of not pursuing sustainable, non-pesticidal management of pests is a continued reliance on insecticides and other pesticides, with potential long- and short- term adverse effects on our environment for future generations.

Generally, researchers of diverse disciplines converge upon a particular crop, target pest and local region rather than developing management models that cut across a broad range of crops, pests and geographic regions. This multistate project has done the reverse, harnessing the intellectual breadth of chemical ecology practitioners and to focus their interests on agricultural pests and pollinators. The group as a whole is working in many of the important crops and agricultural systems in the northeast and US, including field crops, vegetables, and controlled environment agriculture. The multi-state team is remarkably broad, spanning entomologists, applied ecologists, chemists, engineers and economists at University and USDA research locations.

The technical feasibility of the research:

The field of chemical ecology originated 65 years ago with the identification of an insect sex pheromone. That work engendered the applied practice of pheromone mating disruption and pheromone trapping to inform IPM decisions. Since then, it has become clear that understanding how to manipulate agricultural systems to maximize the functions of beneficial species while minimizing the negative effects of pests requires understanding the community-wide biological activity of toxins, nutrients, and signaling compounds exchanged between plants and community members such as insect pests, natural enemies of pests, pollinators, beneficial microbes, and pathogens. In addition, the expertise of chemists and engineers is needed to determine the spatial and temporal activity of signaling compounds so they can be deployed in a meaningful manner. A concrete example of applications arising from this multistate is a team of researchers determining how to optimize pheromone traps for corn earworm monitoring. Applied entomologists, chemists and engineers from Cornell, University of Maryland, and Virginia Tech are working together to determine how the corn earworm pheromone disperses out of different types of traps and which traps effectively catch corn earworm moths in different environmental conditions. In another example, the Rivera Lab, working with chemist Duplais, identified a new Ambrosia beetle attacking apple. Ambrosia beetles are pests that feed on stressed apple trees, creating small holes and galleries for their larvae thereby transmitting fire blight. The group found that fire blight-infected trees draw beetles, likely due to the VOC 2,3-butanediol emitted from damaged trees. This finding suggests 2,3-butanediol as a potential lure for beetle control. This teamwork allows the complete follow through from biological discovery to understanding mechanism and creating a product. As an example, the public can learn about apple research emerging from the multistate project through many avenues including Rivera's Scaffolds podcast.

A key output of the previous multistate was developing a regionally accessible facility for chemical analysis of plant defenses and pesticide residues (Chemical Ecology Core Facility), which will also ensure the technical feasibility of future projects for the group. Currently, researchers in the multistate have access to GC-MS, LC-MS, and a dedicated technician for targeted analysis of metabolites and method development through the Chemical Ecology Core run by McArt (Cornell). To complement this facility, the Cornell AgriTech Mass Spectrometry Facility was recently created for untargeted analysis of plant, insect, and microbe metabolites multistate. We continue to work with breeders and molecular biologists to link needs on the farm with technological advances in biology. In combination with other resources such as the UC Davis Metabolomics center and the Boyce Thompson Cornell Core facility, we are confident of technical feasibility of this groups work.

To keep the research of the group oriented towards the needs of growers, we will develop a group of external stakeholders that gives feedback on the projects. At each of the annual meetings, we will invite two external stakeholders to interact with the projects that fall within two of the project Objectives. These people will attend a 3 -hour block of the meeting that is organized around that multistate Objective. Organizing the annual meetings around the Objectives will also likely build collaborations on gaps in those areas. The multistate research PIs will be encouraged to present their findings and directions for future work leaving time for feedback. These external people will come from relevant commodity groups and geography. Over 2-3 years, we expect to develop this into an advisory board that will help guide projects.

The advantages for doing the work as a multistate effort:

The field of chemical ecology is well represented in various land grant universities within the Northeast and across the US and while there are pest problems that are unique to the Northeast, there is substantial overlap in pest guilds within the areas comprising the region. The project has attracted many leading chemical ecologists from the Northeast and across the country. There are 51 PIs involved, 32 of whom have attended the yearly meetings. In the first meetings, researchers presented the highlights of their research to get to know each other and find points of overlap. The meetings continue to be a place where PIs get helpful input on their projects and new research collaborations and grants form. At the meeting in 2024 (which also included Pennsylvania Agriculture Experiment Station Director [Blair Siegfried](#) and Erica Kistner-Thomas from the USDA), we specifically discussed ways to expand the crops covered by the multistate, include researchers from the USDA, and provide chemical ecology information to regulatory agencies.

The multistate project has been instrumental in allowing researchers to bring in additional resources, with the group bringing in approximately \$7 million in grants from diverse sources ranging from the USDA- NIFA, USDA- SCRI, USDA-CPPM, the Almond Board of California, Cypress Creek Renewables, Inc, and the IR-4 Minor Crop Pesticide Program. The group recently submitted a large NSF Science and Technology Center (STC) proposal. The funding, collaborations and shared resources has resulted in approximately 117 peer-reviewed publications by group members.

Analytical instrumentation is increasingly a limitation for academic researchers. The equipment is expensive to purchase and maintain and requires a skilled operator, which results in both high initial costs and per sample fees. The regional chemical ecology facility has overcome these hurdles in a cost-effective manner. By focusing on developing techniques that are useful to researchers across the region, groups at many institutions can access the analytical power of a cutting-edge facility with a trained chemist to aid them with the chemical analysis component of their project. This allows many more researchers to incorporate high-level chemical analysis and elucidation of interactions and mechanisms previously out of reach.

What the likely impacts will be from successfully completing the work:

Impacts will continue to be seen in several areas. For example, we are increasing our understanding of how to manipulate mixtures of crop cultivars and other forms of plant diversity to affect the behavior of pests, beneficial insects and natural enemies to increase crop yield. Active research is aimed at discovering new plant natural products that can reduce pests and pathogens, while increasing populations of beneficial insects. For example, nectar metabolites with anti-pathogenic properties are being evaluated as new crop protection tools, wildflower strips are being designed to increase pollinator health, and soil management practices are being tested for their impact on cultivating resistance inducing microbes in the soil. The effect of insecticides, fungicides and herbicides in the agroecosystem will continue to be tested to discover which chemicals are both effective and safe for non-target organisms. And, crop varieties will be promoted that are the most valuable given the current pest problems in the region.

Areas advantageous for future multistate efforts have been identified, in addition to continuing many existing projects. These include collaborative work on: 1) Emerging pests of economically important crops, 2) the unintended effects of pesticides on pollinator populations 2) development of new approaches that combine complementary chemical methods of control, 3) improving trap designs, and 4) protecting plants through manipulating cover crops. By examining crop protection across multiple scales—from individual plots to entire landscapes and regions—this initiative aims to provide growers with context-specific insights into risks and the availability of conventional and alternative management strategies, as well as creating an awareness of new developments in semiochemical-based tools.

Related, Current and Previous Work

Critical Review:

Substantial achievements were made over the past 5 years; in this section we outline the work that was accomplished as well as work that is incomplete or in need of further investigation.

Previous Objective 1: Develop chemical ecology tools and information to support sustainable agriculture by reducing damage by pests in crops such as potatoes, brassicas, dry beans, cucurbits, apples, blueberries, and sweet corn, while maintaining pollinator health in agricultural systems.

The work conducted on this Objective included the evaluation of 1) plant defense elicitors for pest control, and 2) isolation and identification of attractants and repellents. We have made substantial progress in a wide range of cropping systems important in the northeast, including new target pests that are invasive species and have a high potential for causing significant damage (e.g. spotted lanternfly). As outlined below, we will continue the work we started and expand to include controlled environment agriculture and new emerging pests.

To aid the application of the plants' natural constitutive defenses in pest control, the Agrawal lab (Cornell) with collaborators Weber and Wallingford (USDA and UNH) used *Curcubita pepo* varieties to study the direct defense traits and their effectiveness against multiple insect pests (Brzozowski et al 2019, Brzozowski et al 2020). The Rodriguez-Saona Lab (Rutgers) used a similar approach to test wild blueberries and cranberries for their natural resistance against various insect pests including the new Spotted-wing Drosophila (Gale et al 2024, Salazar-Mendoza et al 2024). These studies, and previous research on the application of plant resistance traits for pest control, have repeatedly found that the plants can turn on defense mechanisms when they are under attack by herbivores or pathogens, to the detriment of their attackers. Such "induced resistance" is mediated by chemical communication processes that integrate plants' perception of environmental cues with endogenous phytohormonal changes as a result of tissue damage. Some of those external and endogenous elicitors of plant resistance responses are promising as activators of plant resistance. The most effective and readily usable elicitors are phytohormones that are usually associated with the pest-mediated induction of plant resistance. For example, Stout (Louisiana State) and graduate student Kraus examined the ability to protect plants from rice water weevil using wound-responsive phytohormone, methyl jasmonate, as an elicitor of induced resistance and found protective effects, but it also reduced plant growth (Kraus and Stout 2019). More recently, the Stout lab found that systemic induction of the furanoterpenoid ipomeamarone, in sweet potato storage roots, deterred oviposition by sweet potato weevils (in prep.). Rodriguez-Saona tested the efficacy of commercially available plant activators of the salicylate and jasmonate pathways in protecting cranberries against insect pests directly or by reducing pathogenic phytoplasma infection. Findings show that phytoplasma vectored by leafhoppers made cranberry plants more susceptible to non-vector insects (Pradit et al. 2019).

One general insight gathered from the above-mentioned studies and those in the wider chemical ecology literature is that, to a large extent, the repellent function of plants' natural defenses derives from chemical cues that are available to attackers or pathogen vectors before they even interact with the plant. This concept of chemical information orchestrating plant interaction networks opens up new and practical solutions for pest control via a targeted manipulation of information transfer. For example, several of the chemical changes induced in response to attacking herbivores are volatile compounds that are emitted into the headspace of the damaged plant. These chemical cues can function as information for subsequently arriving organisms to inform their decision to interact with the plant (attack) or turn away. Thus, the identification and functional analysis of repellent or attractive plant compounds in interaction with pheromone signaling in pest arthropods is another promising path for applied chemical ecology to explore and this group has already made big steps towards successful applications.

The Rodriguez-Saona (Rutgers) and Loeb (Cornell) labs worked on the chemical ecology of the new invasive pest spotted wing *Drosophila* evaluating an attract and kill approach using HOOK SWD Lure-and-kill (ISCA Technologies, Inc), finding that this technique is most effective at lower spotted wing densities. Work is continuing to focus on whether odors are involved in fly attraction to ooze, thereby facilitating acquisition and transmission. As spotted wing *Drosophila* is a major pest across the region, the multi-state project has been extremely beneficial in connecting researchers from several land grant institutions to address highly overlapping issues. The Weber Lab (USDA) conducts studies on male-produced aggregation pheromones of Chrysomelidae and Coreidae that often interact with induced plant volatiles to affect insect host choice. The group studies the application of pheromones to pest management in vegetables: focal species include Colorado potato beetle, Striped cucumber beetle, and Leaf-footed bugs (*Leptoglossus spp.*). Similarly, the Thaler Lab (Cornell) in collaboration with Weber (USDA) made advances in understanding how predator pheromone can be used to control Colorado potato beetle showing that the pheromone treatment increases potato yield through several mechanisms. A collaborative study demonstrated significant consequences of predator exposure for beetle fitness (Mutz et al 2024, Ugine et al 2024). Notably, the Poveda and Thaler labs have been studying chemical attractants for *Delia platura* maggots (seed corn maggots) to be able to better monitor and control them in the field in an effort to replace neonicotinoid pesticide seed treatments. Preliminary data indicate that the larvae are making choices and that these choices are based on olfactory cues. Current experiments are characterizing the volatiles that are mediating these choices. Finally, the same plant cues that can affect herbivore host choice, can also function as information for predators and parasitoids of herbivores (e.g. information-mediated indirect defenses). While these indirect defenses have been a target of research in this group most promising data come from a special case study. To better understand how predatory lady beetles navigate their environment, find food, mates, and oviposition sites, Dr. Ugine (Losey Lab Cornell) has identified more than 500 chemoreceptors from five species of lady beetle. These include gustatory, olfactory, ionotropic, chemosensory proteins, odor-binding proteins, and sensory-neuron membrane proteins (in prep).

Objective 2: Define variability of chemically mediated interactions between pests, crops, and beneficial organisms in terms of plant chemistry, species interactions and landscape factors in the Northeast.

The use of functional cover or intercrop applications to manipulate the information transfer between plants and their pests for more sustainable pest control has become a significant new focus. Significant progress along these lines of research have been made by the Ali Lab (Pennsylvania State). This group is running long-term cover cropping experiments that test for the functionality of different commonly used cover crop species in mediating soil health, plant protection from pathogens and herbivores, and increased yield (Ray et al 2022, Davidson-Lowe et al 2021). Within that framework, Ali with collaborators from this consortium has proposed a large **NSF Science and Technology Center (STC)** project that is currently in review with NSF. The Kessler Lab has focused on the study of functional intercropping and the associational effects that mediate enhanced maize crop performance. Recent results demonstrate that the presence of certain legume intercrops (e.g. *Desmodium* spp, beans) specifically affects the secondary metabolism of maize plants grown in their vicinity and so increases maize plant resistance to pathogens and herbivores. Interestingly these neighborhood-induced associational resistance effects are found to be mediated by both direct chemical signaling below and above ground but also by indirect microbial community-mediated plants-soil feedback (Jordan and Kessler 2024, Bass et al 2024, Mutyambai et al 2019). These findings suggest cover- and intercropping for a broader application in pest control. The Multistate project will use research into the mechanism (e.g. associational resistance, plant-soil feedback, plant-to-plant communication) underlying these companion cropping techniques as a unifying theme to address objective 1 and test applicability in agriculture

This group has been studying the importance of landscape composition on the chemically mediated interactions between pests, beneficial organisms and crops in a series of different projects. For example, the group of Cesar Rodriguez- Saona spearheaded an experiment to evaluate the attraction of natural enemies to PredaLure (baited with winter green oil - MeSA) in collaboration with 7 different labs from this multistate group across different states in the Northeast (New Jersey, New York, Pennsylvania, Virginia). The goal is to understand if PredaLure can be used as a local management method to increase the presence of natural enemies in the field and determine how context dependent this local management is. Data were collected by the whole group in 2022 and 2023 and the data analysis is still ongoing.

The importance of landscape composition on pollinators of crops and specifically apple orchards was investigated in the McArt lab (Urban-Mead et al. 2023). In this research they found that forested areas, especially forest canopy trees, provide large amounts of early spring resources that facilitate build-up and spillover of wild pollinator populations into apple orchards during bloom. Overall, these data indicate that ensuring there is adequate forest habitat adjacent to orchards can improve the long-term sustainability of pollinator populations that provide essential crop pollination services..

Objective 3: Characterize the non-target effects of pesticides on pollinators, herbivores and natural enemies of pests.

Minimizing the impacts of pesticides on non-target organisms occurs in four major ways. First, evidence of risk from pesticides in certain application contexts can result in knowledge that leads to changes in use of those pesticides to reduce risk. Second, new lower-risk pesticides can be developed that replace existing high-risk pesticides. Third, risk mitigation measures can be implemented, such as feed additives for managed non-target insects that reduce the toxicity of pesticides when ingested. Fourth, non-pesticide strategies to control pests can be implemented, such as attract-and-kill and push-pull systems. Key achievements of our group's multistate efforts on the first point include elucidating when pesticide exposure occurs in multiple crops and application contexts (Graham et al. 2021, 2022, 2024, Rondeau et al. 2022, Bischoff et al. 2023, Siviter et al. 2023, Mueller et al. 2024, Strang et al. 2024, Obregon et al. 2024), determining when pesticide risk to non-target organisms is high (Urbanowicz et al. 2019, Graham et al. 2022, Mueller et al. 2024, Obregon et al. 2024), re-evaluating our current understanding of pesticide toxicity to non-target organisms (Iverson et al. 2019, De Souza et al. 2024, Sanchez et al. 2025), and creating extension materials that guide farmers in best management practices to reduce pesticide risk to non-target organisms (Van Dyke et al. 2019, 2023a,b,c) or shape new legislation that restricts certain uses of pesticides because risks to non-target organisms outweigh economic benefits to farmers (Grout et al. 2020). Key achievements on the second point include evaluating new bioinsecticides that kill target pests but pose less risk than conventional chemical insecticides for non-target organisms (Fanning et al. 2018, Han et al. 2024, Rodriguez-Saona et al. 2024). Key achievements on the third point include the development of enzyme-loaded microparticles and hydrogels that, when included in supplemental feeds, reduce the toxicity of organophosphate and neonicotinoid insecticides to managed bees (Chen et al. 2021, Caserto et al. 2024). Key achievements on the fourth point include developing and evaluating a attract-and-kill and push-pull strategies for pest management in blueberries (Urbaneja-Bernat et al. 2022, Gale et al. 2024).

Objective 4: Assess the impact of domestication on plant and animal chemical ecology in agricultural fields and identify unifying patterns of human and natural selection on chemical interactions of crop plants

Over the past decade, this multi-state project has made substantial contributions to our understanding of domestication and impacts on crop resistance to pests. In particular, Rodriguez-Saona and colleagues (Rutgers) (Rodriguez-Saona et al. 2019, Urbaneja-Bernat et al. 2021) and Whitehead and Poveda (2019, Whitehead et al. 2021) (Virginia Tech and Cornell, respectively), continue work focused on blueberries and apples, respectively, and on impacts of domestication on phytochemistry. Other groups within the project are focused on vegetable crops. Chen's group (Univ. Vermont) used a novel approach to study domestication impacts on pest damage in the center of origin of crops (Ruiz-Arocho et al. 2024), working with squash, maize, tomatoes, and beans. Agrawal and cucurbit breeder Mazourek (Cornell) collaborated with others (Wallingford at New Hampshire/USDA and Weber at the USDA) to utilize existing breeding pools developed in different regions to assess mechanisms of resistance to the major insect pest (*Acalyma* squash beetles), working towards breeding these traits into more susceptible varieties (Brzozowski et al 2019, 2020a, 2020b). Of particular significance, across three states, the group determined that domestication history opposingly impacts the existing major pest (striped cucumber beetle) and the emerging new pest (squash bugs) (Brzozowski et al. 2021). Continued studies will seek to identify varieties that have the resistance to insects while maintaining yield, using domestication history as a guide. Synergy is being achieved through the multistate projects and meetings.

Objective 5 Explore and exploit microorganism mediation of multi-trophic species interactions, including bacteria, fungi and nematodes.

Work on this objective has focused on two areas: (1) exploiting defense-enhancing microbes that occur naturally in agroecosystems and (2) exploring how plant chemical diversity mediates interactions with microbial pathogens in complex environments. In the first area, the Ali (Penn State) and Casteel (Cornell) labs investigated how specific agronomic practices can be used to conserve and cultivate crop resistance-enhancing soil microbes. The Casteel lab previously demonstrated organic vegetable farms contain soil microbes that increase plant foliar resistance to foliar pests through changes in secondary metabolism (Blundell et al 2020). However, the specific organic management practices that cultivate these microbiomes are still unknown. Through a survey of 85 organic vegetable farmers, the Casteel lab determined cover crops, no-tillage, and composting are the most common soil practices used by organic vegetable farmers in NY. Using multi-year and multi-site field trials with dry beans, maize, or soybean cash crops in NY and PA, the Casteel and Ali labs demonstrated that specific cover crops reduce cash crop herbivory in the field through changes in induced defense. However, their results also suggested that different cover crops regulate unique plant defense responses mediated through the soil microbiome. Consequently, different cover crops can fundamentally affect plant metabolism and resistance to particular pests. These results suggest specific cover crops could be used in pest control more broadly to tailor crop resistance to reoccurring pest pressures. In another project related to this area, the Sandler Lab (U Mass Amherst) identified microbe-based products that improved cranberry fruit rot management when integrated with standard fungicide regimes. They also investigated the fruit and soil microbiome of wild and managed cranberry bogs (conventional and organic), which will be a focus of future work.

The Vannette (UC Davis) and Adler (U Mass Amherst) labs have been exploring the function of plant chemical diversity in mediating plant interactions with microbes and multi-trophic interactions. To identify potential antimicrobial compounds Vannette's lab investigated how nectar chemistry influences microbial communities using untargeted metabolomics of 30+ plant species. Key factors affecting microbial growth included nectar nitrogen and peroxides content, and variation in these compounds impact nectar pathogens and pollinator preference. The Adler lab (U Mass Amherst) has been assessing how pollen from certain plant species can reduce pollinator pathogen infections. They show that consuming sunflower pollen strongly reduces *Crithidia bombi* infection in bumble bees (*Bombus impatiens*) regardless of pollen age or origin. They are currently exploring how variation in pollen chemistry and pollen pesticide contamination mediated bumble bee infection and how this is impacted by drought. This suggests that planting sunflowers in agroecosystems and native habitats can be used to improve the health of economically and ecologically important pollinators.

Objective 6 Establish a chemical ecology analytical facility for the Northeast to allow researchers ready access to equipment and technical expertise.

The Chemical Ecology Analytical Facilities at Cornell University have played a pivotal role in advancing research and extension in the Northeast region by providing access to state-of-the-art instrumentation and technical expertise. Key achievements include enabling researchers to conduct sophisticated analyses of pesticide residues and plant secondary metabolites, which have led to significant discoveries in the chemical ecology of pollinators, their exposure to pesticides in agricultural settings (Graham et al. 2021, 2022, 2024, Rondeau et al. 2022, Bischoff et al. 2023, Siviter et al. 2023, Mueller et al. 2024, Strang et al. 2024), and adaptation to plant stress (Sehgal et al. 2025). These facilities have also contributed to critical advancements in chemical ecology methods, including reducing bias in the collection of volatile organic compounds (VOCs) (Seybert and Duplais, 2025a). Collaborative projects supported by the facility and its expertise within have resulted in high-impact publications that address critical agricultural and environmental challenges (Obregon et al. 2024). Furthermore, the facility has trained technicians, undergraduates, graduates, and postdocs in analytical methods, ensuring chemical ecology expertise in the region. These facilities have become a cornerstone for fostering innovation in chemical ecology and supporting diverse research communities in the Northeast. Pesticide analyses have also been opened to the public in an extension capacity, with ~20 beekeepers, farmers, and private citizens per year sending samples and receiving results and data interpretation.

Objective 7 Extension to facilitate adoption and awareness of science-based chemical ecology tools to support sustainable production.

The multistate groups have produced a diverse array of extension and outreach materials encouraging and facilitating the adoption of chemical ecology tools into agricultural systems. One major and unique accomplishment of the chemical ecology multistate group is the submission of a letter to the EPA explaining the array of regulatory difficulties to register semiochemical based products. Within the broader chemical ecology realm, businesses seeking to commercialize products often work with multistate faculty to assist in the research and development of their products as well as demonstrating the products to local potential markets. The demonstration of semiochemical-based products coming to market provides a unique opportunity to share the biological and ecological research which initiated the creation of the product but also to work directly with companies which bring products to market to better understand how the group can assist in advocating for the streamlining of regulatory processes based on sound scientific justification.

Much of the extension and outreach effort related to the chemical ecology multistate project is building on existing communication structures. Many members of the multistate group have extension appointments which are used to build direct relationships with regional agricultural production systems. Those with direct relationships to commodity groups relay information about chemical ecology tools using a standard suite of extension tools such as fact sheets, website and guideline updates, and talks at traditional extension meetings. However, in this new proposal, we will add to this effort with social media usage to promote ideas and concepts resulting from the multistate work. Additionally, faculty with teaching responsibilities have and will continue to implement current research from this project into their courses, providing undergraduate and graduate students with insights into cutting-edge developments in chemical ecology and its applications to agricultural challenges.

Background

Manipulating chemical information transfer offers a promising approach for sustainable pest control

A deeper understanding of plant chemistry as information that orchestrates and fine-tunes a plant's interaction network, and developing chemical manipulators of this network has been suggested as a promising pest control mechanism. For example, the metabolic changes associated with herbivore attack include the increased and *de novo* emissions of volatile organic compounds (VOCs). Such herbivory-induced VOCs can function as information for host/prey-searching parasitoids/predators to facilitate the host search behavior (indirect defenses) and so add to the plant's endogenous defense arsenal. A new commercial product (PredaLure(R)) that uses methylsalicylate as a natural volatile attractant of predators was recently tested by this multistate group. Those same induced VOC emissions can signal bad food quality to herbivores and so have a repellent function that can be utilized in pest control as well. Finally, neighboring plants can perceive herbivore-or pathogen-induced VOCs and ready their endogenous direct defenses before an actual attack happens.

Crop resilience functions can be expanded through chemical ecology informed plant breeding

The crop varieties that form the base of the modern food system appear to be particularly susceptible to abiotic and biotic stress (Yahiaoui et al. 2014, Midega et al. 2016). Indeed, there is growing evidence that domesticated crop plants can be more susceptible to generalist herbivores (reviewed by Chen et al. 2015). Given that environmental change is predicted to impose greater overall abiotic stress and pest pressure (Deutsch et al. 2018, Aguirre-Liguori et al. 2019), there is a continued need to understand how crop varieties may differ in chemically-mediated interactions with pests. Of particular importance is understanding cross-resistance (or trade-offs) in the face of emerging pests (Brzozowski et al. 2021). Historical dogma in plant breeding as well as entomology is that we look to the genetic diversity of wild relatives of crops for traits to introgress into elite germplasm to address pressing biotic and abiotic challenges (Dempewolf et al. 2017; Tanksley and McCouch 1997). With this approach, more than 2000 biotic stress resistance traits have been identified in crop wild relatives; however, the vast majority of traits identified are for disease resistance, and less than one quarter of these target insect pests (Dempewolf et al. 2017). Thus, strategies for breeding for resistance to insect pests must also be inclusive of secondary centers of diversity, and contemporary breeding pools. The context in which these breeding pools were developed may also better reflect the context of agricultural plant-herbivore interactions than wild systems, where major secondary metabolites (such as cucurbitacins in the Cucurbitaceae and alkaloids in the Solanaceae) may have different effects. In the diverse pools of cultivated germplasm with distinct breeding histories, plant breeders may discover alternative, perhaps quantitative resistance traits. Although of lower value than discrete and complete resistance traits often sought after in disease resistance, such traits are uncommon in insect resistance. Screening material for the most promising, but less obvious traits will benefit by being informed by chemical ecology and incorporated into breeding programs.

Crop diversification can be used to increase sustainable pest control

Companion cropping uses diversification and ecological intensification as core concepts to sustainably control pests while maximizing crop production. One of the most successful examples is the Push-Pull intercropping technology that has been developed to control major insect pests in corn and sorghum in East Africa. This technology uses plant species repellant to the major pests (push) as intercrops between rows of crop plants and plants particularly attractive to the major pests (pull) as trap crops around the field. The push-pull approach is now being investigated in several systems in the northeast by members of the multistate group. Moreover, functional intercropping also makes crop plants directly more resistant to herbivores and pathogens, while soil quality and drought resistance continuously improve with this technology. This multistate group has already begun to develop similar intercropping as well as cover-cropping applications for corn in the northeast. A focus of research going forward is to understand the mechanism of associational resistance associated with functional intercrops (e.g. associational resistance, plant-soil feedback, plant-to-plant communication) in order to optimize cultivation procedures and be able to apply this technology broadly in other crops and different regions.

Landscape variability increases natural enemy habitat and natural pest control

Local management practices in agriculture are closely influenced by the composition of the surrounding landscape (proportion of land use in radii larger than 750 m), which in turn has significant effects on crop, pest, and natural enemy interactions (Tscharntke et al. 2012). The diversity and configuration of landscape elements, such as forest patches, hedgerows, or non-cropped habitats, can alter microclimatic conditions, provide habitat for beneficial organisms, and affect the movement and population dynamics of pests and natural enemies (Bianchi et al., 2006; Tscharntke et al., 2016). For example, landscapes with more varied habitats tend to support higher biodiversity of natural enemies, which can help control pest populations, while monoculture-dominated landscapes may lead to higher pest pressure due to fewer predators and competitors, decreased thermal buffering and shifting chemical composition from plant volatiles (Landis et al., 2000). Therefore, we expect that local management practices that are based on chemically mediated interaction between crops, non-crop habitat, pest and beneficial organisms, as well as the impact of pesticides on these organisms will depend on the composition of the landscape surrounding the site where these local management strategies are deployed.

Pollinator health can be improved through understanding chemicals mediating risks and benefits

Insect pollination provides vital ecosystem services that sustain agricultural crop yields. Many agricultural crops rely completely on pollinators for successful yields and honeybees are the only managed insect used worldwide for pollination. Successful pollination can be at risk from factors including population declines and diseases, and climate change is disrupting the synchrony of bees and their hosts. Fortunately, there are often native bees to carry out this valuable service. Bartomeus et al. (2013) found that a diverse assemblage of bee species allowed extensive synchrony between bee activity and apple peak bloom due to complementarity among the bee species' activity periods and system stability imparted by differential responses among the species to a warming climate. Despite the potential for successful pollination by species other than honeybees, pollination can be limiting and therefore there are several areas where the field of chemical ecology can contribute to pollinator health and abundance.

There is considerable interest regarding the negative impact that pesticides are having on beneficial non-target organisms. Our group's research shows that pesticide use is linked to wide-scale declines of bumble bees in North America (McArt et al. 2017), which mirrors research from other groups investigating links between pesticides and declines in beneficial non-target organisms (e.g., Guzman et al. 2024). Because of these links, it is important to develop ways to minimizing the impacts of pesticides on non-target organisms. Our group has focused our efforts on improving knowledge that leads to changes in use of high-risk pesticides, evaluating lower-risk pesticides, developing risk mitigation measures, and developing non-pesticide strategies to control pests. Through these efforts, we are working to improve knowledge and provide tools that increase the sustainability of agricultural systems and the services provided by beneficial non-target organisms.

Plant-microbe interactions can be leveraged for improved pest control method and products

Over the last three billion years, microorganisms have interacted and coevolved with each other and, more recently, with plants and insects. This has allowed microorganisms, plants, and insects to innovate metabolically and form various associations with each other and higher trophic levels. For example, some insects and plants depend on mutualistic microorganisms for nutrient provisioning (Hansen et al. 2020), detoxification (Mason et al 2019), and adaptation under different stresses (Holt et al. 2024), while simultaneously deploying defensive metabolites to protect themselves from microbial parasites and pathogens. Pathogenic microbes can cause drastic changes in plant chemistry, with cascading impacts on plant-insect interactions in the community (Bera et al 2020; Bak et al. 2019; Chisholm et al 2019). Disruption of some of these interactions can lead to dramatic fitness consequences for the insect or plant, while in other cases, the relationships are more contextual. Given the sheer number of metabolites produced by plants, insects, and microbes and the prevalence and ubiquity of interactions in the environment, there are likely important ecological functions that additional research can provide insights into. Insights on the ecology of these relationships and the underlying chemistry holds promise for increasing agro-ecosystem sustainability, developing new disease and pest control strategies, and increasing crop yields.

Shared analytical chemistry facilities and training increase knowledge transfer

Chemical ecology is an interdisciplinary field that requires access to state-of-the-art tools in analytical chemistry and expertise to study the complex chemical interactions between organisms in their environment. The Northeast has a high concentration of agricultural research programs that benefit from such capabilities. Chemical ecologists in the region have faced challenges in accessing high performance analytical equipment such as gas chromatography-mass spectrometry (GC-MS) and liquid chromatography-mass spectrometry (LC-MS) due to cost and availability constraints. The establishment of the Chemical Ecology Analytical Core Facility (Ithaca campus) in 2018, under the direction of Drs. Wayne Anderson and Scott McArt, addressed these limitations by providing a centralized hub for cutting-edge research, collaboration and training. To complement this, the Cornell AgriTech Mass Spectrometry Facility (Geneva campus) was created in 2023 under the direction of Lucas Seybert and Dr. Christophe Duplais. These two Chemical Ecology Analytical Facilities allow external users through a pay-for-service arrangement for multi-state researchers such that a consistent and rigorous protocol can be followed for analyses of phytochemistry relevant to crops breeding (Sehgal et al. 2025), insect chemistry for plant toxin detoxification (Ziemke et al. 2024), pesticide residue analysis relevant to non-target effects (Graham et al. 2021, 2022, 2024, Rondeau et al. 2022, Bischoff et al. 2023, Siviter et al. 2023, Mueller et al. 2024, Strang et al. 2024), and analysis of volatile organic compounds relevant to attraction of pests, pollinators, and natural enemies, as well as early detection of plant diseases for diagnostic. Combined the facilities are equipped with a LC-MS/MS triple quadrupole and LC-qTOF High Resolution MS, a GC-MS/MS triple quadrupole, and a GC-MS simple quadrupole coupled with a thermal desorption unit for VOC analysis using thin-film SPME. These instruments enable high sensitivity for targeted analysis of pesticides (more than 260), plant hormones (JA, SA, GA, auxins), and plant chemical defenses (terpenoids, alkaloids, polyphenols), while also providing high resolution for untargeted analysis for the discovery of chemical markers.

Objectives

1. Develop chemical ecology tools and knowledge for pest management to aid in the development of sustainable agricultural practices in row, field, and forage crops, orchards, and urban landscapes, while maintaining ecosystem functions (e.g. pollinator, predator and soil health, productivity).
2. Identify the importance of variability and diversity at local and landscape scales and across States on chemically mediated interactions between pests, crops, and beneficial organisms.
3. 3. Work to find ways to minimize the impact of pesticides, manage pesticide resistance, and discover new pesticides that reduce the impact on pollinators, herbivores, microbes and natural enemies of pests.
4. Exploit knowledge of domestication and breeding history to deploy better strategies to improve crop resilience to novel stressors such as environmental change and emerging pests.
5. Explore and exploit microorganism mediation of multi-trophic species interactions, including bacteria, fungi and nematodes.
6. Broaden utilization a chemical ecology analytical facility for the Northeast to allow researchers ready access to equipment and technical expertise and increase training of High Quality Personnel.
7. Conduct Extension and Outreach to facilitate adoption and awareness of science-based chemical ecology to support sustainable production and promote human health and welfare.

Methods

Nearly all projects will involve a field and laboratory component, with specific, hypothesis-appropriate experimental designs, and shared and coordinated methodologies essential for cooperative data sharing. Research will focus on tomatoes, potatoes, brassicas, dry beans, cucurbits, apples, blueberries, field and sweet corn, and ornamentals in field and controlled environment agriculture. Many projects begin with discovery- based science in the lab and field and promising techniques will be further studied in collaboration with growers in the field.

Objective 1: When signaling molecules are large or otherwise have low volatility, such as polyphenols, various phytohormones, alkaloids, cucurbitacins, sterols, and cardiac glycosides, wet extraction with polar and non-polar solvents, followed by liquid chromatography-mass spectroscopy (LC-MS) will be employed to separate, identify and quantify potential signaling compounds. For arthropod responses to such non-volatile compounds, we will use a combination of electrophysiological tip-recording, base recordings, or single sensillum recordings to assess the neuronal responses of candidate tastants to determine their biological activity. To assess plant responses to non-volatile elicitors, compounds will be applied in aqueous solutions directly onto damaged or undamaged tissues, and transcriptional (e.g. PCR), metabolic (e.g. HPLC, GC-MS), and resistance responses (bioassays) will be measured. When signaling is thought to be occurring via plant, insect, or other volatile emissions, we will employ standard, published methods to trap and identify candidate compounds. Additionally, for a functional assessment, the GC-separated compounds will be passed over the antennae of insects to measure electrophysiological responses to each individual compound using a technique called electroantennographic detection (EAD). This will allow us to make inferences about which classes of compounds cause neurological responses in the insect receiving the signal and so identify candidates of potential ecological function. Those compounds causing neurological responses in the insects can then be identified by gas chromatography coupled with mass spectrometry. In plants, responses to volatile compounds will be assessed by measuring transcriptional, metabolic, and resistance changes (see description above) in plants that are exposed to volatile compounds in flow-controlled chambers or by applying the compounds dissolved in a lipophilic paste (e.g. lanolin). The ultimate test of elicitor functionality for both plants and arthropods will be behavioral bioassays. This is necessary because transcriptional, metabolic, or electrophysiological responses, respectively, do not always translate into a behavioral response or ecological relevance; it merely indicates that the organism can perceive the respective chemical information. Behavioral assays will typically run the gamut of laboratory choice and no-choice tests (performance, such as growth and reproduction). Other tests will be conducted in small-plot field trials where plants with and without the signaling compounds of interest are offered as choice and no-choices options to target pests and pollinators. Finally, plant associational resistance effects caused by cover- or intercropping will be studied with (partially already established) larger-scale field experiments that manipulate the companion crop and measure their effects on plant metabolism and resistance as well as soil microbial community, and general soil health over time. These experiments will be backed up with direct plant-plant interaction greenhouse bioassays for a more detailed mechanistic understanding. These experiments allow the manipulation of the soil microbial community as well as the chemical information exchanged between companion plants to test for plant-soil feedback and plant communication as the major hypotheses for companion-crop-mediated associational resistance.

For example, Stout (LA) and Thaler (NY) are testing the potential for using methyl jasmonate to induce seed resistance to insects pests in rice and corn. This work focuses on seed corn maggot in corn grown in a variety of fertility practices and rice's resistance to rice water weevil. Duplais is collaborating with several researchers including Weber (MD) to measure volatile release patterns from different volatile semiochemical dispensing devices against pests, for example vittatalactone, an aggregation pheromone under development for control of striped cucumber beetle which is a major pest of cucurbits. Ali in collaboration with Casteel is testing for the effects of cover crops on resistance to western corn root worm and other pests of corn. Agrawal is testing squash varieties in the field for traits that provide resistance to squash vine borer. Cesar Rodriguez-Saona, in collaboration with Hany Dweck (Connecticut Agricultural Experiment Station), and Greg Loeb (Cornell) is continuing work on behavior-based control of spotted-wing drosophila including assessing attract-and-kill and push-pull techniques and continued identification of potential attractants and repellents to improve these techniques.

Objective 2: Field experiments with replication in different states and geographic locations will be conducted to assess the variability of chemical signaling between pests, crops, and beneficial organisms in terms of plant chemistry, species interactions and landscape factors in the Northeast. Trials will be conducted using methods standardized among cooperating states so that the data are robust among the regions and amenable to meaningful analyses or meta-analyses. Typically, these will consist of multiple varieties, chemically mediated local practices or changes from pesticide-based to more ecologically based local management practices in different agricultural contexts (in different states, regions or landscapes), while measuring and quantifying impacts on pests, pollinators, and natural enemies. This objective will also employ GIS-based landscape level analyses to complement experimental work. For example, in the coming years we want to take particular advantage of the imminent ban of neonicotinoid seed treatment in field crops. This will allow us to perform longitudinal tracking of pesticide exposure to non-target organisms as new monitoring and control tools are adopted in New York and Vermont in response to this ban.

Many projects are conducting pest management research in parallel experiments across states to determine the reliability of approaches. For example, Don Weber (USDA, ARS, MD) and Jennifer Thaler (NY) are testing using a combination of attractive and deterrent aggregation pheromones to manipulate the location of Colorado potato beetles in field plots of potatoes. This work will be conducted in both NY and MD potato fields to account for differences in context. Clare Casteel (NY) is collaborating with Jared Ali at Penn State (PA) and Ian Kaplan at Purdue University (IN) to 1) improve predictions of the plant resistance-inducing capacity of soil microbiome by measuring soil chemistry from our 85+ org farm network, 2) evaluate the effectiveness of the tool using data from new farms within NYS and outside (Pennsylvania and Indiana), and 3) expand farmer knowledge on microbiome mediate resilience within NY and regionally. Rodriguez-Saona (Rutgers, NJ) is leading a project involving collaborators from across the northeast (Whitehead, VA; Rivera, Thaler, Poveda, NY; Chen, VT; Hermann, PA) to evaluate the effectiveness of methyl salicylate in attracting predators across a variety of crops and geographical locations. Sara Hermann, Flor Acevido and Kelli Hoover (Penn State) and Anurag Agrawal (Cornell) will conduct parallel experiments in Pennsylvania and New York on the role of alternate host plants in attracting and potentially killing invasive spotted lanternfly (as compared to its feeding on grapes, apples, tree of heaven).

All of these projects are examples of teams working in multiple locations to compare the effectiveness of a particular technique.

Objective 3:

Experiments will be conducted to test the effects of conventional pesticides on target and non-target organisms, evaluate lower-risk pesticides, and document evolution of resistance to pesticides in the field. In the laboratory, bioassays with larvae and adult organisms are used to test the impacts of conventional pesticides (Iverson et al. 2019, De Souza et al. 2024, Sanchez et al. 2025), new lower-risk pesticides (Fanning et al. 2018), and risk mitigation strategies such as enzyme-loaded microparticles and hydrogels (Chen et al. 2021, Caserto et al. 2024). Field experiments are used to determine when pesticide risk to non-target organisms is high (Urbanowicz et al. 2019, Graham et al. 2022, Mueller et al. 2024, Obregon et al. 2024) and evaluate attract-and-kill and push-pull strategies for pest management (Urbaneja-Bernat et al. 2022, Gale et al. 2024). Yolanda Chen (Vermont) is working on the factors that influence resistance in Colorado potato beetle, an insect notorious foe evolving resistance to pesticides (Darrington et al 2025). Poveda, Nault and McArt are investigating pesticide resistance in seed corn maggot, a pest that may be affected by the upcoming neonicotinoid ban.

This work is supported by the Core Facility, which makes it possible to directly test pesticides levels in field samples. Core analytical methods include HPLC-MS/MS and GC-MS/MS for quantification of pesticides from environmental samples. Technical expertise is provided through individual consultations, collaborative project development, and customized training workshops tailored to researchers' needs. High quality staff are trained through hands-on experience with instrumentation, data analysis workshops, and interdisciplinary collaborations. Pesticide analyses have also been opened to the public in an extension capacity, with ~20 beekeepers, farmers, and private citizens per year sending samples and receiving results and data interpretation (<https://blogs.cornell.edu/cccef/>). Empirical results and literature syntheses are communicated via extension websites (e.g., <https://cals.cornell.edu/pollinator-network>) in addition to peer-reviewed publications.

Objective 4: The impact of domestication on plant and insect diversity in agricultural fields will be evaluated in replicated experimental designs that compare crops and their wild progenitors. Such trials will examine the differences between crops and wild-types and will allow us to quantify aspects of phytochemistry that affect the attraction of pests, pollinators, and natural enemies. Of particular importance will be using replicate varieties within and between domestication classes, or along a gradient from the progenitor to currently favored varieties. In other words, we will not compare single crop varieties to single progenitors. Such phenotypic studies will frequently involve pest damage treatments, including the study of how domestication has impacted inducible defenses and their specificity. Studies that employ molecular genetic methods to determine which genes are affected and which are expressed will help expedite resistance breeding by focusing on specific functions that control the chemical interactions that occur among species. Here, “model crops” such as maize and Cucurbita will feature prominently. The goal of this objective is to identify novel targets and methods for manipulating crop phytochemistry for the purpose of crop resistance and pollination efficacy. Ultimately this will help expedite the breeding process, will lead to the discovery of new mechanisms of resistance to pests, and will generate breeding lines that manipulate and exploit the crops’ natural phytochemistry to control pests and facilitate pollination. For example, Agrawal, Mazourek and colleagues are testing for cross-resistance to striped cucumber beetles and squash bug across North American and European squash lineages in the field.

Objective 5: Successfully leveraging microbes in sustainable pest control will require knowledge about microbial associations, whether certain microbe species or metabolites are more critical than others for functions in a community, and how and to what degree composition and function can be manipulated. To assess microbial association and establish putative functions, amplicon sequencing, and metagenomics will be paired with mass spectrometry. Tissue will be collected from different plants and insects, in the environment (such as soil), and in different agroecosystems and related natural systems. DNA will be extracted, libraries prepared, and sequencing conducted. The in-house Minion sequencing facility set up by the Casteel lab will be used for long-read sequencing and short-read sequencing will be outsourced. Metabolites will also be extracted from tissue samples and analyzed using LC-MS or GC-MS at Chemical Ecology Core to evaluate small molecules that may be mediating interactions. To determine which microbes or metabolites are most important for ecological functions, we will use machine learning methods paired with laboratory or field bioassays that monitor the ecology of insects, plants, or their microbial partners. These data can be leveraged by culturing specific microbes or purifying metabolites from various selective growth media or selective techniques. Manipulations can be accomplished by adding microbes of interest or purified metabolites to sterile substrates, or by inducing or inhibiting metabolite production, followed by assessments of the impacts on insects or plants. Much of this work is a multistate collaboration between Casteel, Ali, Kaplan, Kessler and Jander working on organic farms across New York, Pennsylvania and Indiana to document microbial communities and test their role in plant resistance.

Objective 6: The facilities use a multi-staged approach to support research and training. Core analytical methods include GC-MS for VOC and pyrethroids analysis, LC-MS for secondary metabolite and hydrophilic pesticide detection/quantification, and nuclear magnetic resonance (NMR) spectroscopy for structural elucidation of novel compounds (Rubiano-Buitrago et al. 2024). Technical expertise is provided through individual consultations, collaborative project development and customized training workshops tailored to researchers' needs. High quality staff are trained through hands-on experience with instrumentation, data analysis workshops and interdisciplinary collaborations. Future directions include continuing to work with researchers to develop new methods for specific organisms and chemicals. We will also increase the use of the facility as a training platform for graduate students and postdocs by facilitating researchers from Cornell and other institutions, including USDA (Sehgal et al. 2025), to run their samples and learn not only how to perform advanced GC-MS and LC-MS analysis, but also how to process spectral data with advanced metabolomics pipelines such as the open-source software MZmine (Seybert and Duplais, 2025a), and pipelines for annotation by exploring mass spectrometry-free databases such as Global Natural Product Social Molecular Networking (GNPS).

Objective 7: Many members of this project are actively involved in field demonstrations and outreach efforts related to the sustainable management of key agricultural pests affecting apples, corn, blueberries, cranberries, broccoli, dry bean, tomato, potato, squash and more. There will be annual and continued delivery of research updates to the relevant stakeholder community through open meetings, published proceedings and reports published in peer reviewed publications, trade journals, eXtension, appropriate electronic media and various other electronic avenues.

For example, the Casteel and Ryan labs (Cornell) and Atallah lab (University of Illinois) worked with a network of 80 organic farmers to identify practices they thought were the most and least important for culturing crop resistance inducing microbes in the soil (Bloom et al. 2024). **To share knowledge and promote engagement on the national level, an eOrganic webinar was developed highlighting the findings. The webinar engaged over 120 attendees from 36 US states, and 7 international attendees from Mexico, India, Canada, and Spain. The audience breakdown included: 10 agricultural professionals, 13 extension agents, 18 farmers, 24 government agency researchers, 16 nonprofit organization staff, 3 organic certifiers and inspectors, 22 university researchers, and 14 participants representing other aspects of food systems (e.g., gardeners). The webinar is permanently posted to eOrganic and freely available on YouTube. In $\approx$ 2mo, the recording has received > 280 views and 11 likes ($\approx$ 140 views/mo). We will continue to work with eOrganics to develop content and to share the content broadly with growers.**

In another example, Dr. Yolanda Chen (Vermont) will establish and update an online information center (Swede Midge Information Center for the US) to provide accessible data and best practices. Webinars will be conducted to communicate our findings on pheromone-mating disruption strategies for increasing organic broccoli yields. Additionally, partnerships with commercial pest control companies will be cultivated to develop cost-effective tools for managing spotted-wing drosophila through attract-and-kill technology and repellents. Where feasible, new extension materials developed through this project will be evaluated using real-time polling (e.g., Poll Everywhere) to assess changes in stakeholder knowledge and perception. When hosted on participant websites, Google Analytics will be used to track stakeholder engagement and optimize content accessibility. Additionally, we will collaborate with regional integrated pest management (IPM) programs and other agricultural organizations to leverage existing networks for broader dissemination. These partnerships will enhance outreach efforts through established media channels and stakeholder engagement programs, ensuring that research-based pest management practices are effectively communicated and adopted by the target audience.

The Vanette lab (CA) in collaboration with the California Center for Urban Horticulture is producing online guidelines homeowners about landscaping and watering regimes that promote pollinators:

<https://vannettelab.faculty.ucdavis.edu/about/landscaping-for-pollinators>;

The Adler lab (MA) is coordinating extension to conduct public outreach about bees, including hosting workshops on bee health and biology, and conducting beekeeper-initiated surveys of hobbyist beekeepers on threats to hives in Massachusetts <https://websites.umass.edu/lynnadler/extension-outreach/>).

Please see Outreach Plan for more details of extension activities.

Measurement of Progress and Results

Outputs

- The project will result in the conversion of research-based knowledge of chemical ecology into tools useful to supporting sustainable and economically sound pest and pollinator management in agricultural systems.
- It will generate data and knowledge regarding the role of chemical communication within and among species of crops, pests, and pollinators in landscapes with an agricultural component.
- It will also generate data and applied knowledge by measuring and quantifying pesticide loads and their effects on pollinators and natural enemies of agricultural pests of importance in the Northeastern Region.
- The project will measure and quantify how crop domestication affects the interactions among agricultural crops and their pests, pollinators and natural enemies.
- The strong presence of chemical ecology researcher laboratories in the Northeast Land Grant Universities will facilitate the coordination, aggregation, sharing, and financial support of analytical equipment to be used among cooperating researchers in the region so that standardized methods and lower-variance data can be generated and utilized among various cooperative research projects.

Outcomes or Projected Impacts

- • The overarching objective of this project is to develop novel, cutting-edge and economically attractive approaches that will provide options and allow growers to integrate environmentally friendly, non-pesticidal control of various agricultural pests and improve management of natural enemy and pollinator services.
- • We will provide a greater understanding of the ecology of pests, pollinators and natural enemies and this will assist with generating recommendations for a more integrated approach to pollinator and pest management. Increased knowledge is likely to help conserve important pollinator and natural enemy populations and improve their services in agriculture and other ecosystems.
- • This project represents a collaborative network of researchers. It will facilitate and expedite cooperation among researchers in the field of chemical ecology and focus the application of fundamental and basic science on priority problems in agriculture.
- • Specific recommendations will be provided for the design and deployment of pheromone traps for pest monitoring.
- • Specific recommendations will be generated for which types of cover crops in specific soils and regions will promote plant resistance and growth.
- • We will provide new tools for controlling invasive pests such as spotted lantern fly.
- • We will provide recommendations for new repellents and a phagostimulant (Combi-protec) to be used against spotted-wing drosophila
- • The project will facilitate the surveillance, collection and maintenance of population data for establishment of baselines and assessment of pollinator health in the Northeast and elsewhere.
- • The knowledge generated by coordinated research will facilitate and expedite plant breeding for enhanced pest resistance and pollinator efficacy by providing explanatory mechanisms for plants responses to pests and pollinators. Coupled with molecular methods that identify pathways for signal chemicals, plant breeders will be able to focus on target genes during the selection and crossing process. The outcome will be horticulturally acceptable crop varieties with enhanced productivity in the face of herbivores.

Milestones

(2025): • Roll-out of this Multistate Project and solicitations for new participants.

(2025): Meeting of Executive Committee and potential participants to establish project work plan.

(2025): Commencement of research by participants beginning FY Oct. 1, 2025

(2025): Establishment of standardized protocols for inter- and intra- state collaborative projects for a) pest management and b) pollinator health objectives.

(2025): Compilation and distribution of available chemical analytical protocol's list to participants.

(2025): Project participants' organizational meeting and mini-symposium to present and discuss research and developments (in-person and virtual option).

(2026): • Project participants' organizational meeting and mini-symposium to present and discuss research and developments.

(2026): • Annual business meeting will be held to discuss developments or changes in project objectives, etc.

(2026): • Establishment of pest management and pollinator sub-committees to guide research directions in each aspect.

(2026): • Education and outreach efforts will be developed based on success in research.

(2027): • Integration of any new participants into project plans.

(2027): • Annual business and participants meeting to discuss developments or implement changes in project execution, updates to equipment services, dovetailing of research efforts, etc.

(2027): • Publish and disseminate via outreach avenues any relevant findings generated by project.

(2028): • Initiate and organize symposium to present findings on integration of chemical ecology and agricultural priority issues to be combined with a relevant annual conference of entomology, ecology, pollination, etc.

(2028): • Publish and disseminate via outreach avenues any relevant findings generated by project.

(2028): • Apply for new grants based on research findings.

(2029): • Conduct self-assessment and review of the project as a means to prepare for project renewal pending participant and stakeholder consensus that the project has generated sufficient returns to warrant renewal.

(2029): • Continue publication and outreach dissemination.

(2030): • If decision is to continue, work on grant renewal

(2030): • Continue publication and outreach dissemination.

(2025): • Discuss advisory panel with group and compile list of stakeholders to invite for each Objective.

- (2026):**• Invite external stakeholders to provide feedback on projects within Objectives 1 and 2 at the annual meeting.
- (2027):**• Invite external stakeholders to provide feedback on projects within Objectives 3 and 4 at the annual meeting.
- (2028):**• Invite external stakeholders to provide feedback on projects within Objectives 5, 6, and 7 at the annual meeting.
- (2029):**• Invite external stakeholders to provide feedback on overall projects and future directions.
-

Outreach Plan

Many members of this project are actively involved in field demonstrations and outreach efforts related to the sustainable management of key agricultural pests affecting apples, corn, blueberries, cranberries, broccoli, and more. Many team members interact regularly with stakeholders, including farmers, agricultural professionals, government agencies, commodity groups, and researchers in related disciplines, to disseminate information and foster the adoption of behavior-based pest management strategies. Traditional extension meetings and educational programs will be conducted with producers, industry representatives, consultants, and regulators to discuss findings and share information. Additionally, project members with teaching appointments will incorporate research findings into undergraduate and graduate curricula, ensuring students gain exposure to the latest developments in chemical ecology and behavioral pest management.

Our findings and conclusions will be communicated through multiple channels, including but not limited to:

1. Sharing annual reports among participants at project meetings;
 2. Publishing peer-reviewed research articles on candidate repellents and attractants for managing spotted-wing drosophila;
 3. Producing podcasts detailing information on semiochemicals and how chemical ecology is used in agricultural systems;
 4. Producing and disseminating educational factsheets for growers;
 5. Publishing non-refereed materials such as newsletter articles, bulletins, blogs, and factsheets;
 6. Presenting research findings at scientific conferences on behavioral control strategies for spotted-wing drosophila;
 7. Delivering in-person and virtual presentations to stakeholders, including growers and extension educators;
 8. Conducting on-farm demonstrations to assess the efficacy of attract-and-kill technology for managing spotted-wing drosophila.
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Organization/Governance

Organization of the project is delegated to an Executive Committee comprising an Administrative Advisor, Chair, Secretary and Representative at Large. The Administrative Advisor will be Blair Siegfried the Director of Pennsylvania Agriculture Experiment Station and the remainder of the committee will be elected by and from regional project membership. Excepting the Administrative Advisor, Executive Committee members will hold a two year appointment. The Representative at Large will succeed the Secretary who will in turn succeed the Chair. It will be the responsibility of the Chair to prepare technical and executive meeting agendas, preside at meetings, and prepare an annual progress report on the research activities of the regional project. The Secretary duties will be to record the minutes of technical and executive committee meetings and perform other duties as necessary. The Representative at Large will assist both Secretary and Chair with their responsibilities as necessary. Subcommittees may be named by the Chair as needed for specific assignments such as developing new project outlines for continuing the project, to prepare publications, or other assignments. An annual meeting of the full Executive Committee will be held to summarize and critically evaluate progress, analyze results, and plan future activities, reports, and publications.

Literature Cited

- Adler, L. S. 2000. The ecological significance of toxic nectar. *Oikos* 91:409–420.
- Adler, L.S., K.M. Michaud, S.P. Ellner, S.H. McArt, P.C. Stephenson, R.E. Irwin. 2018. Disease where you dine: plant species and floral traits associated with pathogen transmission in bumble bees. *Ecology* 99: 2535-2545.
- Aguirre-Liguori, J. A., S. Ramírez-Barahona, P. Tiffin, and L. E. Eguarte. 2019. Climate change is predicted to disrupt patterns of local adaptation in wild and cultivated maize. *Proceedings of the Royal Society B: Biological Sciences* 286:20190486.
- Babu, A., E. M. Rhodes, C. Rodriguez-Saona, O. E. Liburd, C. G. Fair and A. A. Sial. 2023. Comparison of multimodal attract-and-kill formulations for managing *Drosophila suzukii*: Behavioral and lethal effects. *PLOS ONE* 18(12):e0293587.
- Bak A, Patton MF, Perilla-Henao LM, Aegerter BJ, Casteel CL (2019) Ethylene signaling mediates potyvirus spread by aphid vectors. *Oecologia* 190:139–148. <https://doi.org/10.1007/s00442-019-04405-0>
- Bass, E., Mutyambai, D.M., Midega, C.A., Khan, Z.R. and Kessler, A., 2024. Associational effects of Desmodium intercropping on maize resistance and secondary metabolism. *Journal of Chemical Ecology*, pp.1-20.
- Bera S, Blundell R, Liang D, Crowder DW, Casteel CL (2020) The oxylipin signaling pathway is required for increased aphid attraction and retention on virus-infected plants. *J Chem Ecol.* <https://doi.org/10.1007/s10886-020-01157-7>

- Bianchi, F. J. J. A., Booij, C. J. H., & Tscharntke, T. (2006). Sustainable pest regulation in agricultural landscapes: A review on landscape composition, biodiversity and natural pest control. *Proceedings of the Royal Society B: Biological Sciences*, 273(1595), 1715-1727.
- Bischoff, K., N. Baert, and S. H. McArt. 2023. Pesticide contamination of beeswax from 72 managed honeybee colonies in New York State. *Journal of Veterinary Diagnostic Investigation* 35:617-624.
- Bloom, Elias H., Shady S. Atallah and Clare L. Casteel. Motivating organic farmers to adopt practices that support the pest-suppressive microbiome relies on understanding their beliefs. *Renew. Agric. Food Syst.*. 2024. Vol. 39. DOI: 10.1017/S174217052400005X
- Blundell, Robert, et al. "Organic management promotes natural pest control through altered plant resistance to insects." *Nature plants* 6.5 (2020): 483-491.
- Boucher, M., Collins, R., Cox, K., and Loeb, G. 2019. Effects of exposure time and biological state on acquisition and accumulation of *Erwinia amylovora* by *Drosophila melanogaster*. *Applied & Environmental Microbiology*, 85:e00726-19.
- Brzozowski, L.J., Mazourek, M. and Agrawal, A.A., 2019. Mechanisms of resistance to insect herbivores in isolated breeding lineages of Cucurbita pepo. *Journal of Chemical Ecology*, 45, pp.313-325.
- Brzozowski, L.J., M.A. Gore, A.A. Agrawal, and M. Mazourek. 2020a. Divergence of defensive cucurbitacins in independent Cucurbita pepo domestication events leads to differences in specialist herbivore preference. *Plant, Cell & Environment* 43:2812-2825.
- Brzozowski, L.J., J. Gardner, M.P. Hoffmann, A. Kessler, A.A. Agrawal, and M. Mazourek. 2020b. Attack and aggregation of a major squash pest: parsing the role of plant chemistry and beetle pheromones. *Journal of Applied Ecology* 57: 1442-1451.
- Brzozowski, L.J., D.C. Weber, A.K. Wallingford, M. Mazourek, and A.A. Agrawal. 2021. Tradeoffs and synergies in management of two co-occurring specialist squash pests. *Journal of Pest Science* 95: 327-338.
- Calderone, N. W. (2012). Insect pollinated crops, insect pollinators and US agriculture: Trend analysis of aggregate data for the period 1992-2009. *PLoS One*, 7, e37235.
- Caserto, J. S., L. Wright, C. Reese, M. Huang, M. Salcedo, S. Fuchs, S. Jung, S. H. McArt and M. Ma. 2024. Ingestible hydrogel microparticles improve bee health after pesticide exposure. *Nature Sustainability* 7:1441-1451.
- Chen, Y. H., R. Gols, and B. Benrey. 2015. Crop domestication and naturally selected species interactions. *Annual Review of Entomology* 60:35-58.
- Chen, J., J. Webb, K. Shariati, S. Guo, J. K. Montclare, S. H. McArt and M. Ma. 2021. Pollen-inspired enzymatic microparticles to reduce organophosphate toxicity in managed pollinators. *Nature Food* 2:339-347.
- Chisholm PJ, Eigenbrode SD, Clark RE, Basu S, Crowder CW. (2019) Plant-mediated interactions between a vector and a non-vector herbivore promote the spread of a plant virus. *Proceedings of the Royal Society B* 286 (1911), 20191383
- [Darrington, M. J. Solocinski, S. K. Zhou, M. C. Lecheta, S. R. Palli, Y. H. Chen, N. M. Teets](#). 2025. Environmental factors affecting RNAi efficacy: Temperature but not plant cultivar influences Colorado potato beetle's response to insecticidal dsRNA *Insect Molecular Biology* <https://doi.org/10.1111/imb.12996>
- Davidson-Lowe, E., Ray, S., Murrell, E., Kaye, J. and Ali, J.G., 2021. Cover crop soil legacies alter phytochemistry and resistance to fall armyworm (Lepidoptera: Noctuidae) in maize. *Environmental entomology*, 50(4), pp.958-967.
- Dempewolf, H., Baute, G., Anderson, J., Kilian, B., Smith, C., & Guarino, L. (2017). Past and future use of wild relatives in crop breeding. *Crop Science* 57: 1070-1082.
- Deutsch, C. A., J. J. Tewksbury, M. Tigchelaar, D. S. Battisti, S. C. Merrill, R. B. Huey, and R. L. Naylor. 2018. Increase in crop losses to insect pests in a warming climate. *Science (New York, N.Y.)* 361:916-919.
- De Souza, D., C. Urbanowicz, W. H. Ng, N. Baert, A. A. Fersch, M. L. Smith and S. H. McArt. 2024. Acute toxicity of the fungicide captan to honey bees and mixed evidence for synergism with the insecticide thiamethoxam. *Scientific Reports* 14:15709.
- ESI. 2024 The Organic Agriculture Industry in Pennsylvania. <https://econsultsolutions.com/the-organic-agriculture-industry-in-pennsylvania/>
- Fanning, P. D., A. VanWoerkom, J. C. Wise and R. Isaacs. 2018. Assessment of a commercial spider venom peptide against spotted-wing drosophila and interaction with adjuvants. *Journal of Pest Science*. 91(4):1279-1290.
- Fleischer, Joerg, et al. "Access to the odor world: olfactory receptors and their role for signal transduction in insects." *Cellular and Molecular Life Sciences* 75.3 (2018): 485-508.
- Gallai, N., Salles, J.-M., Settele, J., & Vaissière, B. E. (2009). Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. *Ecological Economics*, 68, 810-821.
- Gale, C. C., B. Ferguson, C. Rodriguez-Saona, V. D. C. Shields and A. Zhang. 2024. Evaluation of a push-pull strategy for spotted-wing Drosophila management in highbush blueberry. *Insects*, 15(1):47.

- Gherman, B. I., A. Denner, O. Bobis, D. S. Dezmirean, L. A. Marghitas, H. Schluns, R. F. A. Moritz, and S. Erler. 2014. Pathogen-associated self-medication behavior in the honeybee *Apis mellifera*. *Behavioral Ecology and Sociobiology* 68: 1777-1784.
- Graham, K. K., M. O. Milbrath, Y. Zhang, A. Soehnlen, N. Baert, S. H. McArt and R. Isaacs. 2021. Identities, concentrations, and sources of pesticide exposure in pollen collected by managed bees during crop pollination. *Scientific Reports* 11:16857.
- Graham, K. K., M. O. Milbrath, Y. Zhang, N. Baert, S. H. McArt and R. Isaacs. 2022. Pesticide risk to managed bees during blueberry pollination is primarily driven by off-farm exposures. *Scientific Reports* 12:7189.
- Graham, K. K., S. H. McArt and R. Isaacs. 2024. High pesticide exposure and risk to bees in pollinator plantings adjacent to conventionally managed blueberry fields. *Science of the Total Environment* 922:171248.
- Grout, T. A., P. A. Koenig, J. K. Kapuvári and S. H. McArt. 2020. Neonicotinoid insecticides in New York: Economic benefits and risk to pollinators. 432 pp. <https://pollinator.cals.cornell.edu/pollinator-research-cornell/neonicotinoid-report/>
- Guzman, L. M., E. Elle, L. A. Morandin, N. S. Cobb, P. R. Chesshire, L. M. McCabe, A. Hughes, M. Orr and M. A. M'Gonigle. 2024. Impact of pesticide use on wild bee distributions across the United States. *Nature Sustainability* 7:1324-1334.
- Han, P., C. Rodriguez-Saona, M. P. Zalucki, S. Liu and N. Desneux. 2024. A theoretical framework to improve the adoption of green Integrated Pest Management tactics. *Communications Biology* 7:337.
- Hansen AK, Pers D, Russell JA (2020) Chapter five - symbiotic solutions to nitrogen limitation and amino acid imbalance in insect diets. In: Oliver KM, Russell JA (eds) *Advances in Insect Physiology*. Academic Press, Cambridge, pp 161-205
- Holt JR, Cavichioli de Oliveira N, Medina RF, Malacrinò A, Lindsey ARI. Insect-microbe interactions and their influence on organisms and ecosystems. *Ecol Evol*. 2024 Jul 21;14(7):e11699. doi: 10.1002/ece3.11699.
- Iverson, A. L., C. Hale, L. Richardson, O. Miller and S. H. McArt. 2019. Synergistic effects of three sterol biosynthesis inhibiting fungicides on the toxicity of a pyrethroid and neonicotinoid insecticide to bumble bees. *Apidologie* 50:733-744.
- Jones, P. L., Martin, K. R., Prachand, S. V., Hastings, A. P., Duplais, C., Agrawal A. A. 2023. Compound-specific behavioral and enzymatic resistance to toxic milkweed cardenolides in a generalist bumblebee pollinator. *Journal of Chemical Ecology* 49, 418-427.
- Jordan, JP, A. Kessler, Submitted. Direct and indirect effects of companion cropping alter maize secondary metabolism and affect herbivore resistance. *Plant, Cell & Environment*.
- Klein, A.-M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B: Biological Sciences*, 274, 303-313.
- Koch, H., J. Woodward, M. K. Langat, M. J.F. Brown, P. C. Stephenson. 2019. Flagellum Removal by a Nectar Metabolite Inhibits Infectivity of a Bumblebee Parasite. *Current Biology* 29: R1077-R1079.
- Kraus EC, Stout MJ (2019) Seed treatment using methyl jasmonate induces resistance to rice water weevil but reduces plant growth in rice. *PLoS ONE* 14(9): e0222800
- Landis, D. A., Wratten, S. D., & Gurr, G. M. (2000). Habitat management to conserve natural enemies of arthropod pests in agriculture. *Annual Review of Entomology*, 45, 175-201.
- Mason CJ, Jones AG, Felton GW (2019) Co-option of microbial associates by insects and their impact on plant-herbivore interactions. *Plant Cell Environ* 42:1078-1086
- McArt, S. H., H. Koch, R. E. Irwin, and L. S. Adler. 2014. Arranging the bouquet of disease: floral traits and the transmission of plant and animal pathogens. *Ecology Letters*. 17: 624-636.
- McArt, S. H., C. M. Urbanowicz, S. McCoshum, R. E. Irwin and L. S. Adler. 2017. Landscape predictors of pathogen prevalence and range contractions in United States bumblebees. *Proceedings of the Royal Society of London B* 284:20172181.
- Midęga, C. A. O., J. Pickett, A. Hooper, J. Pittchar, and Z. R. Khan. 2016. Maize Landraces are Less Affected by *Striga hermonthica* Relative to Hybrids in Western Kenya. *Weed Technology* 30:21-28.
- Mueller, T. G., N. Baert, P. A. Muñiz, D. E. Sossa, B. N. Danforth and S. H. McArt. 2024. Pesticide risk during commercial apple pollination is greater for honeybees than other managed and wild bees. *Journal of Applied Ecology* 61:1289-1300.
- Mutyambai, D.M., Bass, E., Luttermoser, T., Poveda, K., Midęga, C.A., Khan, Z.R. and Kessler, A., 2019. More than “push” and “pull”? plant-soil feedbacks of maize companion cropping increase chemical plant defenses against herbivores. *Frontiers in Ecology and Evolution*, 7, p.217.
- Mutyambai, D.M., Mutua, J.M., Kessler, A., Jalloh, A.A., Njiru, B.N., Chidawanyika, F., Dubois, T., Khan, Z., Mohamed, S., Niassy, S. and Subramanian, S., 2024. Push-pull cropping system soil legacy alter maize metabolism and fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) resistance through tritrophic interactions. *Plant and Soil*, 498(1), pp.685-697.
- Mutz, J., Thaler, J.S., Ugine, T.A., Inouye, B.D. and Underwood, N., 2024. Predator densities alter the influence of non-consumptive effects on the population dynamics of an agricultural pest. *Ecological Entomology*, 49(3), pp.306-318.

- Obregon, D., Guerrero, O., Sossa, D., Stashenko, E., Prada, F., Ramirez, B., Duplais, C., K. Poveda (2024) Route of exposure to veterinary products in bees: unraveling pasture's impact on avermectin exposure and tolerance in stingless bees. *Proceedings of the National Academy of Sciences USA Nexus* 3(3), 68.
- Palmer-Young, Evan C., et al. 2019. Chemistry of floral rewards: intra-and interspecific variability of nectar and pollen secondary metabolites across taxa." *Ecological Monographs* 89: e01335.
- Pradit, N., Mescher, M.C., Wang, Y., Vorsa, N., and Rodriguez-Saona, C. 2019. Phytoplasma infection of cranberries benefits non-vector phytophagous insects. *Frontiers in Ecology and Evolution* section Chemical Ecology 7:181.
- Ray, S., Wenner, N.G., Ankoma-Darko, O., Kaye, J.P., Kuldau, G.A. and Ali, J.G., 2022. Cover crop selection affects maize susceptibility to the fungal pathogen *Fusarium verticillioides*. *Pedobiologia*, 91, p.150806.
- Rodriguez-Saona, C., L. Parra, A. Quiroz, and R. Isaacs. 2011. Variation in highbush blueberry floral volatile profiles as a function of pollination status, cultivar, time of day and flower part: implications for flower visitation by bees. *Annals of Botany*. 107: 1377-1390.
- Rodriguez-Saona, C., Cloonan, K.R., Sanchez-Pedraza, F., Zhou, Y., Giusti, M.M. and Benrey, B., 2019. Differential susceptibility of wild and cultivated blueberries to an invasive frugivorous pest. *Journal of chemical ecology*, 45, pp.286-297.
- Rodriguez-Saona, C., R. Holdcraft and B. Ferguson. 2024. Evaluation of a new insecticide for controlling spotted-wing drosophila in highbush blueberries, 2023. *Arthropod Management Tests* 49(1):tsae048.
- Rondeau, S., N. Baert, S. H. McArt and N. E. Raine. 2022. Quantifying exposure of bumblebee (*Bombus* spp.) queens to pesticide residues when hibernating in agricultural soils. *Environmental Pollution* 309:119722.
- Rubiano-Buitrago P., White, R. A., Hastings, A. P., Schroeder, F. C., Agrawal, A. A., Duplais, C. (2024) Cardenolides in *Asclepias syriaca* seeds: exploring the legacy of Tadeus Reichstein. *Accepted in Journal of Natural Products*. <https://doi.org/10.1021/acs.jnatprod.4c00960>
- Ruiz-Arocho, J., González-Salas, R., LeMay, G., Steinthal, N., Mastretta-Yanes, A., Wegier, A., Vargas-Ponce, O., Solís-Montero, L., Orozco-Ramírez, Q. and Chen, Y.H., 2024. How is leaf herbivory related to agriculture? Insights from the Mexican center of crop origin. *Arthropod-Plant Interactions*, 18(1), pp.89-104.
- Salazar-Mendoza, P., Miyagusuku-Cruzado, G., Giusti, M.M., and Rodriguez-Saona, C. 2024. Genotypic variation and potential mechanisms of resistance against multiple insect herbivores in cranberries. *Journal of Chemical Ecology*. doi: 10.1007/s10886-024-01522-w.
- Sanchez, A. B., D. A. de Souza, W. H. Ng, C. Zhao, B. X. DeMoras and S. H. McArt. 2025. Six fungicides used during crop pollination are acutely toxic to honey bee larvae at field-realistic exposure levels. *In prep for Environment International*.
- Sehgal, A., Deys, K., Szewc-McFadden, A., Duplais, C., Gutierrez, B., Meakem, V., Galarneau, E., Londo, J. P., Blair N. Turner, Cadle-Davidson L. E., Zhong, G-Y., Gouker, F.E., Kirubakaran, S. 2025. Effect of grapevine rootstock and foliar biostimulants in regulating scion physiology, secondary metabolites, and root architectural adaptation to drought stress. *In review in Plant Physiology and Biochemistry*. <https://doi.org/10.2139/ssrn.4897138>
- Seybert, L., Duplais, C. (2025a) Understanding your biases in collecting organismal VOCs. *In review in Journal of Chemical Ecology*. <https://www.researchsquare.com/article/rs-5462922/v1>
- Seybert, L., Duplais, C. (2025b) Metabolomics tutorial for GC-MS data processing and analysis in chemical ecology. *In preparation*.
- Siviter, H., G. Pardee, N. Baert, S. H. McArt, S. Jha and F. Muth. 2023. Wild bees are exposed to low levels of pesticides in urban grasslands and community gardens. *Science of the Total Environment* 858:159839.
- Stout, M.J., K. McCarter, J. Villegas, and B.E. Wilson. 2024. Natural incidence of stem borer damage in U.S. rice varieties. *Crop Protection* 177, March 2024, 106565
- Strang, C., S. Rondeau, N. Baert, S. H. McArt, N. Raine and F. Muth. 2024. Field agrochemical exposure impacts locomotor activity in wild bumblebees. *Ecology* e4310.
- Tanksley, S. D., & McCouch, S. R. (1997). Seed banks and molecular maps: unlocking genetic potential from the wild. *Science* 277: 1063-1066.
- Tscharntke, T., Klein, A. M., Kruess, A., Steffan-Dewenter, I., & Thies, C. (2016). Landscape perspectives on agricultural intensification and biodiversity—ecosystem service management. *Ecology Letters*, 19(6), 733-744.
- Tscharntke T, Tylianakis JM, Rand TA, Didham RK, Fahrig L, Batáry P, Bengtsson J, Clough Y, Crist TO, Dormann CF, Ewers RM, Fründ J, Holt RD, Holzschuh A, Klein AM, Kleijn D, Kremen C, Landis DA, Laurance W, Lindenmayer D, Scherber C, Sodhi N, Steffan-Dewenter I, Thies C, van der Putten WH, Westphal C. Landscape moderation of biodiversity patterns and processes - eight hypotheses. *Biol Rev Camb Philos Soc*. 2012 Aug;87(3):661-85. doi: 10.1111/j.1469-185X.2011.00216.x. Epub 2012 Jan 24. PMID: 22272640.
- Ugine, T.A., Mutz, J., Underwood, N. and Thaler, J.S., 2024. Do maternal allocations towards offspring quality and quantity ameliorate the effects of predators on offspring survival?. *Journal of Applied Entomology*.

Urban-Mead, K. R., P. Muñiz, M. Van Dyke, A. D. Young, B. N. Danforth and S. H. McArt. 2023. Early spring orchard pollinators spill over from resource-rich adjacent forest patches. *Journal of Applied Ecology* 60:553-564. <https://doi.org/10.1111/1365-2664.14350>

Urbaneja-Bernat, P., Cloonan, K., Zhang, A., Salazar-Mendoza, P. and Rodriguez-Saona, C., 2021. Fruit volatiles mediate differential attraction of *Drosophila suzukii* to wild and cultivated blueberries. *Journal of Pest Science*, 94(4), pp.1249-1263.

Urbaneja-Bernat, P., R. Holdcraft, J. Hernández-Cumplido, E. M. Rhodes, O. E. Liburd, A. A. Sial, A. Mafra-Neto and C. Rodriguez-Saona. 2022. Field, semi-field and greenhouse testing of HOOK SWD, a SPLAT-based attract-and-kill formulation to manage spotted-wing drosophila. *Journal of Applied Entomology* 146:1230-1242.

Urbanowicz, C. M., N. Baert, S. E. Bluher, M. Ramos, K. Böröczky and S. H. McArt. 2019. Low maize pollen collection and low pesticide risk to honey bees in heterogeneous agricultural landscapes. *Apidologie* 50:379-390.

Van Dyke, M., E. Mullen, D. Wixted and S. H. McArt. 2019. A pesticide decision-making guide to protect pollinators in landscape, ornamental, and turf management. 36 pp. <https://pollinator.cals.cornell.edu/resources/grower-resources/>

Van Dyke, M., D. Wixted and S. H. McArt. 2023a. A guide to reducing pesticide risk to bees in tree fruit orchards. 34 pp. <https://cornell.app.box.com/v/ProtectionGuide-Orchard2023>

Van Dyke, M., D. Wixted and S. H. McArt. 2023b. A guide to reducing pesticide risk to bees in small fruit, grape, and hops in New York. 35 pp. <https://cornell.app.box.com/v/ProtectionGuide-FruGrapHop2023>

Van Dyke, M., D. Wixted and S. H. McArt. 2023c. A guide to reducing pesticide risk to bees in vegetable agriculture and field crops in New York. 39 pp. <https://cornell.app.box.com/v/ProtectionGuide-FieldCrop2023>

Whitehead SR, Poveda K (2019) Resource allocation trade-offs and the loss of chemical defences during apple domestication. *Ann Bot* 123:1029-1041.

Whitehead, S.R., Wisniewski, M.E., Droby, S., Abdelfattah, A., Freilich, S. and Mazzola, M., 2021. The apple microbiome: structure, function, and manipulation for improved plant health. *The apple genome*, pp.341-382.

Yahiaoui, S., A. Cuesta-Marcos, M. P. Gracia, B. Medina, J. M. Lasa, A. M. Casas, F. J. Ciudad, J. L. Montoya, M. Moralejo, J. L. Molina-Cano, and E. Igartua. 2014. Spanish barley landraces outperform modern cultivars at low-productivity sites. *Plant Breeding* 133:218-226.

Ziemke, T., Wang, P., Duplais, C. (2024) The fate of a *Solanum* steroidal alkaloid toxin in the cabbage looper (*Trichoplusia ni*). *Insect Biochemistry and Molecular Biology* 175, 104205.

Land Grant Participating States/Institutions

CA,MA

Non Land Grant Participating States/Institutions

Participation

Participant	Is Head	Station	Objective	Research						Extension	
				KA	SOI	FOS	SY	PY	TY	FTE	KA

Combined Participation

Combination of KA, SOI and FOS				Total SY		Total PY		Total TY	
Grand Total:				0.30		0.10		0.00	
211				0.03		0		0	
212				0.03		0		0	
314				0.03		0		0	
216				0.03		0.1		0	
216				0.03		0.1		0	
216				0.03		0.1		0	
211				0.1		0		0	

Program/KA	Total FTE
Grand FTE Total:	0.15
216	0.03
215	0.03
211	0.02

Response to Reviewers: NE_TEMP2501: *Harnessing Chemical Ecology to Address Agricultural Pest and Pollinator Priorities.*

Comment 1: My only criticism of the proposal is the focus on one-way communication in the prior and proposed outreach plans. The team should also work to understand barriers to adoption and stakeholder priorities through two-way communication. My reading suggests measurement of "changes in knowledge" will be prioritized but there are no clear plans to measure changes in behavior or barriers to use of some of the more readily implementable strategies (e.g., those that require changes in practices but not commercialization of new technologies). It would also be great to see more emphasis on that translation process being proposed. The group has accomplished many things during the prior project period - which outputs require next steps for them to be used by stakeholders? What are those next steps and how can the group work together to facilitate them? There is a little bit in the proposal about this but it is not fleshed out. It is great to produce many new technologies and options but the next step is to figure out how to take them to the stakeholders and what barriers need to be overcome for this to happen

Response 1: This is a good idea and we are working towards moving the group from producing new knowledge to changing behaviors. We propose to explicitly address this in the next five- year period, leveraging the strength within the group and bringing in external stakeholders. Within the group currently, several members have extension appointments, directly collaborate with growers and industry, and conduct research informed by these interactions. Each year we already hear about grower and industry needs at the annual meeting, and this will be enhanced in the next cycle.

In addition, the group has a history of bringing in external stakeholders to advise on specific projects at the annual multi-state meeting. For example, Ajenor Mafrá-Neto the CEO of ISCA Technologies, a company specializing in the development of semiochemical solutions for pest management, attended the annual meeting in 2022. This was a useful conversation, helping us understand the barriers towards developing multi-component semiochemicals and led to conversations with members of ISCA and the multistate group with EPA regulators on how to create a path forward for easing the costs of developing these technologies.

At each of the annual meetings, we will invite two external stakeholders to interact with the projects that fall within two of the project Objectives. These people will attend a 3 - hour block of the meeting that is organized around that multistate Objective. Organizing the annual meetings around the Objectives will also likely build collaborations on gaps in those areas. The multistate research PIs will be encouraged to present their findings and directions for future work leaving time for feedback. These external people will come from

relevant commodity groups and geography. Over 2-3 years, we expect to develop this into an advisory board that will help guide projects.

We added a description of the development of the external advisory board to the section on Technical feasibility of the research and to the project Milestones.

Comment 2: I was expecting to see a mention of resistance management to chemical pesticides. I understand that the focus of the project is on reducing pesticide use, but the approaches developed through the project should also provide growers with alternative methods of pest control that can address and manage pesticide resistance. This is not a criticism of the work proposed as much as it is a missed opportunity in the framing of the project.

Response 2: Good point! Several members of the multistate group work on managing pesticide resistance, both as components of their primary research (Yolanda Chen, Vermont; Poveda, NY) and in collaboration with other non-multistate researchers (McArt and Duplais, NY; Ali, PA). This topic was added as a component of Objective 3 which was retitled: Work to find ways to minimize the impact of pesticides, manage pesticide resistance, and discover new pesticides that reduce the impact on pollinators, herbivores, microbes and natural enemies of pests.

Reference added:

Darrington, M. J. Solocinski, S. K. Zhou, M. C. Lecheta, S. R. Palli, Y. H. Chen, N. M. Teets. 2025. Environmental factors affecting RNAi efficacy: Temperature but not plant cultivar influences Colorado potato beetle's response to insecticidal dsRNA *Insect Molecular Biology* <https://doi.org/10.1111/imb.12996>

Comment 3: In Objective 2 it would be nice to see some examples of specific multi-state collaboration listed - for example, could approaches be tested within the same crop at different types of geographic sites (with their underlying diversity of farm sizes/approaches) to better understand landscape level impacts on chemical ecology mediated pest control? The one example mentioned of neonicotinoid seed treatments nicely addresses coming policy in NY, VT, and beyond. The proposal would be strengthened through greater demonstration of specific planned research with multi-state collaboration (beyond sharing analytical facilities and information exchange).

Response 3: *We added more specifics on the planned multistate collaborations to the Methods section for Objective 2.*

For example: Rodriguez-Saona (Rutgers) is leading a project involving collaborators from across the northeast (Whitehead, VA; Rivera, Thaler, Poveda, NY; Chen, VT; Hermann,

PA) to evaluate the effectiveness of methyl salicylate in attracting predators across a variety of crops and geographical locations.

Don Weber (USDA, ARS, MD) and Jennifer Thaler (NY) are testing using a combination of attractive and deterrent aggregation pheromones to manipulate the location of Colorado potato beetles in field plots of potatoes. This work will be conducted in both NY and MD potato fields to account for differences in context.

Clare Casteel is collaborating with Jared Ali at Penn State and Ian Kaplan at Purdue University to 1) improve predictions of the plant resistance-inducing capacity of soil microbiome by measuring soil chemistry from our 85+ org farm network, 2) evaluate the effectiveness of the tool using data from new farms within NYS and outside (Pennsylvania and Indiana), and 3) expand farmer knowledge on microbiome mediate resilience within NY and regionally.

Comment 4: The primary weakness of this project: it advertises (in the non-technical summary) developing sustainable pest control strategies, but in reality focuses almost entirely on studying chemical interactions in many systems with the vague hope that understanding interactions will ultimately prove useful in developing control strategies. Looks like a push-pull strategy is being tested to control spotted wing Drosophila - and this is very good - but what about all the other pests mentioned? I recognize that many (most?) academics assume that if one studies a pathosystem long enough, control strategies will emerge. And, in some cases, they do. But I'd argue not nearly often enough. I'd challenge the team to test, early and often, in the field, whether their understanding of particular signaling allows for pest control in the manner they expect. (There are hints this is indeed happening, but the pests being targeted are not identified - see, e.g., section titled 'crop diversification can be used to increase sustainable pest control'). And for the majority of cases where it doesn't, to then develop and test new hypotheses about what else needs to change for the pest to be controlled. The best way to solve problems is to try to directly solve them. Not just studying aspects of the system in isolation, reveling in whatever newfound knowledge emerges, publishing, and moving on. A project whose true goal was pest control would organize the proposal around the pests for which control was being sought, would document substantial collaboration with growers affected by those pests, and outline what control strategies were being tested.

Response 4: Thanks for this comment, we agree field testing in realistic circumstances is important although some projects do not get this far. We added a sentence to the beginning of the Methods explaining the goal of conducting more realistic field experiments. We think working with the proposed team of external stakeholders, as

described in Comment 1, will help push us further towards this goal. We have also added more examples throughout the proposal where multistate researchers are currently testing multistate objectives in the field against specific pests or implementing extension based on their research findings. In hindsight, it's clear that the original proposal undersold how much of this is currently happening and will continue to flow from this multistate project. We made sure that each Objective now has examples of specific field research that is being planned.

Appendix G: Peer Review (Submitted)

Status: Complete

Project ID/Title: NE_TEMP2501: Harnessing Chemical Ecology to Address Agricultural Pest and Pollinator Priorities

Rate the technical merit of the project:

1. Sound Scientific approach:

Approve/continue project

2. Achievable goals/objectives:

Excellent

3. Appropriate scope of activity to accomplish objectives:

Excellent

4. Potential for significant outputs(products) and outcomes and/or impacts:

Good

5. Overall technical merit:

Excellent

Comments

This comprehensive proposal presents a well-developed, multi-disciplinary approach to discovering and implementing chemical ecology based solutions to pest and disease management and pollinator protection in major Northeastern crops. The proposing team has a long history of working in this area, with many ongoing collaborations that have been productive over the prior project period. The implementation and maintenance of chemical ecology infrastructure is a great component, and connecting that infrastructure to researchers via this multistate project will continue to help this research area flourish in the region. The proposed research areas range from pheromone research to microbial effects on plant chemistry to plant breeding and cover crop effects. It covers all the major areas we know are the main access points to use chemical ecology to improve crop production via reducing reliance on broad spectrum pesticides. Approaches proposed are feasible for implementation in the Northeast given its agronomic practices and farm sizes. My only criticism of the proposal is the focus on one-way communication in the prior and proposed outreach plans. The team should also work to understand barriers to adoption and stakeholder priorities through two-way communication. My reading suggests measurement of "changes in knowledge" will be prioritized but there are no clear plans to measure changes in behavior or barriers to use of some of the more readily implementable strategies (e.g., those that require changes in practices but not commercialization of new technologies). It would also be great to see more emphasis on that translation process being proposed. The group has accomplished many things during the prior project period - which outputs require next steps for them to be used by stakeholders? What are those next steps and how can the group work together to facilitate them? There is a little bit in the proposal about this but it is not fleshed out. It is great to produce many new technologies and options but the next step is to figure out how to take them to the stakeholders and what barriers need to be overcome for this to happen.

Your Recommendation:

Approve/continue project

Appendix G: Peer Review (Submitted)

Status: Complete

Project ID/Title: NE_TEMP2501: Harnessing Chemical Ecology to Address Agricultural Pest and Pollinator Priorities

Rate the technical merit of the project:

1. Sound Scientific approach:

Approve/continue project

2. Achievable goals/objectives:

Excellent

3. Appropriate scope of activity to accomplish objectives:

Excellent

4. Potential for significant outputs(products) and outcomes and/or impacts:

Excellent

5. Overall technical merit:

Excellent

Comments

The proposed multistate project draws together researchers from the northeastern states and across the US to support sustainable insect pest control in agriculture using approaches under the broad umbrella of "chemical ecology". The group aims to reduce the potentially harmful effects of traditional pesticide use on pollinators, beneficial insects and the broader environment through the development of practices that take advantage of natural methods (plant resistance through breeding, intercropping, microbe-plant-pest interactions, and landscape-level management approaches) while also seeking to optimize the use of traditional chemical pesticides to reduce harm. A centerpiece of this work is the Chemical Ecology Analytical Core Facility, located at Cornell, which provides access to analytical chemistry tools for project members (and the broader research community) and allows for measurement of pesticides and plant phytochemicals. These analytical tools are a linchpin for the work proposed as the cost and expertise required for these methods is often a barrier and the incorporation of this Core Facility into the Multistate project, combined with the broad expertise of the participants, lays the groundwork for substantial advances in developing pest control approaches that minimize environmental impact. While the work proposed is broad in scope, as would be expected with a large team, their history of conducting productive meetings, publishing, and securing collaborative grants suggest that the multistate project will be effective at synergizing the research conducted by the participants and providing actionable solutions to pest control problems in the region. It is important to note that the work of the project has been and will continue to be effectively communicated to stakeholders through traditional Outreach and Extension programs, in addition to webinars and other online outputs.

Strengths:

The availability of the Chemical Ecology Analytical Core Facility at Cornell, with access to both instrumentation and expertise, is a real highlight of the project and will accelerate research on chemical ecology among group members. This spans the entirety of the project, from detecting pesticides in bees, to measuring phytochemical content, to identifying and quantifying insect and plant signalling molecules.

Inclusion of work on the invasive insect pests spotted wing Drosophila and the spotted lanternfly addresses problems in NE agriculture that will be applicable to other regions of the US as these invasive insects spread.

The coming ban on neonicotinoid seed treatments in NY and VT provides a unique opportunity for collaborative longitudinal studies to assess the impact of this pesticide use on both beneficials and pollinators, as well as impact on agricultural production.

A focus on breeding resistance in crop plants and the phytochemicals mediating crop resistance, with a focus on crops grown in the NE US, is extremely promising.

The contribution of microbial communities to pest resistance is a relatively new field of research, with novel approaches under development, that will benefit greatly from the collaborative relationships this multistate project will foster.

The large group has had successful meetings, with 51 PI's involved and 32 attending their meeting. They have been very successful at publishing their work, with 117 publications, and have garnered \$7 million in grants from governmental and non-governmental sources. They have submitted a large collaborative grant to establish a NSF Science and Technology Center (CTC)

Weaknesses:

I was expecting to see a mention of resistance management to chemical pesticides. I understand that the focus of the project is on reducing pesticide use, but the approaches developed through the project should also provide growers with alternative methods of pest control that can address and manage pesticide resistance. This is not a criticism of the work proposed as much as it is a missed opportunity in the framing of the project.

Your Recommendation:

Approve/continue project

Appendix G: Peer Review (Submitted)

Status: Complete

Project ID/Title: NE_TEMP2501: Harnessing Chemical Ecology to Address Agricultural Pest and Pollinator Priorities

Rate the technical merit of the project:

1. Sound Scientific approach:

Approve/continue project

2. Achievable goals/objectives:

Good

3. Appropriate scope of activity to accomplish objectives:

Good

4. Potential for significant outputs(products) and outcomes and/or impacts:

Excellent

5. Overall technical merit:

Excellent

Comments

The proposal represents a unique multi-state and multi-disciplinary collaboration using chemical ecology tools to understand and solve agricultural issues with pest control and pollination using solutions that can greatly reduce pesticide use. A core strength of the proposal is shared-used core analytical facilities that all members an access cost effectively. The proposal builds nicely off of previous work. The inclusion of social media to the outreach and extension objective is timely. The new inclusion of controlled environment agriculture crops is also a nice addition responding to a production system that is increasing. In Objective 2 it would be nice to see some examples of specific multi-state collaboration listed - for example, could approaches be tested within the same crop at different types of geographic sites (with their underlying diversity of farm sizes/approaches) to better understand landscape level impacts on chemical ecology mediated pest control? The one example mentioned of neonicotinoid seed treatments nicely addresses coming policy in NY, VT, and beyond. The proposal would be strengthened through greater demonstration of specific planned research with multi-state collaboration (beyond sharing analytical facilities and information exchange). The outreach plan appears sound and comprehensive, the group might brainstorm a cohesive collaborative activity such as a collection of extension bulletins/fact-sheets or a multi-part series of articles on the specific topics being addressed.

Your Recommendation:

Approve/continue project

Appendix G: Peer Review (Submitted)

Status: Complete

Project ID/Title: NE_TEMP2501: Harnessing Chemical Ecology to Address Agricultural Pest and Pollinator Priorities

Rate the technical merit of the project:

1. Sound Scientific approach:

Approve/continue project

2. Achievable goals/objectives:

Excellent

3. Appropriate scope of activity to accomplish objectives:

Excellent

4. Potential for significant outputs(products) and outcomes and/or impacts:

Fair

5. Overall technical merit:

Good

Comments

Two considerable strengths of this project: 1. It brings many chemical ecologists together, fantastic for idea exchange. 2. The chemical ecology analytical facility provides an essential tool that few can afford, but many can now use.

The primary weakness of this project: it advertises (in the non-technical summary) developing sustainable pest control strategies, but in reality focuses almost entirely on studying chemical interactions in many systems with the vague hope that understanding interactions will ultimately prove useful in developing control strategies. Looks like a push-pull strategy is being tested to control spotted wing Drosophila - and this is very good - but what about all the other pests mentioned?

I recognize that many (most?) academics assume that if one studies a pathosystem long enough, control strategies will emerge. And, in some cases, they do. But I'd argue not nearly often enough. I'd challenge the team to test, early and often, in the field, whether their understanding of particular signaling allows for pest control in the manner they expect. (There are hints this is indeed happening, but the pests being targeted are not identified - see, e.g., section titled 'crop diversification can be used to increase sustainable pest control'). And for the majority of cases where it doesn't, to then develop and test new hypotheses about what else needs to change for the pest to be controlled. The best way to solve problems is to try to directly solve them. Not just studying aspects of the system in isolation, reveling in whatever newfound knowledge emerges, publishing, and moving on.

A project whose true goal was pest control would organize the proposal around the pests for which control was being sought, would document substantial collaboration with growers affected by those pests, and outline what control strategies were being tested.

Your Recommendation:

Approve/continue project

NECC_TEMP2501: Sustainable Farm Energy Production and Use

Status: Submitted As Final

Duration

10/01/2025 to 09/30/2030

Admin Advisors:

[\[Puneet Srivastava\]](#)

NIFA Reps:

Non-Technical Summary

Farm energy production and use is a critical component for the success of agriculture in the United States and worldwide, as energy utilization “powers” the modern agriculture enterprise and on-farm energy production is a critical component of plans to shift the nation’s energy basis to a more renewable, sustainable basis. This regional project group will work together to carry out research, education, and extension activities on farm energy topics. The work will be targeted to benefit farmers who will be able to make informed decisions about energy production, energy use and efficiency, and have access to new opportunities for farm energy production and utilization. The group’s development of a shared farm energy teaching curriculum will help prepare ag professionals to understand and utilize energy in an effective manner, while the research and extension activities will connect farmers to the latest understanding with respect to energy on the farm.

This regional project will continue and expand on previous work in the area of ag energy. Some significant work and collaborations have occurred during the past project timeline. Some highlights include:

2021-2024

1. Research and Demonstration Projects

- **GREENBOX Urban Farming Trials** (Connecticut):
 - Lab trials on indoor year-round vegetable production.
 - Energy/water use comparison and simulation model development.
- **Agrivoltaics Projects:**
 - Research on integrating crop/livestock systems with solar energy (Rutgers, Illinois, Virginia).
 - Participation in DOE FARMS program and evaluation of NJ’s Dual-Use Solar Pilot Program.
- **Bioenergy Research:**
 - Biochar and anaerobic digestion with poultry litter (Penn State, Maryland).
 - Biomass and biogas technology trials and student research (Penn State).
- **Solar Farm Development** (Illinois):
 - Completed 12.32 MW Solar Farm 2.0 with pollinator habitat under panels.
- **Geothermal Energy Tools and Outreach** (Illinois):
 - Developed a decision-support tool using geologic data; held related webinars.
- **Motor Efficiency Prototype** (Michigan):
 - Tested an alternative to variable-frequency drives for large farm motors.

2. Educational Programs and Outreach

- **Online & In-Person Educational Events:**
 - Webinars and videos on solar, anaerobic digestion, and farm energy (Maryland, Penn State).
 - Smart Meter and Energy Efficiency outreach to underserved communities (Illinois).
- **University Courses:**
 - Penn State offered courses in Biorenewable Systems and hosted the Renewable Energy Academy.
- **Guidebooks and Publications:**
 - Book: *Regional Perspectives on Farm Energy* (Penn State, 2022).
 - Guide: *Planning & Zoning for Solar Energy Systems* (Michigan State).
 - Two book chapters on greenhouse and on-farm renewables (Rutgers).
- **Conferences:**
 - MSU organized the 2022 National Extension Conference on Energy Efficiency.

3. Technical Assistance and On-Farm Support

- **Energy Audits & Assessments:**

- USDA REAP Energy Audits conducted in Michigan.
- Use of CART tool for resource assessments.
- Maryland provided technical support for poultry litter digesters.

- **Smart Energy Management:**

- Use of smart meters and campus energy dashboards (Illinois).

- **Infrastructure & Efficiency Upgrades:**

- LED greenhouse lighting replacements and digester support (Rutgers, Penn State).

4. **Collaborative Proposals and Grant Work**

- **Multi-institutional Initiatives:**

- Energy for the New Farm Video Series (Michigan, Penn State, Nebraska, Rutgers, Virginia, Illinois)
- Participation in MASBio and C-Change projects.
- USDA-NIFA Sustainable Agricultural Systems proposals.
- Ongoing collaborations in agrivoltaics (Virginia, Maryland, NJ).

- **Solar Energy Workforce Training:**

- MSU coordinated with industry and government on solar technician workforce needs.
- Nebraska solar installation workforce training and solar workforce economic analysis training.

Statement of Issues and Justification

Farm energy production and use is a key component of the region's sustainable agricultural future. While the advent of cheap fossil fuel in the 20th century undergirded phenomenal growth in agricultural productivity and labor efficiency, the new millennium has featured twin drivers of rising and highly variable cost of energy coupled with increased demand for sustainable and local resources. The agricultural community faces increased risk and decreasing profits from the first factor, and faces a potential new market opportunity from the second. These issues can be addressed by means of improving the sustainable production and use of energy on the farm.

Sustainable energy use entails the adoption of advanced energy management strategies to reduce energy waste and improve effectiveness of use. This includes taking advantage of new market opportunities in the semi-deregulated energy markets of the region. Not all strategies are effective in all settings, as climate, productivity, use patterns, regulatory constraints and available resources all vary from farm to farm.

Farm-based energy production and use is a subject of research, extension, and educational need in the Northeast Region and throughout the nation. On the production side, limited adoption of solar, wind, biogas, and biomass energy has indicated that potential exists to improve the energy productivity of farms, but the lack of continued growth, due to knowledge gaps in the science and engineering of energy production, combined with limited understanding in the farm community and limited access to financing for proven technologies, are roadblocks that must be surmounted.

Energy use is a significant knowledge gap area in the agricultural sector. While some limited research has been conducted in the past on energy use patterns, very little is really understood about farm energy use patterns, or the factors that influence those patterns. The recent and ongoing development of the energy marketplace, including deployment of smart grid technologies, deregulated energy markets, an emphasis on distributed generation, and the growth of the renewable energy credit marketplace have contributed to a changing context for energy production and use. How these changes are affecting the farming community is still not apparent.

The Farm Energy Multistate Coordinating Committee will work together to address critical issues and opportunities related to the production and use of energy on the farm. These issues include:

- lack of understanding of current farm energy use patterns
- the need to evaluate the impacts and opportunities for farms arising from the changing energy production sector
- the need for improved technologies, systems, and approaches for optimizing energy use on the farm
- the need to enable the expansion of on-farm production of renewable and sustainable energy
- the need for farmers and farm professionals who are well educated and capable of understanding and improving farm energy performance

The coordinating committee will work collaboratively to carry out research, extension, and education in this important area. More specifically, the project will include:

Research: Investigation into farm energy utilization benchmarks, renewable energy system performance, renewable energy economics, and new opportunities for effective utilization and production of energy in the agricultural sector. Surprisingly, farm energy use benchmarks are not well established for the major farm types. Key research questions to be addressed include

- How does energy use vary across the major farm sectors in the region?
- What factors influence the intensity of farm energy use?
- What new technologies can be developed to produce energy on the farm?
- What new technologies can be developed to dramatically reduce energy use on the farm?
- How does the performance of renewable energy systems vary seasonally and annually when operated in an agricultural environment?
- What systems and approaches for energy production are readily scalable to farm production?
- What are the impacts of farm-based energy production and use on the stability and reliability of the regional energy distribution network?
- What are some cost effective ways to improve the electrical grid in rural areas to facilitate the export of electricity from farms?
- How do economic factors impact the adoption, expansion, and financial sustainability of renewable farm-based energy production?

Extension: Extension efforts are needed, in the form of state and regional programs and sharing of extension resources across states. This will lead to stronger, better resourced programs and a better educated, more capable farm community. Extension efforts that are needed in this area include:

- Written, Online, or Video outreach materials – made widely available and shared among educators
- Joint Extension Activities – leveraging regional skills and experience for greater overall impact
- Demonstrations Projects – showcasing innovative early adopters of sustainable energy systems and approaches
- Case Studies – demonstrating the feasibility and key challenges facing sustainable energy on the farm
- Assessment Tools – making it easier for farmers to self-assess and educators to provide guidance to the process of identifying energy opportunities

Education: Educational needs in this area will be addressed through sharing and joint development of educational content for primary, secondary, and tertiary audiences. The foci of the education efforts will be on enhancing the capabilities of ag professionals, growing the energy savvy of ag producers, and demonstration of energy strategies at the farm scale. Education efforts in this area are to include:

- Creation and sharing of educational materials for lectures and student discussion
- Creation and sharing of educational materials for labs and practical training
- Creation and sharing of assessment materials and approaches
- Needs assessment for education in this topic area

The breadth and depth of these efforts will be dependent in large part on the degree of project funding generated by the group (proposal preparation will be a priority).

How the proposed activity addresses national and/or regional priorities:

Work in this area is important for the future of farms in America. Energy conservation is a key need that contributes to improved profitability, reduced risk, and improved ecological and environmental attributes of farms. The changing landscape of energy markets, including deregulation, development of smart grid technologies, growing concerns about energy sustainability, emissions, and the recent growth of unconventional energy production, has shifted the energy landscape considerably and created new constraints and opportunities that need to be understood and addressed. Energy production is a significant opportunity within this context, providing sustainable energy inputs to farming operations and the communities in which they are located. Research work in this topic area will inform extension and education efforts, education work in this area will prepare the next generation of ag professionals and practitioners, and extension work will empower the ag community to make wise and fully informed choices with respect to energy production and use on the farm.

Failure to develop effective research, extension, and education programs on this topic will reduce the agricultural sector's robustness and resilience, and as a result of higher energy expenditures, reduced farm sustainability, and lost economic opportunities.

The stakeholders to be reached as a result of this project will primarily include farmers, but will also include farm consultants, farm equipment providers, and end users of farm products.

Objectives

1. Prepare an updated survey report on the "regional farm energy status and outlook"
 2. Review and update the shared e-extension online Farm Energy website
 3. Create a shared curriculum resource for teaching both undergraduate and graduate level courses covering farm energy
 4. Prepare and submit joint proposals for funded projects in farm energy research, education, and extension
-

Procedures and Activities

The regional coordinating committee in Sustainable Farm Energy and Use will meet in person on an annual basis, and will meet telephonically on a quarterly basis each year. The quarterly meetings will consist of 50% informal seminar presentation and 50% project business updates. During the first year, the group will establish specific tasks for achieving its stated objectives, and work together to accomplish those objectives. One team member will be assigned “task coordinator” duties for each of the four project objectives, and will establish a detailed timeline and milestones for achieving that objective.

Expected Outcomes and Impacts

- Exchange of ideas and information related to farm energy
 - Publication of a regional farm energy report
 - Identification and pursuit of key research, education, and extension issues
 - Coordination of research and extension programs in farm energy
-

Educational Plan

Ease of Access to Services/Information:

Services and information for the general public will primarily be delivered through the Cooperative Extension services of the participating universities. These organizations are committed to equal access and availability of services and information, thus assuring full access of project outputs. Research outputs will be made available through research reports, papers, presentations, and demonstration projects. Project outputs and resources will, as much as is possible, be posted online in an appropriate format that is accessible and usable.

Focus on Under-Served Communities/Consumers:

This project is focused on the agricultural sector, and by that very nature is relevant to and valuable for rural communities in the region that typically are economically disadvantaged and lag the urban areas in economic opportunities and income. The team will assess the availability and suitability of extension products for emerging and underserved sectors of the ag economy.

Plans for disseminating information:

Information will be disseminated via workshops, presentations, research papers, and online and print material generated by the members of the regional team.

Opportunities to interact with and/or deliver value to peer groups, stakeholders, clientele, other regional activities:

Whenever possible, meetings and workshops will be held in conjunction with other events held in the region, thus maximizing the opportunity for interacting with and adding value to peer groups, stakeholders, and clientele. Private consultants, practitioners and industry personnel will be welcomed to take part in the regional project group as non-voting “associates”.

Organization/Governance

The group will be led by a chair and vice-chair, selected by vote of those present at the annual meeting. The term of office for vice-chair and chair is two years, such that the first year will be as vice chair, and the second year as chair.

Committee Chair: Schedule and convene group meetings, establish agenda, and facilitate the distribution of tasks related to the group's research, education, and extension objectives. Prepare group progress reports as required.

Committee Vice Chair: Host the annual meeting and quarterly online calls, assist the committee chair with his/her tasks, record and distribute minutes of the annual meetings.

A committee secretary can be appointed by the chair, if so desired, to assist with group paperwork, communication, etc.

Activities of the group will be carried out on a collaborative, consensus-driven basis as much as possible, with votes of members (one vote per land grant institution) used on any matters where consensus has not been reached. Meetings will be conducted using procedures adapted from “Roberts’ Rules of Order”.

Literature Cited

Brown, E., and R. N. Elliott. 2005a. On-Farm Energy Use Characterizations. American Council for an Energy Efficient Economy. Report #IE052.

Brown, E., and R.N. Elliott. 2005b. Potential Energy Efficiency Savings in the Agriculture Sector. American Council for an Energy Efficient Economy. Report #IE052.

Carroll, E., M. Brown, F. Xavier, and C. Kumar. 2010. Small and Medium Sized Business Customers: Proactive Services to Increase the Installation Rate of Efficiency Upgrades,” in Proceedings, 2010 ACEEE Summer Study on Energy Efficiency in Buildings, 15-20 August 2010, Pacific Grove, CA, pp. 4-19-4-31.

Ciolkosz, ed. (2022). Regional Perspectives on Farm Energy. Cham: Springer International Publishing.

Craumer, P.R., 1979. Farm Productivity and Energy Efficiency in Amish and Modern Dairying. Agriculture and Environment, 4(1978-79)281-299.

Ludington, D., and E. Johnson. 2003. Dairy Farm Energy Audit Summary. NYSERDA Project Report. New York State Energy Research and Development Authority. Albany, NY.

Morris, M, Dana, R., Hill, H., and A. Kurki. 1999. Farm Energy Audits: Availability, Usefulness, and Cost. USDA Risk Management Agency Report #06IE08310060-P.

Perlack, R.D., and Stokes, B.J. (leads). 2011. U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN. 227p.

Pimentel, D., Berardi, G., and S. Fast. 1983. Energy Efficiency of Farming Systems: Organic and Conventional Agriculture. Agriculture, Ecosystems and Environment, 9(1983)359-372.

Shaw, S. 2008. Progress Report on Small Wind Energy Development Projects Receiving Funds from the Massachusetts Technology Collaborative (MTC). Cadmus Group Inc.

Slocombe, J.W., Feyerherm, A.M., and L.E. Stetson. 1992. Electrical Energy Usage on Kansas Grain Farms. Transactions of the ASABE. 8(2):263-266.

USDA, 2007, USDA Census of Agriculture.

USDA, 2009. On-Farm Renewable Energy Production Survey: Farms Reporting Photovoltaic (PV) and Thermal Solar Panels by Type, Capacity, Installation. USDA Census of Agriculture.

Land Grant Participating States/Institutions

IL,NJ,VT,MD,CT,NE

Non Land Grant Participating States/Institutions

Participation

Participant	Is Head	Station	Objective	Research						Extension	
				KA	SOI	FOS	SY	PY	TY	FTE	KA

Combined Participation

Combination of KA, SOI and FOS	Total SY	Total PY	Total TY
Grand Total:	0.50	0.00	0.10
601	0.05	0	0
609	0.05	0	0
206	0.1	0	0.1
205	0.1	0	0
132	0.1	0	0

Program/KA	Total FTE
Grand FTE Total:	0.11
206	0.03
205	0

In response to review comments, the technical team added the language below to the non-technical summary to capture activities from the previous 5-year cycle of this coordinating committee.

This regional project will continue and expand on previous work in the area of ag energy. Some significant work and collaborations have occurred during the past project timeline. Some highlights include:

2021-2024

1. Research and Demonstration Projects

- **GREENBOX Urban Farming Trials** (Connecticut):
 - Lab trials on indoor year-round vegetable production.
 - Energy/water use comparison and simulation model development.
- **Agrivoltaics Projects:**
 - Research on integrating crop/livestock systems with solar energy (Rutgers, Illinois, Virginia).
 - Participation in DOE FARMS program and evaluation of NJ's Dual-Use Solar Pilot Program.
- **Bioenergy Research:**
 - Biochar and anaerobic digestion with poultry litter (Penn State, Maryland).
 - Biomass and biogas technology trials and student research (Penn State).
- **Solar Farm Development** (Illinois):
 - Completed 12.32 MW Solar Farm 2.0 with pollinator habitat under panels.
- **Geothermal Energy Tools and Outreach** (Illinois):
 - Developed a decision-support tool using geologic data; held related webinars.
- **Motor Efficiency Prototype** (Michigan):
 - Tested an alternative to variable-frequency drives for large farm motors.

2. Educational Programs and Outreach

- **Online & In-Person Educational Events:**
 - Webinars and videos on solar, anaerobic digestion, and farm energy (Maryland, Penn State).
 - Smart Meter and Energy Efficiency outreach to underserved communities (Illinois).
- **University Courses:**
 - Penn State offered courses in Bio renewable Systems and hosted the Renewable Energy Academy.
- **Guidebooks and Publications:**
 - Book: *Regional Perspectives on Farm Energy* (Penn State, 2022).

- o Guide: *Planning & Zoning for Solar Energy Systems* (Michigan State).
 - o Two book chapters on greenhouse and on-farm renewables (Rutgers).
- **Conferences:**
 - o MSU organized the 2022 National Extension Conference on Energy Efficiency.
- 3. **Technical Assistance and On-Farm Support**
- **Energy Audits & Assessments:**
 - o USDA REAP Energy Audits conducted in Michigan.
 - o Use of CART tool for resource assessments.
 - o Maryland provided technical support for poultry litter digesters.
- **Smart Energy Management:**
 - o Use of smart meters and campus energy dashboards (Illinois).
- **Infrastructure & Efficiency Upgrades:**
 - o LED greenhouse lighting replacements and digester support (Rutgers, Penn State).
- 4. **Collaborative Proposals and Grant Work**
- **Multi-institutional Initiatives:**
 - o Energy for the New Farm Video Series (Michigan, Penn State, Nebraska, Rutgers, Virginia, Illinois)
 - o Participation in MASBio and C-Change projects.
 - o USDA-NIFA Sustainable Agricultural Systems proposals.
 - o Ongoing collaborations in agrivoltaics (Virginia, Maryland, NJ).
- **Solar Energy Workforce Training:**
 - o MSU coordinated with industry and government on solar technician workforce needs.
 - o Nebraska solar installation workforce training and solar workforce economic analysis training.

Appendix J1: CC Evaluation (Submitted)

Status: Complete

Project ID / Title:
NECC_TEMP2501: Sustainable Farm Energy Production and Use

Questions

- | | |
|---|-----------|
| 1. Goals and objectives clearly stated and appropriate to committee activity(s) | Excellent |
| 2. There is a good potential to attain the objectives and plan identified in the activity. | Good |
| 3. Activity addresses priority research and is not duplicative with existing activities. | Excellent |
| 4. Activity has moved beyond individual activity(s) and ideas to a collective, interdependent activity. | Excellent |

For renewal projects only:

- | | |
|--|------|
| 5a. Attendance of the preceding project has been adequate and reflects broad participation by designated project participants. | Good |
| 5b. The project has developed and demonstrated technology transfer to clientele. | Good |

Recommendation
Approve/continue with normal revision.
Comments:

Appendix J1: CC Evaluation (Submitted)

Status: Complete

Project ID / Title:
NECC_TEMP2501: Sustainable Farm Energy Production and Use

Questions

- | | |
|---|-----------|
| 1. Goals and objectives clearly stated and appropriate to committee activity(s) | Excellent |
| 2. There is a good potential to attain the objectives and plan identified in the activity. | Excellent |
| 3. Activity addresses priority research and is not duplicative with existing activities. | Excellent |
| 4. Activity has moved beyond individual activity(s) and ideas to a collective, interdependent activity. | Excellent |

For renewal projects only:

- | | |
|--|-----------|
| 5a. Attendance of the preceding project has been adequate and reflects broad participation by designated project participants. | Excellent |
| 5b. The project has developed and demonstrated technology transfer to clientele. | Excellent |

Recommendation

Approve/continue with normal revision.

Comments:

This is an important project and should be approved. I do think a discussion, effort to understand adoption and use this information to enhance the project would be a welcome addition. The biggest obstacle this project may face is rejection by producers.

Appendix J1: CC Evaluation (Submitted)

Status: Complete

Project ID / Title:
NECC_TEMP2501: Sustainable Farm Energy Production and Use

Questions

1. Goals and objectives clearly stated and appropriate to committee activity(s)	Excellent
2. There is a good potential to attain the objectives and plan identified in the activity.	Excellent
3. Activity addresses priority research and is not duplicative with existing activities.	Excellent
4. Activity has moved beyond individual activity(s) and ideas to a collective, interdependent activity.	Excellent
For renewal projects only:	
5a. Attendance of the preceding project has been adequate and reflects broad participation by designated project participants.	Needs Improvement
5b. The project has developed and demonstrated technology transfer to clientele.	Needs Improvement

Recommendation
Approve/continue with normal revision.

Comments:
I can't tell if this is a renewal project or not. If it is, no previous results were provided.