# RESEARCH INTERESTS

The overarching aim of my research program is to explore how habitat structure at local and landscape scales influences species diversity and ecosystem functioning and to apply that knowledge towards advancing sustainable management of agricultural systems. Currently, over 50% land area is devoted to agriculture and grazing. This intensification in land-use practices has altered the structure and composition of the environment with major consequences for species diversity and key ecological processes. Yet, improving agricultural productivity is essential to sustaining the growing human population. Though we must protect our remaining natural habitats, it is also important to improve the land we are already using in ways that create a win-win for conservation and agricultural production. *As a broadly trained community and evolutionary ecologist, I use tools ranging from phylogenetics to landscape ecology to investigate both basic ecological and applied agricultural questions* related to this issue. The principle focus of my research program is understanding and conserving ecosystem services provided by arthropods, such as pollination and biological control, in order to create solutions for more resilient and sustainable agricultural production.

*Previous Research*

Ecologists and agricultural researchers have increasingly recognized the value of biological control and pollination services provided by unmanaged insects in crop production systems worldwide. Yet, the factors that influence their abundance and contribution to crop production remain poorly understood. It is unclear if practices aimed at promoting one service will support or undermine the other. By studying the action of pests, their natural enemies, and pollinators within the same study system, my research has provided clarity to this important question, including guidance for optimizing management practices. I combine data from remote sensing of landscape composition with extensive insect community inventories including molecular detection of parasitoid larvae in their hosts to show that both pollinator and natural enemy communities were negatively impacted by agriculturally simplified landscapes; although at different scales, suggesting different management strategies would be more effective for their conservation. Furthermore, I found that the highly diverse community of wild bees (>90 species) not only dramatically outnumbered managed honey bees in strawberry fields, but were equally efficient in providing pollination services.
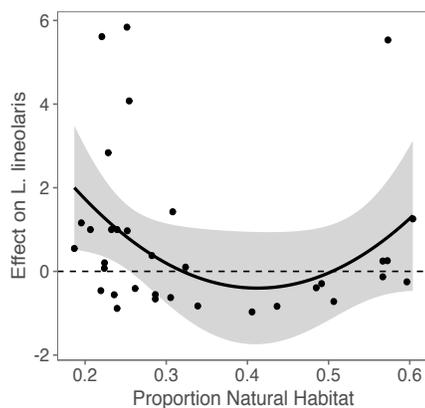


Figure 1. Wildflower borders reduce pest pressure only in landscapes with intermediate natural land cover.

To promote pollinator conservation, the US government, through the Conservation Reserve Program, currently invests millions of dollars in planting flower rich habitats on working lands. Theory suggests that local diversification strategies like these will be most effective when implemented in particular landscape contexts. In a large-scale multi-year experiment, I tested the effectiveness of perennial wildflower restoration plantings on the structure of pollinator, herbivore and parasitoid communities and their combined effects on strawberry yield in various landscape contexts. I found that wildflower strips were most effective at decreasing pest pressure (Fig. 1) and supporting pollinator communities in landscapes with intermediate amounts of natural habitat. More interestingly, the effects of flower strips translated to higher yields in intermediate landscapes, but not in simple or complex landscapes. My work will allow conservation

practitioners to target their efforts towards areas that create a win-win for conservation and agricultural production.

In landscapes where implementing pollinator plantings is less effective or impractical, my research suggests that planting sequentially blooming crops can promote pollinator abundance and crop pollination services. In collaboration with another research group (Danforth Lab) studying wild bee pollination of apples, we designed a large-scale field experiment to determine how nearby mass blooming apple impacts the pollination rates of co-blooming strawberry. Both crops have high overlap in their pollinator community (Fig. 2). The results of this study are the first empirical evidence that mass blooming crops have a strong impact on the pollination rate and yield of co-blooming crops and can act as an important driver of pollinator community dynamics and pollination services at local and landscape scales.
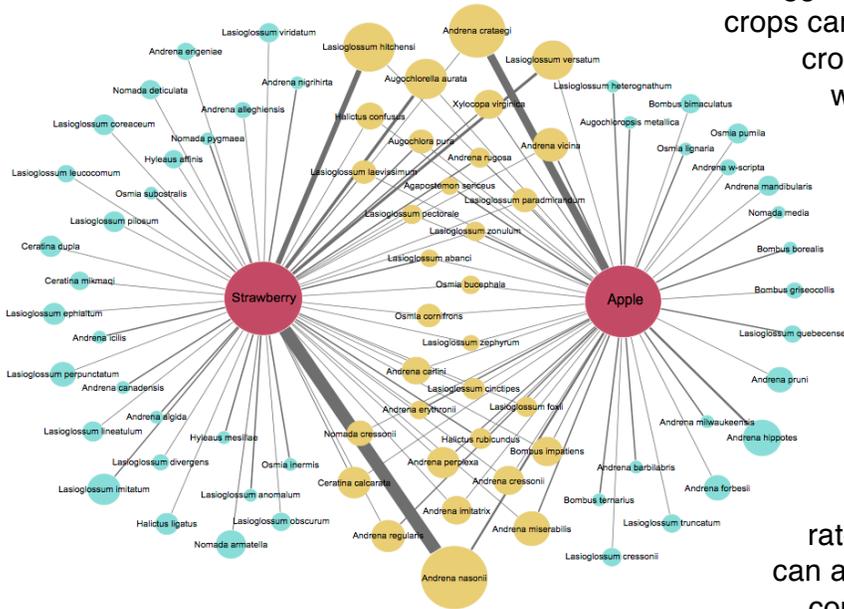


Figure 2. Plant pollinator network highlighting overlap between apple, a mass flowering crop, and co-blooming strawberry.

## Ongoing Research

My previous research suggests that improving habitat with wildflower plantings in the appropriate landscape context can promote wild bee communities; however, very little is known about which bee species successfully use the plantings. We also know very little about the consequences for pathogen transmission dynamics when attracting wild pollinators to these dense resource patches. To better understand these dynamics, I am collaborating with undergraduate researchers and colleagues (McArt Lab) to create detailed plant pollinator networks based on exhaustive sampling of bees visiting both strawberry and wildflower plantings. We have found to date that the wildflower plantings tend to support generalist bees with long flight seasons rather than specialists with shorter periods of activity. Furthermore, shifts in network structure are associated with increased risk of pathogen transmission between bee species (Fig 3). These findings will be critically important in informing pollinator management strategies as policies have begun supporting the planting of floral resource habitats for managed honey bees in areas where they are likely to come in contact with native bees.



Figure 3. Plant-pollinator network highlighting bee pathogens (purple = *Trypanosomes*, yellow = *Neogregarines*, blue = *Nosema*) shared between flowers (left) and bees (right)
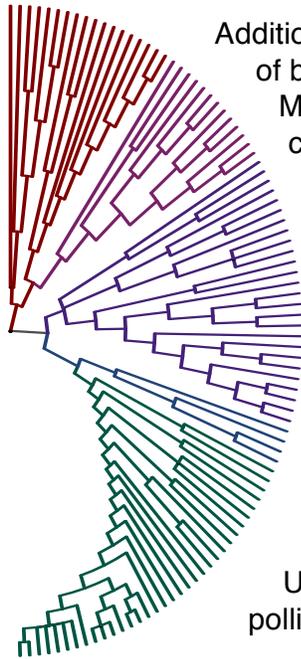
Figure 4. Phylogeny of the apple pollinator community

Additional ongoing collaborations include a study of the phylogenetic diversity of bee communities across landscape gradients with the Danforth Lab and Michael Branstetter at the USDA ARS. Using Illumina sequencing of ultra conserved elements (UCE's) we created a phylogeny of the apple pollinator community (Fig. 4) based on thousands of loci across the genome. We find that closely related bee species share many similar traits that mediate their response to landscape simplification ultimately leading to a pattern in which whole clades are lost from agricultural landscapes. Non-random loss of taxa means that bee communities in high agriculture landscapes are more closely related and functionally similar in pollination behavior resulting in lower pollination services and fruit quality.

Ecologists are increasingly recognizing the role of intra-specific variation in community ecology and ecosystem functioning. As part of an ongoing collaboration with Rufus Isaacs at Michigan State University, I am exploring the extent of intra-specific body size variation in pollinator communities across a landscape gradient. We are finding that individuals of many species are smaller in highly agricultural landscapes (Fig. 5) but the addition of floral resources can recover body size for some species.

*Future Research*

My goal continues to be the study of processes driving species diversity and ecosystems services in agricultural landscapes. In order to predict, conserve, and manage the valuable services provided by wild insects, we require a greater understanding of the traits of both insects and agricultural landscapes that allow them to persist. I have developed a diverse skill set including molecular and phylogenetic analyses, large-scale field studies, landscape analysis and quantitative methods that can be applied to solve agricultural challenges in Kansas and worldwide.


Figure 5. *Andrena nasonii* collected in low (left) and high (right) agriculture landscapes.

In my future research, I would like to build on my previous findings by addressing the role of species traits in facilitating species persistence and ecosystem services including natural enemies and pollinators. I am particularly interested in using bioinformatics approaches in natural history collections and manipulative field experiments to explore how plasticity or rapid evolution in traits like body size allows species to survive in agriculturally dominated landscapes. I would also like to use meta-analytic tools to contribute to a more global understanding of how land use intensification impacts ecosystem services and crop yield. I hope to use this knowledge to mitigate the negative consequences of landscape simplification on key ecosystem service providers. I feel my research program and expertise is complementary to existing strengths in the Department of Entomology. My interests are broad, and I would maintain a dynamic and collaborative lab that provides an engaging environment for students to develop as independent scientists. I would look forward to incorporating new local study systems, topics, and collaborations with colleagues both within Entomology and across other departments.

To read more about my research interests including more detailed project descriptions, photos from the field, and media coverage please visit www.landscape-agroecology.com/