
Photo by Jason Gibbs

OPERATION POLLINATOR: 2016 REPORT

Department of Entomology
Michigan State University

This report contains a summary of research conducted in Michigan in 2014, 2015 and 2016. We are evaluating whether maturing and established wildflower restoration plantings increase pollinator abundance, diversity, and reproduction in farmland. This project also examines optimal pollinator restoration design, establishment and maintenance for the Great Lakes Region.

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INTRODUCTION

Operation Pollinator is a program supporting research and education efforts to promote wild pollinators in agricultural landscapes across the globe. In the United States researchers at Michigan State University are continuing to explore the role of habitat restoration for supporting bee diversity and abundance on farmland.

PROJECT OBJECTIVES

- **Evaluate response of bee communities to new and mature wildflower restoration plantings**
- **Assess if wildflower plantings enhance bee reproduction and population stability**
- **Determine important nesting habitat for spring-emerging ground-nesting bees**
- **Develop optimal planting and management methods for on-farm habitat enhancements**
- **Create extension and outreach programming to highlight benefit of pollinator habitat for growers**

New plantings were sown in the fall of 2013 and spring of 2014 and were compared with mature perennial plantings ranging from 5-15 years old. The project aims to study how pollinator communities establish through time on restoration plantings and how quickly pollinator communities in new plantings reach levels of species richness and abundance found in mature plantings.

Additionally, we aim to determine if plantings promote increased nesting by different species of bees or if they simply attract foraging bees to dense flowering patches. We also identify key nesting habitat surrounding farmland during crop bloom for important spring-emerging blueberry pollinators. This is a critical component for understanding long-term impacts of enhanced habitat and landscape composition for increasing pollinator populations.

MICHIGAN BEE DIVERSITY

There are over 463 different species of bees found in Michigan. More than 90 percent of wild bee species are solitary and build nests in tunnels underground or other cavities found in nature. These bees provide important pollination services for economically valuable crops like blueberries, apples, cherries, almonds, and melons as well as many wildflowers.

So far, this study has found over 100 different species of wild bees from 23 different genera in wildflower restoration plantings. That is almost one third of all the species in Michigan.

Common Bee Species

Miner Bees (*Andrena*)

Bumble Bees (*Bombus*)

Mason Bees (*Osmia*)

Leaf Cutter Bees (*Megachilidae*)

Cellophane Bees (*Colletes*)

Carpenter Bees (*Xylocopa*)

Long Horned Bees (*Melissodes*)

Honey Bees (*Apis*)

Sweat Bees (*Halictidae*)

Photos by Jason Gibbs, University of Manitoba

STUDY SITES

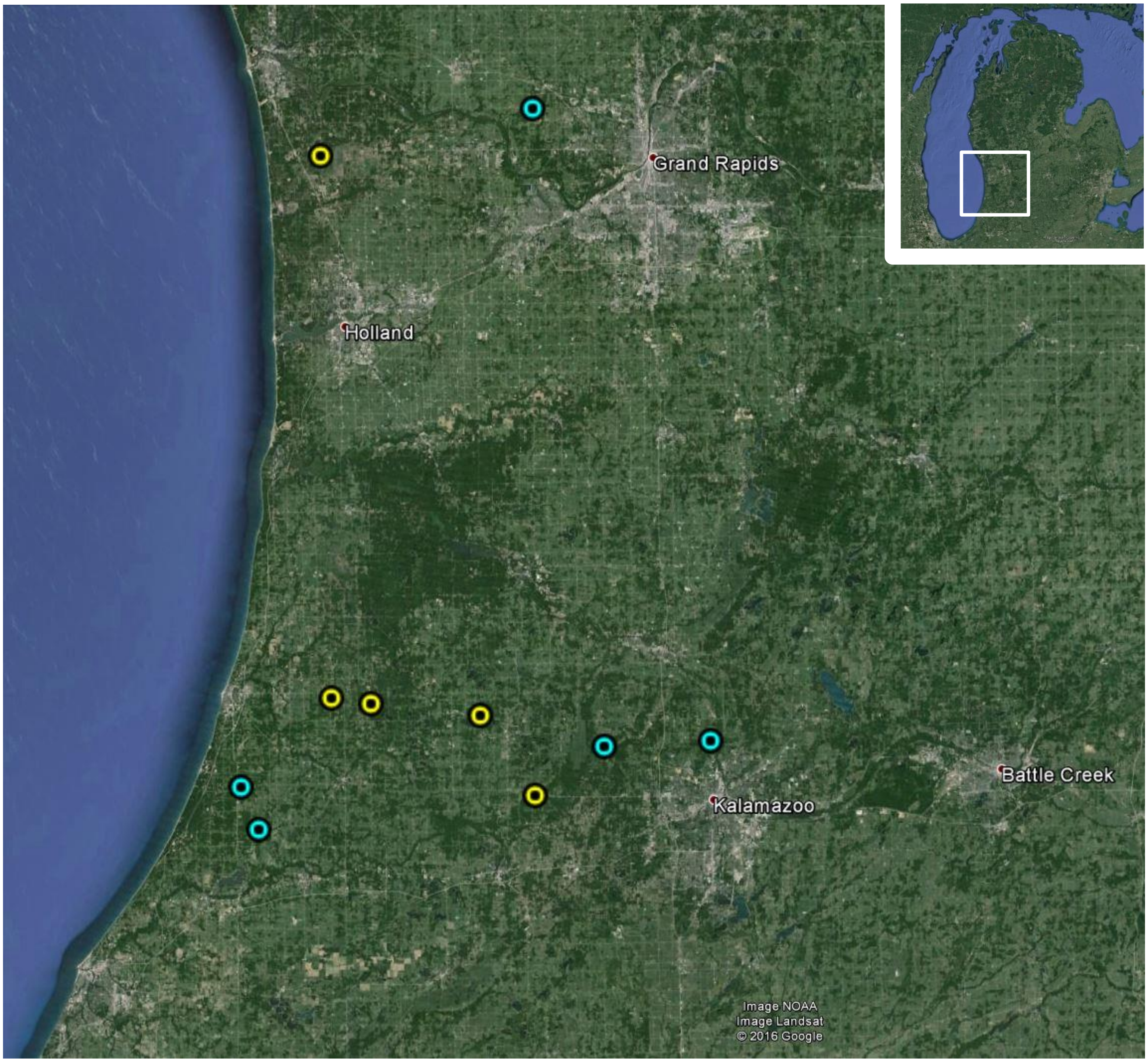


Figure 1. Map of 2016 Operation Pollinator sites sampled for bees in Michigan. Yellow dots are farms with newly established plantings, and light blue dots are mature plantings.

METHODS

Starting at the end of May or early June and continuing until late September we sampled five newly established and five mature wildflower plantings (Figure 1). All 10 sites were paired with a nearby control area that was a grassy field margin, wooded edge, or fallow field with some weedy plants available for bees to visit. All sites were sampled in three rounds in the summer of 2014 and four rounds in the summer of 2015 and 2016. There were four to five weeks between sampling dates to capture shifts in bee community and floral phenology through the season. Within each sample round, sites were visited within quick succession and the order of site sampling was changed between rounds. Plantings and controls within each pair were measured on the same day, and relative timing of sampling was flipped each round.

New plantings were adjacent to blueberry farms but mature sites varied in their proximity to agricultural fields. Each planting had a control area at least 100 m away from plantings. These control sites were considered to be the alternative habitat for bees to choose from and represent what is present without wildflower plantings. Control sites for new wildflower plantings were mown grassy margins, and control sites for mature plantings were wooded edges or fallow, unrestored field areas (Figure 2).

Figure 2. Habitats sampled for bees under the Operation Pollinator project in Michigan. a) Control for new wildflower plantings, b) New wildflower planting, c) Control for mature wildflower planting, d) Mature wildflower planting. All photos taken in late July.

Bee Abundance and Diversity

Figure 3. Field assistant, Shaana Way, net collecting bees in the field.

We sampled pollinators only when conditions were >16 °C, the wind was <3.5 m/s, and when the sky was sunny, partly cloudy, or bright overcast. In early spring, sampling started later in the day to accommodate for weather conditions. Weather conditions were recorded before and after sampling and used in the analysis.

At each site, bees were sampled along a 100 meter transect, one meter to each side in both the planting and control sites. Transects were started at a randomized location during each sample round. We walked the length of the transect and net collected flower-visiting insects for 40 minutes, stopping the timer to transfer insects into cyanide vials (Figure 3). The flower species visited by the insect was recorded. A "visit" was defined as an insect landing on the flower and collecting resources. To ensure sampling was spread along the transect, we did not spend more than two minutes on patches of flowers in each transect. After the 40 minute sampling period, we walked throughout the plot to opportunistically collect pollinating insects for an additional 10 minutes, stopping the timer for netting and vial transfer to capture bees concentrated in areas at the site not present in our transect.

Honey bees that were possible to catch within the transect were counted and the flower species they visited was noted and analyzed separately from the netted specimens.

Floral Abundance and Diversity

At each site and sample round, a photo of the site was taken from the same location. Flowers were sampled at the same time bees were sampled from the same 100 m transect in 20 1m x 1m quadrats placed at five meter intervals along the transect. In each quadrat, the numbers of fresh, open flowers were counted for each species, and the species were recorded. Additionally, each flower was measured to determine the floral area (Figure 4). Percent bare exposed soil, percent forbs, and percent grass were also recorded for each quadrat.

Figure 4. Measuring the diameter of New England Aster (*Symphyotrichum novae-angliae).*

Bee Nesting

STEM NESTING BEES:

Tunnel nesting tubes of various sizes and substrates were placed at each new and established wildflower planting and at the on-site control in early spring of 2014, 2015, and 2016. They were left at each site until late fall. Nests were comprised of a set of 40 of five types of tubes (5mm cardboard, 6mm cardboard, 7mm cardboard, 8mm cardboard, natural reeds) and a wood block (Figure 5). These were placed in blue boxes placed two meters above the ground and mounted on metal posts.

Figure 5. 2015 Nest box design with wire mesh to keep predators out of the box.

The numbers of completed nest tubes with mud, leaf, or grass caps made my nesting bees or wasps were recorded by site, treatment (restoration/control), and tube type. Tubes were overwintered in mesh bags to control for predation by winter birds. In spring, bees that nested in the tubes in the previous year emerged and were counted. Species and abundance were recorded for treatment and tube type.

GROUND-NESTING BEES:

During blueberry bloom, 40 emergence traps were placed in three farms under blueberry bushes, field margins, wooded edges, and in the wildflower planting to determine important nesting habitat for ground-nesting blueberry pollinators (Figure 6). Microhabitat measurements (bare ground, leaf litter, surface cracks, ant nests, slope, and aspect) were recorded. Traps were placed in the evening and left for three days before being rotated to new locations in order to cover as much area as possible. The abundance and species of bees collected in each habitat type was recorded.

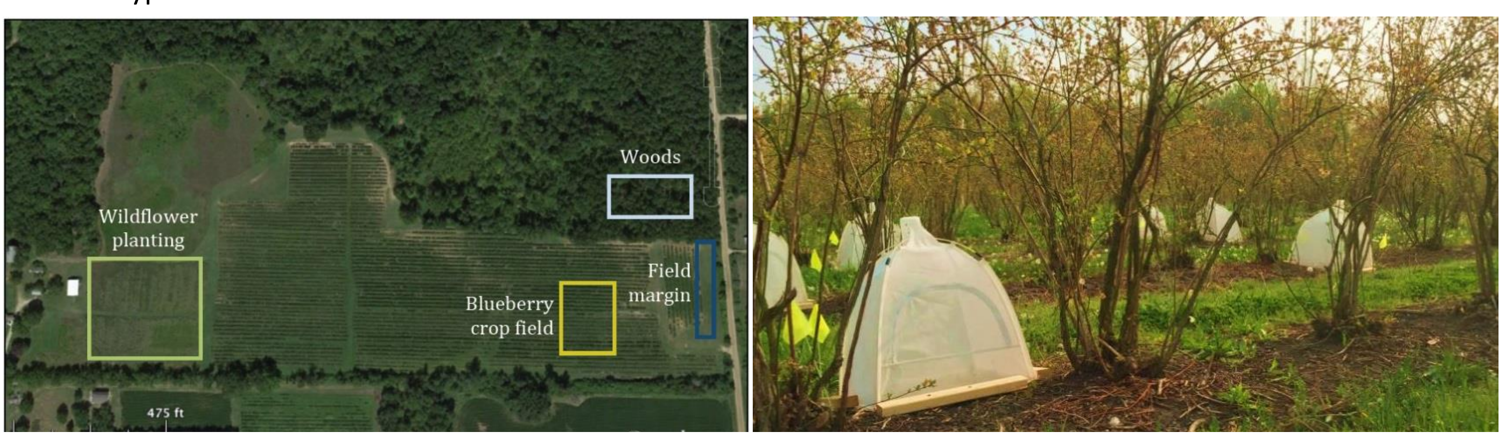


Figure 6. a) Layout of study design with locations of traps. B) Emergence traps in under blueberry bushes during crop bloom.

Figure 7. Foxglove Beardtongue (*Penstemon digitalis)* seedling in a plant sample quadrat.

Newly sown plantings were sampled in the fall each year to determine the diversity of seeded plants. In each plot, percent cover of target species, weeds, and bare ground was determined in 40 1m x 1m quadrats stratified randomly throughout the plot. Additionally, the numbers of each sown plant species were counted in each quadrat (Figure 7). When weeds accounted for more than 25% of quadrat, they were identified.

SITE MANAGEMENT

Overview

Sites with new wildflower plantings were intensively managed for weeds throughout the summer and fall in 2014-2016. Field margins adjacent to crop fields are high in weed pressure and implementing successful perennial wildflower plantings that support bees and other insects requires active management inputs during the first few years of establishment (Figure 8).

Figure 8. Field assistant, Erin Forster, spot-spraying weeds with herbicide.

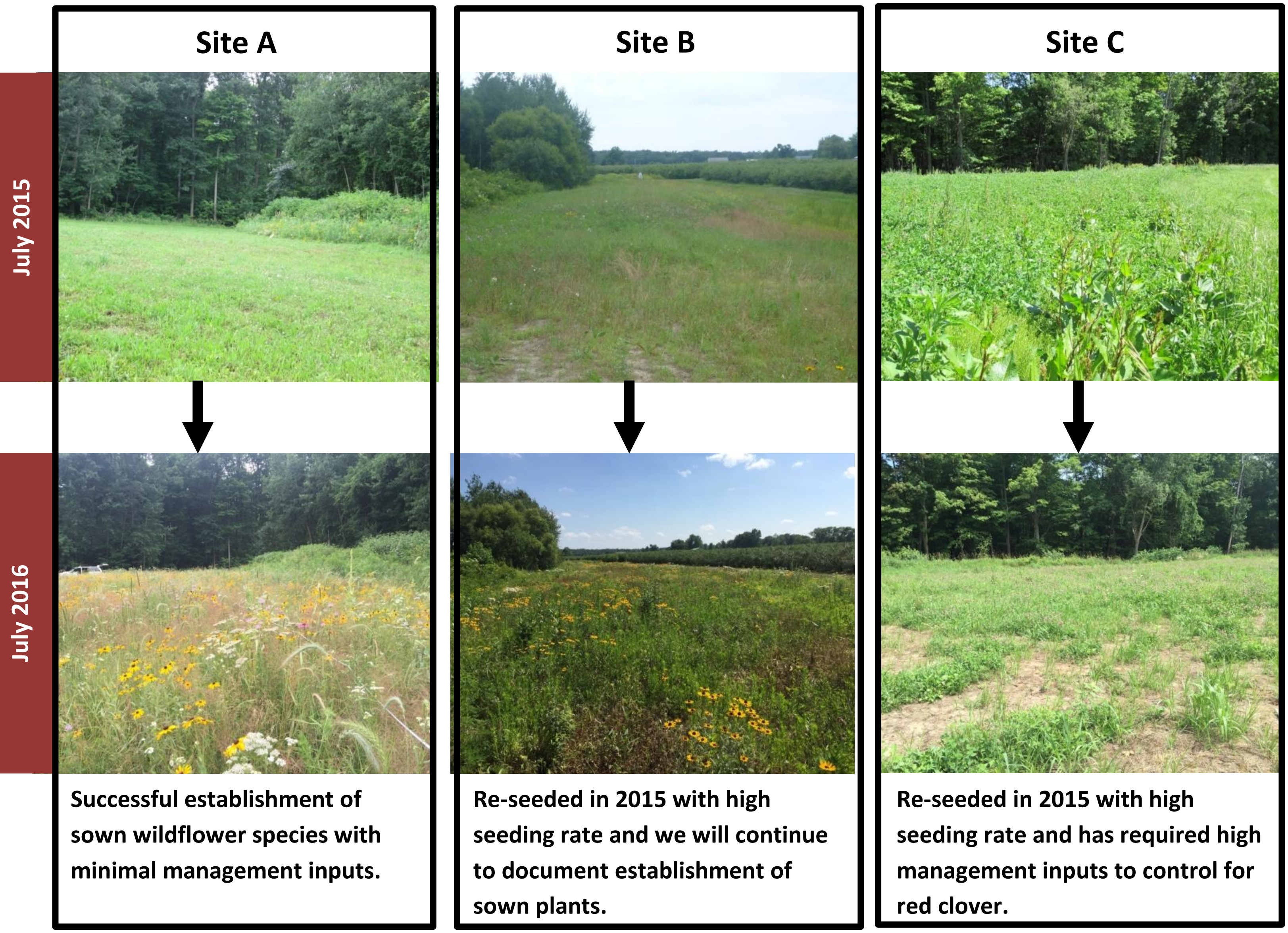
Perennial wildflowers primarily concentrate energy to their root system during the first few years of growth whereas weedy plants concentrate energy to produce leafy vegetation. Weeds can out-compete and prevent growth of seeded perennial wildflowers in areas with high weed pressure.

Weed Control Strategies

Managing wildflower plantings requires an adaptive management throughout the season and across years. To control weeds, we use a variety of techniques depending on the site and severity of the weed problem.

1. **Mowing 6-8 inches when weedy species are flowering**: This prevents weeds from seeding and further contributing to the seed bank and allows light to penetrate to lower vegetation to encourage growth of seeded species. This is particularly important in years 1-3 after planting.
2. **Hand weeding**: Some annual or biennial weedy species with shallow roots can be controlled by hand pulling.
3. **Herbicide:** Hardy, perennial, clonal, or aggressive weeds are best controlled using glyphosate and dicamba spot and boom spray treatments (Figure 8).
4. **Harrowing:** Gently raking and disturbing the soil exposed new weedy seed banks that can then be eradicated before seeding.
5. **Re-seeding at a high rate:** Sites with poor establishment can be seeded again at a high rate of 11lb/acre of a grass and forb mix.

SITE MANAGEMENT: Variation in successful establishment



Next Steps

In 2017, sites will be monitored for plant establishment and managed as necessary for weeds using mowing and spot spraying with glyphosate herbicide.

Additionally, we will begin a large scale field experiment to determine which management factors drive success of sown wildflower species in order to provide better and more informed recommendations to growers and land managers when implementing restoration. We will examine the interaction between pre-seeding variables (herbicide, cover-cropping, frequent mowing), seed mix variation (low and high rates), and post-seeding management (mowing and spot spraying) to determine which factors are important for success of establishing wildflower species for pollinator habitat restoration.

RESULTS: Wild bee abundance by site

There was high variation in the average abundance of bees caught on the wildflower plantings between sites, treatments and years at both new and mature wildflower plantings (Figure 9).

Some control areas near to mature wildflower plantings had higher bee abundance because these areas can contain attractive weedy species, especially wooded edges or fallow fields. This research highlights the importance of studying bee communities over multiple seasons at established sites to gain insight into natural variation in bee abundance through time and how bee and plant communities vary across sites and habitat types.

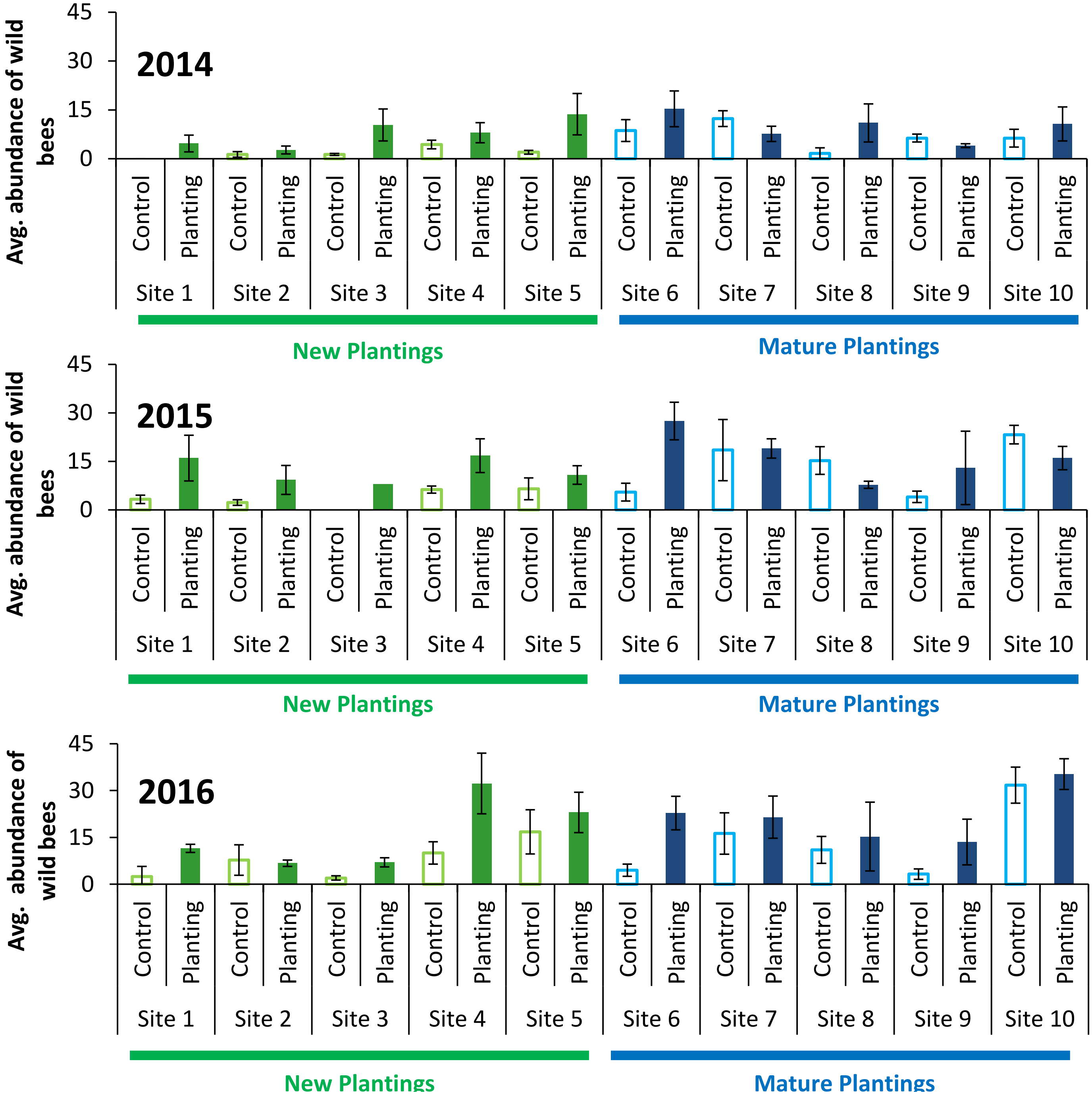


Figure 9. Average abundance of wild bees at each site with new and mature wildflower plantings in 2014, 2015 and 2016.

RESULTS: Wild bee abundance and diversity

Average abundance of bees increased through time in both new and mature wildflower plantings as compared to control areas (Figure 10). However, mature wildflower plantings did not show patterns of higher bee abundance as compared to associated controls. This could be due to various factors including land-use history, habitat type, and diversity of floral resources present at the site.

We also compared bee diversity between years and treatments using the Shannon Diversity Index to better understand the interaction between relative abundances of different bee species between treatments (Figure 11). This measure provides a more holistic understanding of a bee population structure in a given area. For example, two sites could have the same number of different bee species, but one site is dominated by one species with low numbers of other species whereas in another site, the community is an even mix of each species. Our results show that the Shannon diversity indices are similar between control and planted areas with plantings showing a trend toward higher Shannon diversity than grassy control areas.

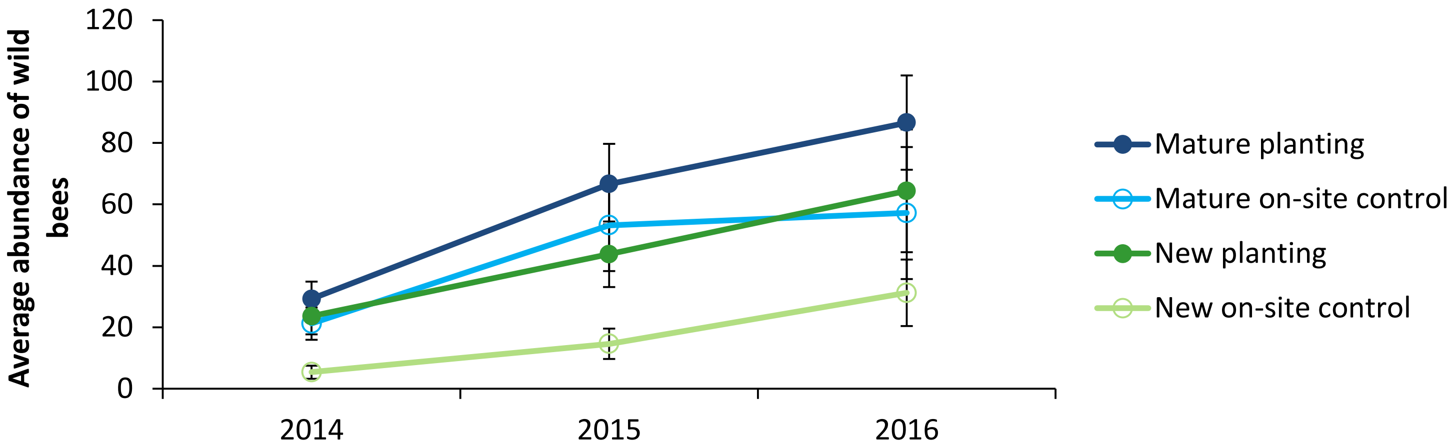


Figure 10. Average abundance of wild bees collected between May-September between treatments in 2014, 2015, and 2016.

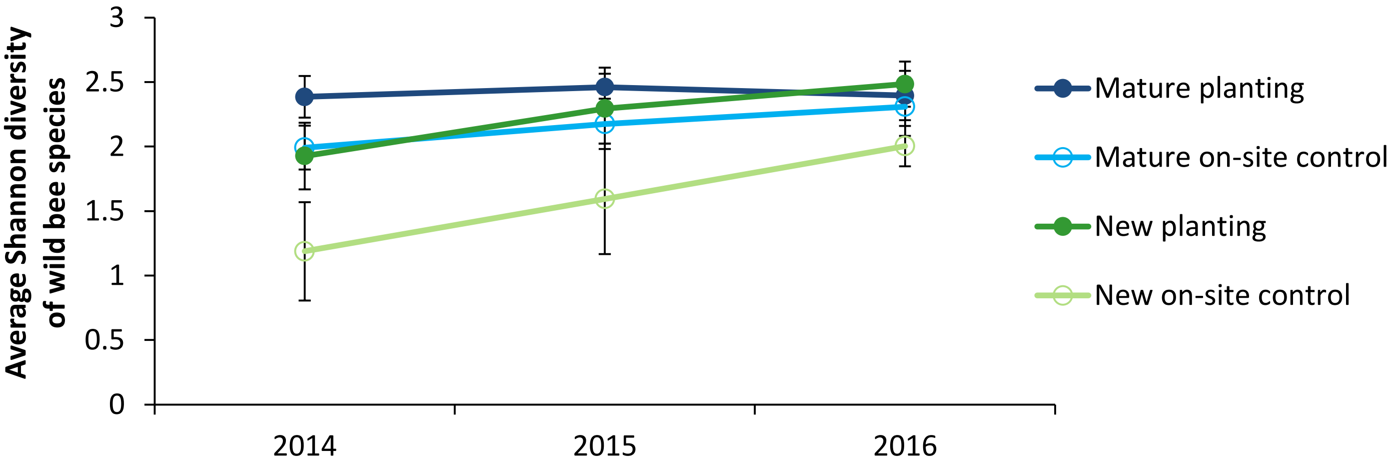
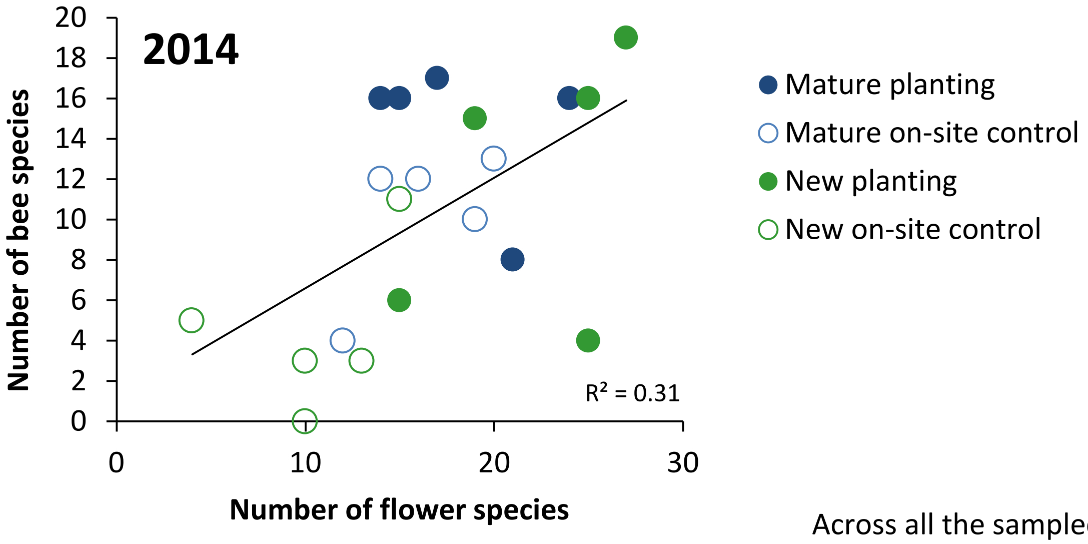
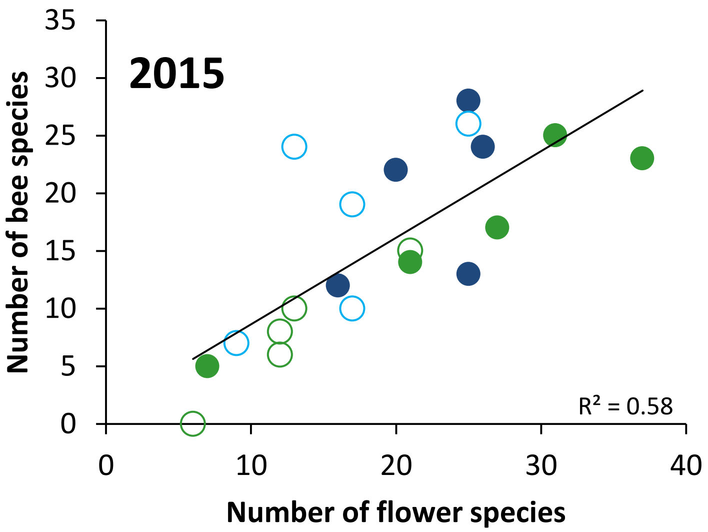


Figure 11. Average Shannon diversity indices of wild bee species collected between May-September between treatments in 2014, 2015, and 2016.





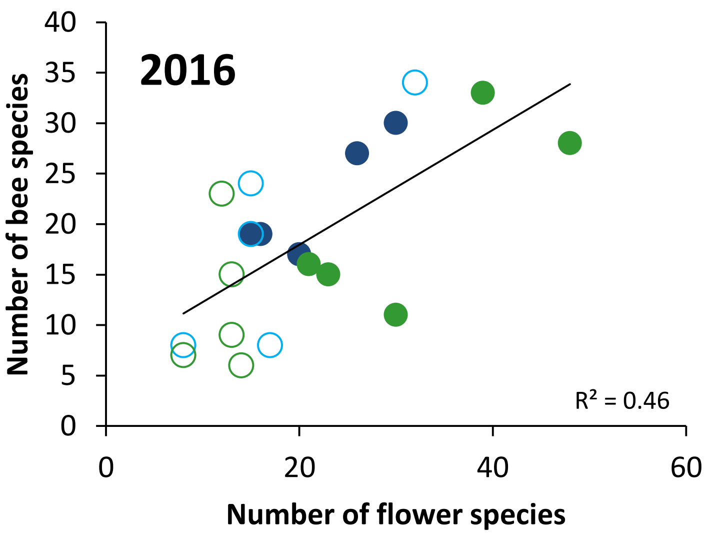


Figure 12. Number of bee species in relation to number of flower species present at a site in a given year.

Across all the sampled sites, the number of bee species increased in relation to the number of flower species present (Figure 12). This relationship was consistent for all three years of the study. These data help inform our understanding of factors driving variation in bee abundance between treatments as some control areas showed high diversity of flower species.

Additionally, these data further demonstrate the variation in floral species richness in habitat plantings between sites and years as they become more established.

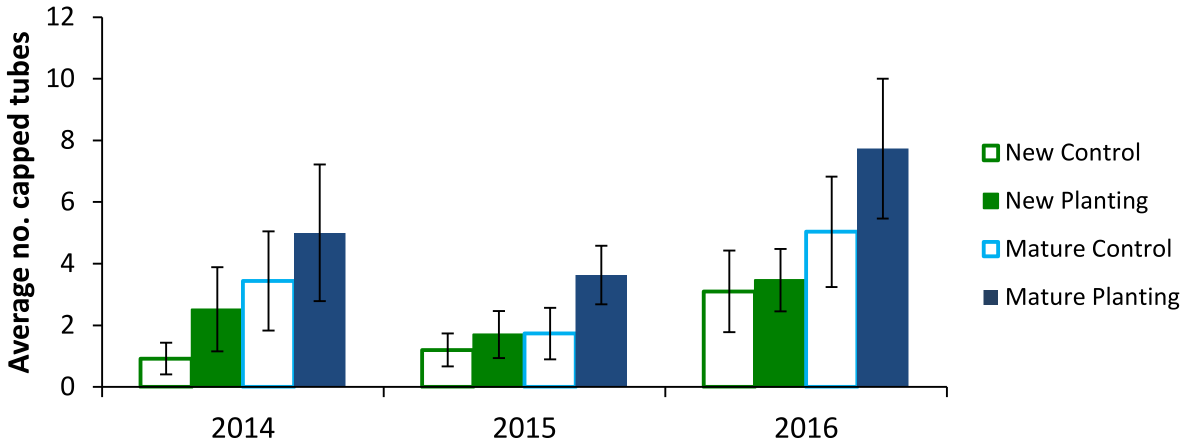
Further research will determine which flowering plant species drive bee diversity and abundance and how changes in floral communities influence bee community dynamics through time. This will provide a better understanding for how to design seed mixes that best support bee populations from implementation to establishment and maturity.

Stem Nesting Bees

The number of tubes with nests is highly correlated to the number of bees that emerged from the tubes in 2014. Because we are currently rearing bees that nested in 2016, we use the number of tubes with nests as a proxy for the numbers of bees in the nest boxes.

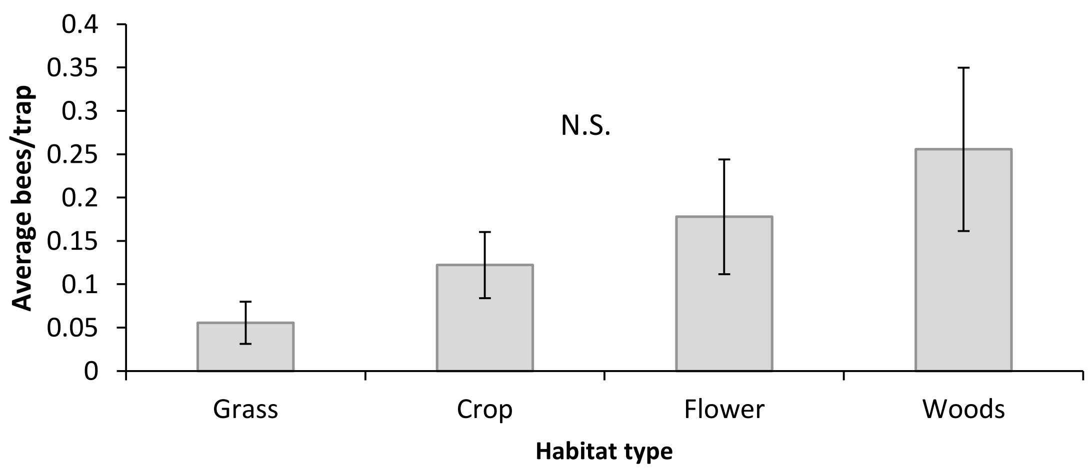
Many different insects will use these nesting boxes including solitary wasps, flies, and other beneficial insects. Mature plantings showed a higher number of nests than the associated controls across all three years. Most nests were found in the natural reeds and wood blocks as these may be more similar to what is available in the surrounding landscape.

Once the bees from 2016 have emerged, we will identify and document nesting insects and re-evaluate the data to better represent our findings.



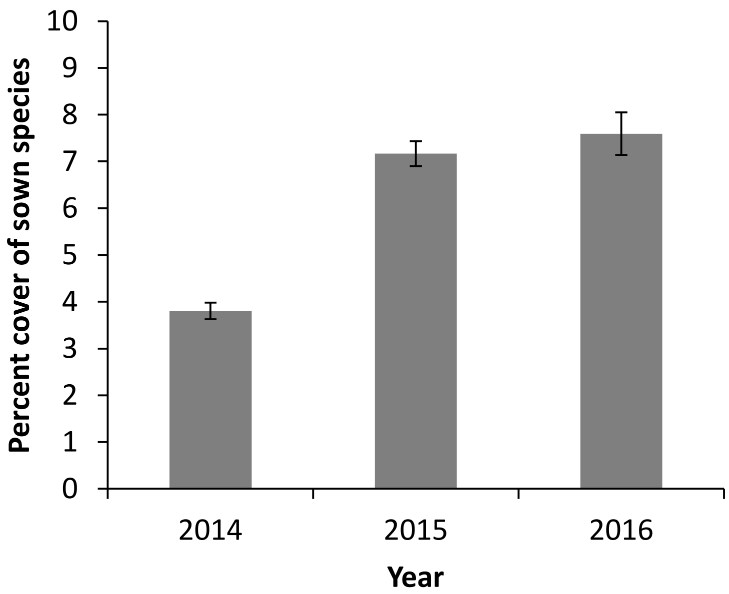
Ground-Nesting Bees

The number of bees caught per emergence trap did not differ significantly between habitat types, however there was a trend toward higher bees per trap in the wooded edges. These bees will be identified and we will determine which habitats were most important for blueberry pollinators. Additionally, we will determine which microhabitat variables correlate with bee abundance in each trap.



RESULTS: Wildflower establishment

Percent cover of sown species in the new wildflower plantings was low but showed a slight increase from 2014 to 2016. Sites with especially low establishment were re-seeded in December 2015 and we will continue to document their establishment in 2017.



Top Established Species

1. Black-eyed Susan (*Rudbeckia hirta*)
2. Lance-leaved coreopsis (*Coreopsis lanceolata)*
3. New England aster (*Symphyotrichum novae-angliae*)
4. Lance-leaved goldenrod (*Euthamia graminifolia*)
5. Bee balm (*Monarda fistulosa*)
6. Evening primrose (*Oenothera biennis*)
7. Smooth penstemon (*Penstemon digitalis*)
8. Yarrow (*Achillea millefolium)*
9. Rough goldenrod (*Solidago rugosa)*
10. Brown-eyed Susan (*Rudbeckia triloba*)

SUMMARY

For the past three years, we have worked to evaluate the response of wild bee communities to newly established and mature wildflower restoration plantings on commercial blueberry farms and natural areas for the Operation Pollinator project. We have assessed whether these wildflower plantings not only attract foraging bees to dense flower patches, but also if these sites enhance reproduction which is important for wild bee population persistence and stability in agricultural landscapes. We also aim to determine effective management strategies for implementing and restoring on-farm wildflower enhancements that will establish and provide resources comparable to those at mature plantings. Finally, we also aim to create extension and outreach programing for growers and community members to highlight the benefits of enhancing habitat for pollinators.

At the 10 sites we surveyed in 2014-2016, we found that new wildflower enhancements on crop fields increased bee abundance over time as compared to field margins. We also found that as flower diversity increased, there was higher bee abundance. Additionally, after two years of establishment, bees have not yet reached the abundance and diversity found at mature wildflower restoration sites.

The nest boxes at mature wildflower plantings have been successful in attracting stem nesting wild bees and provide insight for nest substrate preferences and management strategies to attract and promote ground-nesting bees.

Additionally, our observations of wild bees and honey bee visitation to different flowering species will continue to inform conservation management for plants that are the most attractive for bees and can best support their populations over time.

FUTURE DIRECTIONS

Another year of sampling will be conducted at these sites in 2017 to monitor the progress of maturing plantings in relation to the established plantings for bee diversity, abundance, and reproduction. Seeded sites will be intensively managed for weed pressure starting in early spring through the fall to ensure successful establishment.

Nesting structures placed in spring 2016 are currently being analyzed for abundance and diversity and we have conducted another season of emergence trapping to determine ground-nesting bee habitat in and around blueberry fields.

Using network analysis of the interactions between plants and pollinators, we will determine floral preferences by wild bee crop pollinators. This will help to optimize seed mix design and determine which plant resources are most used by crop pollinators relative to their abundance in the wildflower plantings. Network analyses will provide quantitative measures of population stability through time as determined by the complexity and frequency of interactions between common and rare plant and pollinator species.

Starting in spring of 2017, we have started a pollinator habitat study to understand the outcomes of various site preparation methods for wildflower plantings at research stations and farms throughout the state. We will design a set of experiments that manipulate site preparation and seeding strategies used by growers and evaluate the resulting plant and pollinator community for habitat establishment.

We are developing outreach bulletins for MSU Extension on how to build nesting structures for stem nesting bees, and best practices for implementing successful wildflower habitats adjacent to crop fields.

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