CHESHIRE COUNTY POLLINATOR INITIATIVE

Prepared for:
Cheshire County Conservation District

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Cover photograph – A tri-colored bumble bee (*Bombus ternarius*) collecting pollen from a New England aster (*Symphyotrichum novae-angliae*) at the Franklin Pierce University pollinator garden during its first season.

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USDA
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CHESHIRE COUNTY
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INTRODUCTION

In their book, The Forgotten Pollinators, Buchmann and Nabhan (1996) estimated that animal pollinators are needed for the reproduction of 90% of flowering plants and one third of human food crops. Humanity depends on these industrious pollinators in a practical way to provide us with the wide range of foods we eat. In addition, pollinators are part of the intricate web that supports the biological diversity in natural ecosystems that helps sustain our quality of life. Abundant and healthy populations of pollinators can improve fruit set and quality (Garibaldi et al. 2014, Martins et al. 2015, and Vaughan et al. 2015). In farming situations this increases production per acre. In the wild, biodiversity increases and wildlife food sources increase.

The loss of commercial bee hives to Colony Collapse Disorder is a serious concern for the health of honey bees in our nation. Conservation biologists are also concerned about declines in native and wild bee abundance and species diversity. Besides honey bees, about 450 other bee species live in the eastern United States. Wild bees and other insects are important pollinators of cultivated and natural landscapes, but conversion of the landscape to residential and commercial uses eliminates natural bee habitats. Often, developed landscapes are not managed to create or enhance bee life. In addition, many insecticides and herbicides are either toxic to bees or destroy their habitats by killing flowers that provide bees with nectar and pollen (Black et al. 2016, Lee-Maider et al. 2014, and Vaughan et al. 2015). All these factors are contributing to the loss of bee populations and diversity.

The Cheshire County Conservation District began the Pollinator Initiative in June 2014. The overall purpose of the project was to help address concerns about pollinator conservation in Cheshire County. The primary goal of this project was to help address the current declines in pollinators and their habitats through the creation and enhancement of pollinator habitats throughout the County. Secondary goals included a vigorous public education and outreach campaign to share the innovative methodology of habitat creation and to share the results of the pollinator abundance and diversity monitoring program. Specific objectives to accomplish these goals included:

1. Develop a planting plan for each site based on an inventory of existing floral resources and soil testing;
2. Monitor and maintain each site over the 3-year project period to ensure successful habitat establishment;
3. Conduct pollinator surveys on four sites to determine if pollinator plant installations are having an effect on species diversity and/or abundance;
4. Conduct a variety of workshops to help inform the public about the project and demonstrate practices that can be accomplished by landowners;

The project created and/or enhanced pollinator habitat on 17 sites throughout Cheshire County (Figure 1). These included a variety of farm types such as orchards, berry farms, mixed vegetable farms, diversified farms, and hay operations. These farms included both organic and conventional management practices. There were non-farming landowners that collaborated on the project as well. A variety of methods were used to prepare each site for planting of seeds, plugs, and/or container plants. Herbicide treatment was used on many of the sites while a few sites were prepared using various organic methods. These included sheet mulching, solarization, and repeated light plowing. Management needs were kept to a minimum effort; however, some sites required annual maintenance. These sites will continue to need some form of annual maintenance for the next 2-3 years to ensure success of the habitat installation.

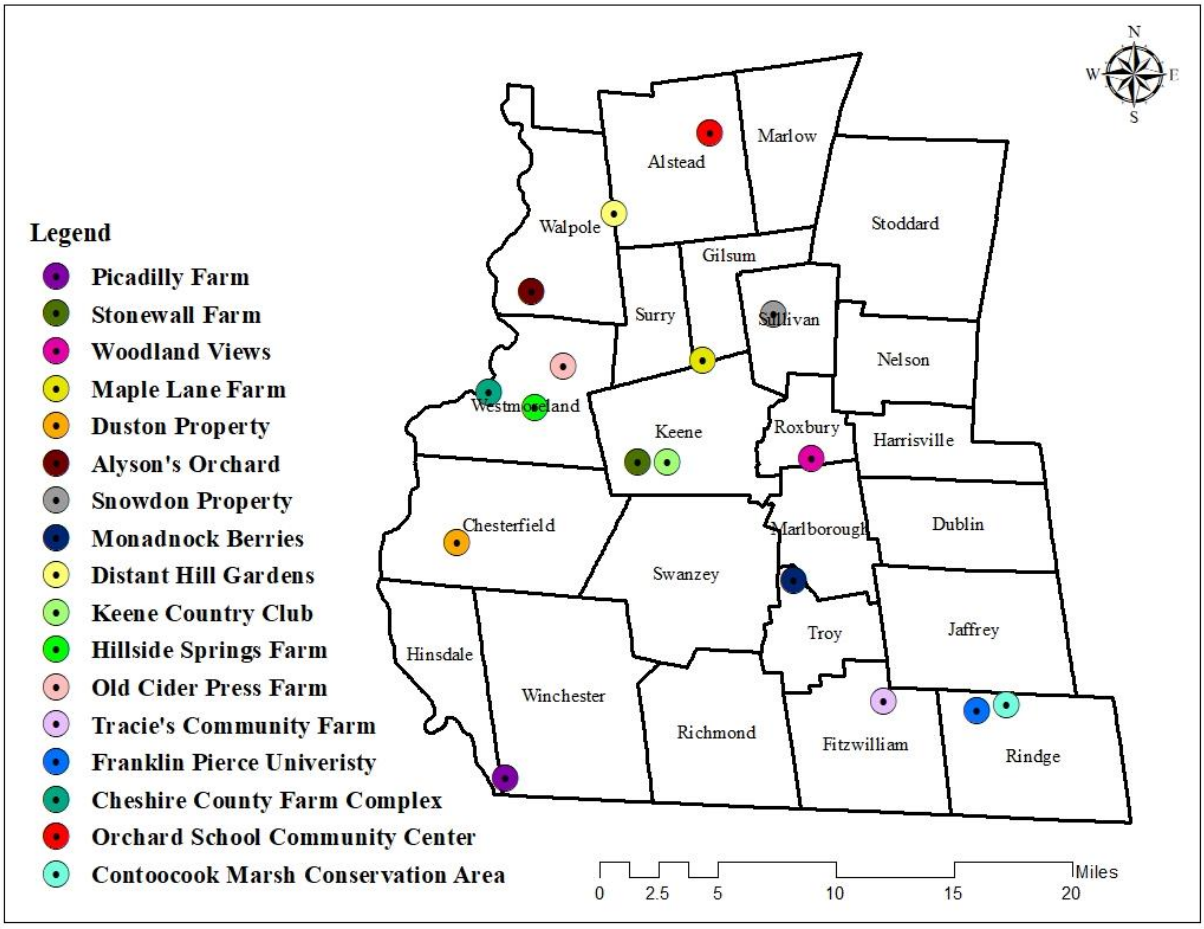

Figure 1 Distribution of the 17 sites for the Cheshire County Pollinator Initiative.

Project Partners and Collaborators

The success of this project was made possible through its funders, partners, and collaborators. Funding for this project was graciously provided by the State Conservation Committee's Conservation Grant Program and a Conservation Innovation Grant from the USDA Natural Resources Conservation Service. Figure 1 provides a list and location of the landowners that collaborated on this project. The following lists additional project partners that provided technical services throughout the duration of the project.

- Jeff Littleton, Moosewood Ecological LLC
- Jarrod Fowler, independent contractor and Xerces Society conservation biologist
- Joan Milam, entomologist

- Jeff Taylor, Vegetation Control Services, Inc.
- John Baybutt, independent contractor

FLORAL RESOURCES and SOIL SURVEYS

Floral resources were surveyed at all sites to help inform each planting plan. Surveys were conducted early in the growing season (June) and again later in the growing season (late August/early September) to ascertain the existing pollen and nectar resources for pollinators. A 1-km radius was surveyed around each site. A soil sample was taken from each site to better understand conditions for plant/seed selection.

POLLINATOR SURVEYS

It is often regarded that increasing pollinator food resources on a site can help to increase food production on farms. Research has shown that by enhancing or creating pollinator habitat farms are better equipped at providing much needed year-round resources to help crop production and reducing the needs to import bees (Lee-Maider et al. 2014, Vaughan et al. 2015).

Our project has included a pollinator inventor component to begin to examine these thoughts and support current research. At the outset of the Pollinator Initiative we identified 4 sites to conduct a 3-year inventory of pollinators, particularly bees, butterflies, and moths. The sites included Alyson's Orchard, Monadnock Berries, Picadilly Farm, and Woodland Views. The goal was to better understand diversity and abundance and to monitor these parameters over the 3-year period.

Pollinator surveys included three techniques: bee bowls (pan traps), direct observations, and aerial netting. Bees were sampled using pan traps set along transects. Each site had two transects; one placed within the pollinator habitat and the other placed within the cropland. Each transect was 100 feet long. Nine pan traps were evenly placed along each transect, for a total of 18 pan traps for each farm. Pan traps included white, yellow and blue cups to attract bees, and soap water was used to trap individuals. Aerial netting was performed along each transect to augment the data collected by the pan traps, which is biased towards bees. Also, the Streamlined Bee Monitoring Protocol (Ward et al. 2014) was employed for direct observations along each transect. These last two techniques provided additional data on other pollinators present at each site.

Joan Milam, entomologist, conducting aerial surveys along pollinator transects.

A total of 865 individual bees were captured in pan traps from 2015-2017, representing 95 species, 5 families, and 21 genera. Overall abundance and diversity of bees increased each year of the study for all sites combined (Table 1). Species abundance by site and year varied, showing a slight decline in total number of bees trapped at all sites except Woodland Views that showed a marked increase in bees in 2017. See Appendix A for the full report.

Table 1 Abundance and diversity of bees, Cheshire County, 2015-2017.

Year	2015	2016	2017	Total
Number of Species	48	60	65	95
Total Abundance	265	294	306	865

Field work setting up pan traps with soap water along transects to sample for bees.

COMMUNITY OUTREACH and EDUCATION

2015 Workshops

Workshop 1 - Eric Mader of the Xerces Society - Managing Habitat for Pollinators on Farms

There were approximately 40 people in attendance at this workshop that was held at Alyson's Orchard in Walpole NH on May 12, 2015. Eric discussed pollinator and beneficial insect economies and conservation status, basic pollinator and beneficial insect ecology, pesticide risk mitigation, and habitat restoration.

Workshop 2 - Jarrod Fowler of UMass Amherst - Native Pollinator Identification Workshop

25 people attended this event that took place on July 1, 2015 in Walpole NH at Distant Hill Gardens. This was an introductory level course on pollinator identification that also touches on the ecology and conservation of these species that play a vital role in our ecosystem.

Workshop 3 - New England Wildflower Society - Saving Seeds for Native Plants that are Beneficial to Pollinators

This workshop was held at Distant Hill Gardens on August 15, 2015. There were 25 people in attendance. The workshop went over how to save seeds from native pollinator plants in the landscape and how to get a new pollinator plot established.

2016 Workshops

Workshop 1 - Joan Milam of UMass Amherst at Stonewall Farm

25 people attended this event that took place on May 11, 2016 from 6-8pm. The focus of this workshop was on bee identification and habitat establishment. There was a tour given of the work that Stonewall Farm plans to do in partnership with NRCS through this project.

Workshop 2 - Jarrod Fowler of Xerces Society at Franklin Pierce University

25 people attended this event that took place on June 20, 2016 from 4:30-6:30pm. The focus was on basic pollinator family identification and ecology as well as habitat establishment techniques that can happen at a large scale farm landscape and also be scaled down for smaller landowners and managers.

Workshop 3 - Jeff Littleton of Moosewood Ecological LLC at Roxbury Town Hall

20 people attended this event that took place on September 10, 2016 from 10am-12:30pm. The focus was on pollinator habitat establishment and reviewed the different site considerations, site preparations techniques, and establishment practices. There was a site visit to the Bodwell Saunders Meadow/Woodland Views to see the habitat established through this CIG.

2017 Workshops

In 2017, despite our education grant commitments being satisfied, we continued to move forward with education on pollinators and habitat establishment through a Pollinator Tour that included three educational workshops on June 24, 2017 at three different Pollinator Initiative Sites, including Stonewall Farm where we focused on plant selection and establishment, as well as conservation bio-control efforts, Cheshire County Farm where there was a workshop on

restoration, riparian and garden plantings, and Distant Hill Nature Trail where the workshop was on working with a native landscape and enhancing pollinator habitat.

Native seed saving workshop led by the New England Wildflower Society.

CASE STUDIES

The following lists highlight some of the case studies chosen for the Cheshire County Pollinator Initiative. These include a cross section of the various techniques used and results observed throughout the project.

Picadilly Farm

Site Description

This site is located on an organic farm in Winchester, NH and covers approximately 2 acres. Previously it was used for hay, however most of the site is relatively wet and the quality of the hay was marginal. The landowners decided to convert 1/3 acre of the area into a red clover patch as part of the Pollinator Initiative with plans to establish rows of raspberries in the future. Since haying conditions were not very good they decided to mow the rest of the site occasionally

to keep open and prevent woody plants from establishing. Another ½ acre of the site was also used as part of the Pollinator Initiative. The majority of this site was wet.

Floral surveys indicated abundant summer-blooming plants and a relative lack of spring and fall-blooming species. Early spring floral resources mostly included trees and shrubs such as maples, poplars, cherry, apple, mountain laurel, rhododendron, and willow along with some wildflowers such as clover, yarrow, dandelion, and strawberry. Fall-blooming wildflowers mainly included a few species of asters and goldenrods along with yarrow, Joe-pye weed, clovers, and dandelions. However, the spring and fall floral resources were in relatively low abundance while vegetable crops, as well as some native perennials, provided ample summer blooming resources.

Site Preparation

A portion of the 2 acres was prepared using the solarization technique. An area roughly 1/3 acre was plowed in fall of 2014 and a cover crop of winter oats were broadcasted. The following spring the site was then covered with clear greenhouse plastic in order to solarize the area prior to seeding with red clover later in the year. Once the clear plastic was removed in fall 2015 it was subsequently plowed, which was not recommended to the landowner since this would enhance germination of unwanted plants, especially grasses.

Red clover pollinator plot prepared for seeding after solarization in 2015.

Plant Installation

The CCCD provided the landowner with 5 pounds of organic red clover to seed the solarized area in fall 2015. The ½ acre site was planted in September 2015 and August 2016. Twenty shrubs were planted in 2015, including 5 elderberries, 5 silky dogwoods, 5 pussy willows, and 5 silky willows. In 2017, the site was further enhanced with shrubs and wildflower plugs. Shrubs included 5 pussy willows, 10 elderberries, 5 silky dogwoods, 5 winterberries, 10 highbush blueberries, 5 steeplebush, 1 Bebb's willow, and 1 cranberry viburnam. Wildflower plugs included iris, swamp milkweed, boneset, rose mallow, blue vervain, Joe-pye weed, New England aster, and smooth aster. Mulch was applied to all plantings to help reduce the effects of competition in the first couple of years. Wooden stakes were installed with all shrubs to clearly note their locations to prevent accidental mowing during future management.

Results

The landowner seeded the site with red clover. However, the first trial was not effective. The site was then lightly plowed and reseeded with red clover. The result was not effective in the

long run as it became established with a variety of grasses. Better oversight of this area was needed to be an effective pollinator plot. The landowners still would like to plant raspberries as planned but this is not their priority currently.

The shrubs planted in 2015 had good success except for the elderberries. Apparently the elderberries were unintentionally mowed soon after installation and did not resprout. All dogwoods survived and only two willows died. None of the shrubs planted in 2015 had wooden stakes to mark their locations and this could have been the factor that contributed to the accidental mowing of the elderberries. Thus, we decided to mark all shrubs with wooden stakes to help prevent accidentally mowing in the future.

Most of the plants installed at Picadilly Farm will provide early spring nectar and pollen resources for pollinators, which is a limiting factor on the property. However, wildflower plugs will continue to provide wildflower resources throughout the remaining part of the season. Not only will pollinators benefit from the plantings but berries will provide a food source for birds and small mammals.

Initial shrub installation of dogwoods, willows, and elderberries in the wet zone of the field.

Shrub and wildflower installation was completed in summer 2017.

It was recommended that the field continue to be mowed on a regular basis to keep the area open and prevent establishment of undesirable woody plants. A mowing every 2-3 years was suggested. A site visit next spring with the landowners will be conducted to go over management recommendations and to inspect the success of the pollinator plot.

Orchard School Community Center

Site Description

This site is located in Alstead, NH. It is associated with an organic apple orchard, vegetable farm, bakery, and community center (previously used as a small school). Two pollinator plots were chosen around the community center; one plot was 1,400 sq. ft. while the other was 2,160 sq. ft. These sites were previously mowed a few times over each season and were dominated by grasses along with some wildflowers.

Similar to Picadilly Farm, floral surveys indicated abundant summer-blooming plants and a relative lack of spring and fall-blooming species. Early spring floral resources mostly included trees and shrubs such as maples, cherry, apple, mountain laurel, and rhododendron along with some wildflowers such as daisy, common fleabane, clover, yarrow, dandelion, and strawberry. Fall-blooming wildflowers mainly included a few species of asters and goldenrods along with yarrow, clovers, and dandelions. However, the spring and fall floral resources were in relatively low abundance (except for the apples) while vegetable crops, as well as some native perennials along the forest edge, provided ample summer blooming resources.

Site Preparation

The landowners on this site decided to use an organic method of solarization to prepare the two plots for seeding. In June 2016, both plots were lightly plowed to loosen the sod. This was then followed up with the application of clear greenhouse plastic to solarize each plot. The larger plot was solarized with a single layer of plastic while the smaller site used a double layer of plastic separated by wooden pallets. Sod, soil, and wooden boards were used to cover the edges of the greenhouse plastic to help prevent heat loss, as well as to prevent gas exchange. The plastic was removed from both sites in October. In December, each plot was prepared for seeding. This involved the use of iron rakes to remove dead vegetation and lightly expose bare soil to promote good seed-to-soil contact.

Plant Installation

These two sites utilized the following mixture for the frost seeding. This seed mixture was provided by Jarrod Fowler of the Xerces Society for Invertebrate Conservation. The Orchard Hill mix contained predominantly perennial seed with about one pound of annual seed added to the mixture. Overall, the perennial seed was evenly mixed by volume to provide season-long floral resources. The greatest percentages of the perennial composition were lanceleaf coreopsis, purple coneflower, common sneezeweed, wild bergamot, New England aster, blue vervain, and golden Alexanders.

The smaller plot was located on relatively flat ground. However, the larger plot was located on a slope. As such, straw was applied to the sloped site after seeding to prevent migration of seeds downhill during rain events prior to germination.

- Giant hyssop
- Dill
- Swamp milkweed
- Butterfly milkweed
- Swamp marigold
- Cornflower
- Partridge pea
- Garden cosmos
- Sulfur cosmos
- Lanceleaf coreopsis
- Plains coreopsis
- Cilantro
- Prairie clover
- Purple coneflower
- Blanketflower
- Indian blanket
- Common sneezeweed
- Common sunflower
- Dense blazingstar
- Sweet alyssum
- Wild bergamot
- Purple bergamot
- Dotted mint
- Common poppy
- Narrowleaf mountainmint
- Black-eyed Susan
- Showy goldenrod
- New England aster
- Blue vervain
- Giant ironweed
- Golden Alexanders

Results

Germination of each plot in 2017 appeared to be successful. Many of the annual plants were in bloom by June and others continued through the summer. Based on a preliminary assessment many of the perennials had germinated. However, there seemed to be lower than expected success with both golden Alexanders and purple coneflower, which was also observed at other sites. Since this was the first growing season it was difficult to gauge the full success. Additional site visits in subsequent years will be needed to more accurately ascertain germination success.

A single layer of plastic was used on the larger plot along a slope to kill the underlying vegetation.

Most of the vegetation was killed during the solarization process. However, note the strip of grasses at the bottom of the slope. This part of the plastic was not sufficiently covered, allowing heat loss and gas exchange that in turn promoted plant growth.

Both plots appeared to have roughly the same success in killing vegetation through the solarization process. The double layer of plastic did not appear to have an added benefit over the single layer of plastic used on the larger plot. A larger sample size and more frequent monitoring are recommended to accurately compare the similarities and dissimilarities of each method.

Straw mulch was used along the sloped site to help prevent seeds migrating to the bottom during rain events.

Annuals provided for early color and floral resources for pollinators during the spring and summer of 2017.

A subsequent visit later in the summer revealed other annuals in bloom, including sunflowers, cosmos, black-eyed Susan, dill, and blanketflower.

Woodland Views

Site Description

Located in Roxbury, NH is the site of an old meadow that was historically used for cultivation starting in the late 1700s and was eventually converted into a hayfield. However, in the most recent years prior to being part of the Pollinator Initiative it was only mowed annually due to the lack of good hay forage. The 3-acre meadow owned by Amy Bodwell and Carol Saunders was fairly homogenous in plant community composition, which was rich in summer and fall floral resources. Species diversity was typical of an "old succession field" and was dominated by goldenrods. Of the three acres only one acre was chosen for the Pollinator Initiative due to slope conditions.

As the Pollinator project progressed the landowners decided to do more habitat management for pollinators, as well as other wildlife. A 15-acre clearcut was performed to

provide early successional habitat that would be beneficial to pollinators. Of these 15 acres, 3.5 acres were converted into a new meadow to be planted IN November 2017 with wildflowers rich in pollen and nectar resources. In May 2017, the Cheshire County Conservation District donated the no-till seeder so a cover crop of daikon radish, winter peas, and crimson clover could be established prior to a frost seeding of perennial and annual wildflowers. We began to feather the edges of the forest on either side of both meadows and created standing snags and brush piles for nesting, cover, and overwintering sites for pollinators. Additional management adjacent to the original 1-acre pollinator plot included the release of 25 apple trees from a white pine overstory, invasives species management, and installation of various native shrubs and wildflowers for the benefit of pollinators. Additional steps are still underway to continue enhancing this site with pollen and nectar-rich native plants. Altogether, this site offers nearly 30 acres of habitat enhanced for pollinators, as well as other wildlife.

Site Preparation

Vegetation Control Services, Inc. applied herbicide to the 1-acre plot in September 2014. This site proved to be very weedy with a large seed source present. As such, herbicide was applied again in spring 2015. The plan was to broadcast a seed mixture afterwards. However, seeding was delayed due to extreme drought conditions and became apparent that another herbicide application was needed on this particular site, which was applied in early fall 2015. After the second herbicide application a York rake was used to remove the thick layer of dead vegetation and encourage the germination of the existing seed bed prior to the third herbicide application to increase the likelihood of project success. In spring 2016 a York rake was used to prepare the seed bed by removing the dead vegetation and exposing the soil for seeding. Care was taken to only scratch the surface enough to prepare the seed bed. A monocot selective herbicide was applied in summer 2016 to help control emerging grasses. No soil amendments were applied to this plot.

Emerging vegetation and a very thick thatch layer was obvious in June 2015. The state was also under an extreme drought. These conditions prompted a change in plans to better prepare the site for a spring 2016 seeding.

This image shows the final result of three herbicide applications and removal of dead vegetation in May 2016 prior to preparing the seed bed with a York rake.

In June 2016 a York rake was used to remove the final layer of dead vegetation to prepare the seed bed.

After the seeds were broadcasted by a hand spreader a Brillion cultipacker was used to ensure good seed-to-soil contact for better germination results.

Plant Installation

The following seed mixture was developed by NRCS and combined with 50lbs of sand per acre. It was hand broadcasted in June 2016 after the seed bed was prepared using a York rake. This mixture pertains to pounds per acre. After seeds were broadcasted a Brillion cultipacker was used to help establish a good seed-to-soil for better germination.

Purple coneflower	8 lbs
Wild bergamot	2 lbs (plus random patches cast by hand)
Blanketflower	3 lbs
Black-eyed Susan	0.6 lb
Lanceleaf coreopsis	7 lb
Golden Alexanders	1 lb
Spotted beebalm	0.5 lb
New England aster	1 lb
Marsh blazing star	1 lb
Blue false indigo	0.5 lb

Results

Germination was very successful despite the little amount of rain that occurred after the seeding in June 2016. This success was attributed to a very well prepared seed bed and the use of the cultipacker to ensure good seed-to-soil contact. The first season was full of blooming black-eyed Susan, blanketflower, and lanceleaf coreopsis. Other species that germinated but not in bloom were wild bergamot, New England aster, and some purple coneflower. However, four species failed to germinate altogether, including golden Alexanders, spotted bee balm, marsh blazing star, and blue false indigo. During the second season in 2017 the pollinator plot was blooming full with black-eyed Susan, blanketflower, lanceleaf coreopsis, wild bergamot, and New England aster. However, there were very few purple coneflowers despite the amount of seeds broadcasted.

In September 2016 the pollinator plot was dense with black-eyed Susan along with blanketflower and lanceleaf coreopsis.

In July 2017 the plot had matured with lesser amounts of black-eyed Susan but queen Anne's lace become more abundant.

Wild bergamot was in full bloom in 2017, providing rich resources for pollinators. This plot was teeming with several types of bees, butterflies and other beneficial insects.

The Cheshire County Conservation District offered their no-till seeder as part of the Pollinator Initiative to sow a cover crop in the new meadow at Woodland Views. The abundance of pollinators using the cover crop over the summer and fall was outstanding.

Extra annual seeds from the Cheshire County Conservation District provided much needed erosion control and pollinators resources. This area was seeded with a perennial mix in November 2017.

New England asters were blooming in abundance during the second season of the pollinator plot in 2017.

Alyson's Orchard

Site Description

Located in Walpole, NH Alyson's Orchard is predominately an apple orchard. However, it also grows peaches, plums, blueberries, pumpkins, and gourds. The property covers about 450 acres. A total of 8 pollinator plots ranging in moisture gradients from very wet to dry were identified and marked in cooperation with Homer Dunn, orchard manager. These plots ranged in size from 6,800 sq. ft. to 25,000 sq. ft. for a total of nearly 3.5 acres of enhanced pollinator sites.

Site Preparation

All sites at Alyson's Orchard were prepared in the same manner and similar to the site at the Woodland Views pollinator plot. Each plot was treated with herbicide by Alyson's Orchard in early fall 2014. The seed bed was prepared mechanically, which was followed by seeding each

plot using a handheld seed broadcaster. A monocot selective herbicide was applied in the spring of the following season to help control emerging grasses.

Plant Installation

A total of five different seed mixes were used in the 8 plots at Alyson's Orchard: wet mix, upland intensive mix, upland standard mix, new mix, and tall mix. Each mix and seed quantities were designed by NRCS and augmented by recommendations from Ernst Seeds. An additional annual seed mix was provided by the Xerces Society for Invertebrate Conservation to be applied to the front and rear entrance to the orchard. All quantities represent pounds per acre. A handheld broadcaster was used for the seed mixes combined with 50lbs of sand per acre. After seeding each plot a flail mower was used to ensure good seed-to-soil contact.

Wet Mix (seeding rates per acre)

Joe-pye weed	1 lb
Swamp milkweed	0.25 lb
Boneset	0.5 lb
St. Johnswort	0.5 lb
New England aster	1 lb
Blue Vervain	2 lbs
Purple coneflower	3 lbs
Lance leaf coreopsis	0.5 lb
Giant ironweed	0.5 lb
Showy goldenrod	0.5 lb

Upland Intensive Mix (seeding rates per acre)

Purple coneflower	8 lbs
Wild bergamot	2 lbs
Blanketflower	3 lbs
Black-eyed Susan	0.6 lb
Lanceleaf coreopsis	7 lb
Golden Alexanders	1 lb
Spotted beebalm	0.5 lb
New England aster	1 lb
Marsh blazing star	1 lb
Blue false indigo	0.5 lb

Upland Standard Mix (seeding rates per acre)

Purple vetch	2 lbs
Red clover	1 lb
White clover (Dutch)	1 lb
Purple coneflower	5 lbs
Perennial blanketflower	4 lbs
Lanceleaf coreopsis	5 lbs
Black-eyed Susan	0.5 lb

New Mix (seeding rates per acre)

Golden Alexanders	0.6 lb
Slender mountain mint	0.1 lb
Marsh blazing star	1.1 lbs
Lanceleaf coreopsis	0.6 lb
Common milkweed	0.6 lb

Tall Mix (seeding rates per acre)

New England aster	0.7 lb
Showy goldenrod	0.7 lb
Giant ironweed	0.6 lb

Xerces-provided Annual Mix (seeding rates per acre)

Bachelors buttons	0.3 lb
Plains coreopsis	0.3 lb
Garden cosmos	0.3 lb
Sulfur cosmos	0.3 lb
Indian blanket	0.2 lb
Common sunflower	0.2 lb
Common poppy	0.3 lb
Black-eyed Susan	0.6 lb

Results

The initial seeding conducted in late fall 2014 had less than optimal success due to intense weed seed pressure introduced during the site preparation process and in particular during soil plowing. As a result the preparation work performed by Alyson's Orchard was over ambitious. Plowing methods at a depth greater than recommended resulted in an over abundance of germination of weedy plants that out competed the native seeds.

As a result NRCS recommended that the preparation process should be repeated that would be more conducive to seed germination of the desirable species. This resulted in two applications of herbicide treatment by Alyson's Orchard on each site during spring and late

summer 2015 and surface plowing of the seed bed, as opposed to deep plowing that had originally occurred. This was followed by seeding and flail mowing as previously described. This effort resulted in much more favorable results.

The annual seed mix provided by the Xerces Society for Invertebrate Conservation had great success. This mix was applied to the front and rear entrance to the orchard. The front entrance can be viewed form NH Route 12 and provided the canvas for many artists, photographers, and general onlookers. Susan Jaffe, orchard owner, and Homer Dunn, orchard manager, provided some anecdotal stories of people inspired to pull over to document their experience of the pollinator plot. It was well documented that this particular plot captured the attention of pollinators and humans alike. This plot exemplified the effectiveness for pollinator habitat enhancement and community outreach.

The five seed mixes listed above demonstrated significant innovative success for enhancing habitat for pollinators, and has offered some important opportunities for future installations. These differences were mostly attributed to on-site conditions such as sun and wind exposure, pH, hydrology, past land use, nutrient availability, and weed pressure.

The two sites seeded with the *Wet Mix* had much dissimilarity. The smaller of the two sites exhibited tremendous pressure from the existing plant source. Bindweed was rather abundant. Its tenacious perennial vines stretching over and capitalizing on surrounding plants affords the perfect opportunity to dominate an area quickly. The other site showed markedly different results. By the second season most of the species had a moderately-low to moderate distribution throughout the plot. Some of the issues of germination could be attributed to site preparation, weed pressure, and low seed count distribution. However, the site is also disbursed with many beneficial native species.

A total of three sites were seeded with the *Upland Intensive Mix*. The two sites at the front and rear entrances performed very well. These plots greatly benefitted from the addition of the annual seed mix. This provided a wonderful splash of color in the first season while offering great pollinator resources. Most of the perennial plants established as planned. Wild bee balm, purple coneflower, lanceleaf coreopsis, New England aster, and black-eyed Susan dominated the plots with the occasion blanketflower and marsh blazing star. Golden Alexanders, blue false indigo, and spotted bee balm had very little to no germination success during the first two seasons.

Plots seeded with the *Upland Standard Mix* performed well. This was a basic, cost effective mix that can work well in many soil conditions. The two plots could have benefitted by increasing the ratio on certain species such as vetch, clovers, and blanketflower.

The front entrance to the Alyson's Orchard was vibrant within the first season due to the annual seed mix. This picture was taken in June 2016.

One month later even more annuals and some perennials were in bloom.

By August 2017 many perennials were in full bloom such as wild bergamot.

During August 2017 the wet mix at the front entrance of the orchard was in full bloom with Joe-pye weed, blue vervain, and queen Anne's lace.

Blue vervain was thriving in another location seeded with the wet mix in August 2017.

This site was seeded with the Upland Standard Mix. By 2017 it was in full bloom.

This was the third site seeded with the Upland Intensive Mix. By 2017 it matured into more blooming plants but was not nearly as productive as the other two sites. Bed preparation and soils conditions most likely attributed to this difference.

Keene Country Club

Site Description

This site was located at the Keene Country Club in an area located next to the fairway and at the edge of a tree row separated by a meadow on an adjacent property. The site was originally mowed on a regular basis and hence presented a dense sod layer in a relatively moist environment. This pollinator plot was approximately 7,500 sq. ft.

Site Preparation

Vegetation Control Services, Inc. and the Keene Country Club applied herbicide to the site twice to kill the exiting vegetation; once in fall 2014 and again in spring 2015. Afterwards in July, the plot was lightly plowed to remove the thatch and to prepare the site for plugs. White

pines lined the east side of the plot and their roots proved to be a significant issue with planting plugs. A monocot selective herbicide was applied in spring 2016 to help control graminoids.

Plant Installation

This site was chosen for the installation of wildflower plugs since it provided easy access for maintenance, as well as a reliable water source needed for this method. A total of 8 species were chosen for this site and planted in complete patches. Straw mulch was applied after installation to help reduce competition and retain moisture.

Slender mountain mint	250 plugs
Butterfly weed	222 plugs
New England aster	200 plugs
Oxeye sunflower	310 plugs
Wild Bergamot	460 plugs
Spotted bee balm	260 plugs
Cardinal flower	50 plugs
Golden Alexanders	215 plugs

Results

The first season showed great results. Weed pressure was low, the plants were becoming established, and a few species began to bloom, including many sunflowers and a few spotted bee balm and New England aster. However, by the end of summer deer had browsed all of the golden Alexanders. The site quickly became engulfed with weedy plants the following spring, particularly curly dock. The site was weeded on three different occasions to get the weed pressure under control in order to promote the favored species. The golden Alexanders did resprout during the second season but they could not keep up with the weed pressure and soon perished. Other plants that did poorly during the second season included spotted bee balm, cardinal flower, and butterfly weed (mostly due to accidental mowing. The mountain mint, wild bergamot, sunflower, and New England aster thrived. The aster was eventually heavily browsed later in the season by deer. The third season offered similar results with weed maintenance needed on a couple of occasions.

This shows the site prior to herbicide application.

Plug installation with straw mulch to help with weed pressure and moisture retention.

This demonstrates the full extent of the site.

Watering the plugs proved to be an essential task, especially during a relatively dry season.

Patches of plugs can be observed here, as well as the many unwanted weedy plants.

Weeding each season proved to be a necessity. Luckily we were able to enlist some volunteers for the task.

Like the aster and wild bergamot, sunflowers did very well each season.

Despite the issues with spotted bee balm and butterfly weed some individuals still continued to thrive throughout the seasons.

Cheshire County Farm Complex

Site Description

The Cheshire County Farm Complex is located along the Connecticut River in Westmoreland, NH. There were three plots enhanced at this site: one along the river and two plots next to the community garden along River Road.

Site Preparation

Vegetation Control Services, Inc. applied herbicide to all three sites in 2015. The plot next to the river was 3,150 sq. ft. and the two plots next to the community garden were 850 sq. ft. and 940 sq. ft. Afterward herbicide application the seed bed was prepared mechanically.

Plant Installation

Two seed mixes were used in the plots adjacent to the community garden, including the Upland Intensive Mix and the Upland Standard Mix described above for Alyson's Orchard. The goal of the plot next to the river was to establish a riparian buffer between the corn field and river using native trees, shrubs, and red clover seeds. The first final installation included silver maples, shadbush, and ash-leaved maple.

Results

The two plots next to the community garden had similar favorable results as the sites at Alyson's Orchard. However, there was very limited success with purple coneflower, golden Alexanders, clovers, and vetch.

The river plot offered a great opportunity to restore a riparian buffer. However, the first round of plant installations proved to have many issues. The site was extremely weedy during the first season in 2016. These weeds quickly out competed most of the clover and overtopped all shrubs. The drought also has a significant affect. One final major factor included a voracious beaver nearly removed all trees and many shrubs. Based on these results a new plan was prepared.

In 2017, the site was mowed back with a brush cutter and string trimmer to prepare the site for tree installation. However, no shrubs or herbaceous plants were included this time. All trees were staked, rodent guards installed, and cages applied to prevent wildlife damage and to

ensure future success. Regular maintenance with weeds will be needed for the next few years to reduce competition while the trees gain stature.

River plot preparation prior to plant installations.

Installation of cages and other measures to prevent wildlife damage.

Site upon completion of full installations. Note the high and dense vegetation on either side of the trees. Vegetation around the trees will need to be maintained for many years.

Broadcasting seed mix in a plot adjacent to the community garden.

Distant Hill Gardens

Site Description

The area planted was a 25-foot by 200-foot strip of moist, rocky, slightly sloped upland field located just north of the trailhead of Distant Hill Nature Trail off March Hill Road in Alstead, NH. The garden was a two-year project in which the 3,500 square feet plot was seeded in November 2016, and an additional 1,500 square feet plot was seeded in November 2017. Grasses and sedges dominated the site, with large areas of native deer tongue grass, and numerous red raspberry plants. Perennial wildflower species were limited, with some common milkweed, clovers, dandelions, asters, and goldenrods. To complement the seeded area, the eastern shore of an adjacent wetland is dominated by a number of native shrubs provide nectar and pollen resources to pollinators, including high-bush blueberry, common winterberry, white meadowsweet, and steeplebush.

Site Preparation

The 3,500 square feet plot was prepared in May 2016. The area was first mowed at 2 inches, and then a single layer of 6-millimeter black plastic was used to smother the existing vegetation. Bricks, old fence rails, and timbers were used to keep the plastic in place. The plastic was removed in November 2016, and the dead vegetation was raked and removed. The remaining 1,500 square feet plot was mowed and covered with black plastic in May 2017, using plastic salvaged from the 2016 planting. This plastic was removed in November 2017, and the same protocol was used to remove the dead vegetation.

Plant Installation

Both areas were seeded in the same manner: the 3,500 square feet plot in November 2016, and the 1,500 square feet plot in November 2017. Each seed mixture was combined with about two bushels of composted sawdust to provide somewhat even distribution of seeds. Once seeded, a riding lawn mower was driven over each section in a crisscross pattern to create good seed to soil contact. Lastly, a layer of straw was placed over the seeded areas.

Seed mixes and many bulk seeds were in short supply from our preferred seed vendor, Earnst Seeds, in Fall 2016 due to high demand. We used a Cheshire County Conservation District (CCCD) bulk seed mix with just six species, and added some packets of seed from

Prairie Moon Seed Company to add diversity of floral resources. Two-thirds of the seed mix was broadcasted in November 2016 and the remaining one-third was used in November 2017. The final seed mix included the following.

Lanceleaf coreopsis	0.7 lb
Purple coneflower	0.7 lb
Blanketflower	0.3 lb
Wild bergamot	0.3 lb
Black-eyed Susan	0.03 lb
Golden Alexanders	0.05 lb
Partridge pea	1.0 lb
Anise hyssop	0.02 lb
New England aster	0.01 lb
Blue wild indigo	0.02 lb
Yellow wild indigo	0.01 lb
Marsh blazing star	0.06 lb
Wild lupine	0.06 lb
Foxglove beardtongue	0.01 lb
Ohio spiderwort	0.01 lb
Wild senna	0.06 lb

Results

Germination for the November 2016 seeding was reasonable. Only three species flowered the first year, which included black-eyed Susan, partdridge pea, and a few lanceleaf coreopsis, but many seedlings of other species were also identified. It is usually difficult to gauge germination success in the first year. The 2018 growing season will allow a better determination of success. Similarly, we will have to wait until the 2019 growing season to assess germination for the 2017 seeding. Lastly, we did have a problem with crab grass beginning to take over the 2016 seeding area in late spring of 2017. We applied one round of a monocot selective herbicide to help control the crab grass in July 2017, which proved to be very effective.

The seven case studies provided above highlight some of the most notable sites and methods employed for this project. The remaining 10 sites offered many similarities, as well as obstacles. The following provides a brief account of these similar methods used.

- Monadnock Berries
    - Herbicide application
    - Seed mix broadcasted
- Snowden Property
    - Plowing of wet soils
    - Seed mix broadcasted
- Maple Lane Farm
    - Herbicide application
    - Seed mix broadcasted
- Old Cider Press Farm
    - Herbicide application
    - Seed mix broadcasted
- Duston Property
    - Repeated plowing
    - Seed mix broadcasted
- Tracie's Farm
    - Trees, shrubs and plugs installed
- Contoocook Marsh Conservation Area
    - Trees, shrubs and plugs installed
- Franklin Pierce University
    - Herbicide application
    - Plugs installed
- Stonewall Farm
    - Solarization, sheet mulching, and cover cropping
    - Trees, shrubs, and plugs installed

- Hillside Springs Farm
    - Solarization
    - Clover seeds

Vendor List

The following provides a list of vendor's we used to purchase plants and seeds for the project. Many of these companies are wholesale dealers although a few sell to the public.

Ernst Seeds
ernstseed.com

New England Wetland Plants
newp.com

Kohl Gardens
978-544-3179
kohlgardens@gmail.com

Nasami Farm
newenglandwild.org/visit/nasami-farm

Prairie Moon Nursery
prairiemoon.com

CONCLUSIONS

The following provides some very basic recommendations based on experiences and lessons learned throughout this 3-year project.

- Site selection and preparation is extremely important and should not be rushed.
- A full planting plan is highly recommended that provides clear instructions on site preparation, plant installations, and future maintenance.
- Some of the seed mixes used in this project need a little refining to help dial in the certain species. For example, it was quite a surprise about the lack of germination success with purple coneflower.

- Professional oversight of all steps is imperative to ensure a successful project. Volunteers are very useful but proper oversight should be applied.
- Plan for follow up maintenance based on site conditions and accessibility.
- Encourage landowners, private and public, to enhance their lands for pollinators.

In conclusion, this 3-year project offers some very different and innovative methods that landowners can proceed with to create or enhance habitat for pollinators. Options exist for large and small properties, farmers and non-farmers, residential or rural. Many options are available depending upon the needs and desires of each individual project. These include organic and nonorganic methods for site preparation, as well as different means to establish plants. One of the most important first steps is better understanding the various site characteristics, both large and small scale, which will provide direction on how best to proceed with a pollinator planting plan.

The Cheshire County Conservation District and all its partners have achieved great success throughout this project. We have demonstrated how farms can benefit from habitat enhancement, how public spaces can increase much needed pollinator resources while creating attractive gardens, how restoration can be achieved using native plants rich in pollinator resources, how large scale habitat modifications can greatly benefit pollinators as well as other wildlife, and how every landowner can beautify their property while collectively helping our pollinators. Many lessons have been learned throughout this process as well, and these will be shared with interested community members. These case studies can serve as models for future pollinator habitat installations statewide.

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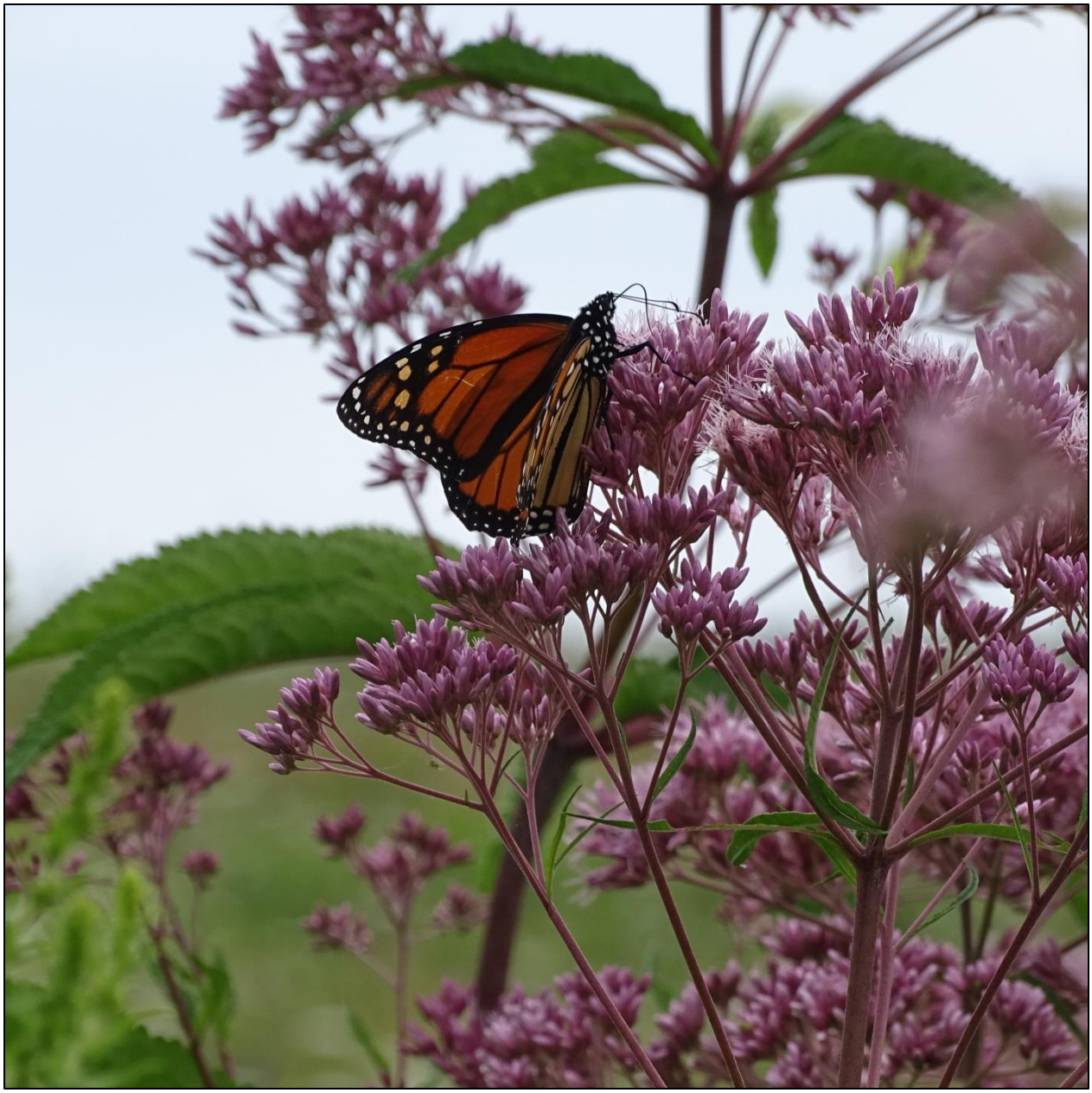

APPENDIX A

BEE SURVEY REPORT

Bee Surveys at four sites in Cheshire County, New Hampshire, 2015-2017 Using Bee Bowls and Streamlined Monitoring to Assess Bee Abundance and Richness in Pollinator Enhancement Habitats

Summary report submitted to:
Cheshire County Conservation District
Walpole, NH

Joan Milam
Adjunct Research Fellow, Dept. Environmental Conservation, UMass-Amherst

Introduction

The Cheshire County Conservation District (CCCD) worked with farmers and private landholders to implement and create pollinator habitat in agricultural settings. Pollinators provide important pollination services to augment crop production. Although there are several animal pollinators (butterflies, moths, wasps, flies, beetles, and ants), native bees are the most proficient pollinators. The CCCD worked with the United States Department of Agriculture Natural Resources Conservation Service (USDA NRCS) to provided assistance to three agricultural establishments (Alyson's Orchard, Monadnock Berries, Picadilly Farm), and a private landholder (Bodwell/Saunders) to establish and plant pollinator enhancement sites that provide locally appropriate floral resources to support native pollinators throughout their flight season. The CCCD monitored the success of the project by surveying pollinator enhancement sites and crops at each site (2015 to 2017) by capturing bees in "bee bowls" filled with soapy water deployed along a fixed transect and by using the Streamlined Monitoring Protocol. The four sites were monitored three times in 2015, and four times in 2016 and 2017.

Specific questions addressed by the surveys included:

1) Does bee species richness and abundance differ between the crop and pollinator enhancement sites?
2) What is the species composition and abundance at each of the four sites by habitat and year?

Methods

Study Sites

Three agricultural sites and one private site managed to create early-successional and field habitat site were surveyed for three years. The three agricultural sites differed in crop production. Alyson's Orchard was predominantly an apple orchard with less extensive plantings of peaches, plums, pears, nectarines, blueberries, raspberries and quince (alysonsorchard.com). Monadnock Berries was dominated by highbush blueberries in addition to a variety of berries including black and red raspberries, black and red currants, and gooseberries (monadnockberries.com). Picadilly Farm is a certified organic community supported agriculture

farm that grows groups throughout the growing season. The Bodwell/Saunders site is privately owned and managed to support wildlife, including native bees. The major corps at Alyson's Orchard and Monadnock Berries bloom in spring, while Picadilly Farm had crops that bloom throughout the season. Alyson's Orchard had two or three honey bee hives housed in their orchard maintained by a neighbor in addition to roughly 30 hives rented each year to augment pollination in the orchard (Norm, Alyson's Orchard pers. comm). The farmer at Monadonk Berries purchased bumble bee colonies in the spring to supplement the blueberry crop pollination. Picadilly Farm had honey bee hives located across the street from their farm to assist in pollination, but they did not purchase bumble bee colonies (Jenny, Picadilly Farm pers. comm). The Bodwell/Saunders site had hired a contractor to remove the forest canopy on their property to create field and early-successional habitat to support wildlife, native pollinators. The Bodwell/Saunders site had several old apple trees on the property, remnants of an older farm, that were being reclaimed to provide flowers for pollinators and fruit for wildlife. A species list of flowering plants for each site was created in 2015 (Table 1).

Bees were sampled three times in 2015 and four times in 2016 and 2017. Two methods were used to sample bees: deployed bee bowls along established transects following LeBuhn et al. (2003) and a streamlined monitoring protocol for assessing pollinator habitat (Ward et al. 2014). Bee bowls consisted of 100 ml plastic bowls painted florescent blue, yellow, or left white and filled two-thirds full with soapy water. At each site, 15 bowls were placed at 3 m intervals along a transect alternating the three colors. Bowl colors were selected to mimic flowers that attract pollinators (Campbell and Hanula 2007). Bowls were left out for 24 hours to ensure the capture of bees active at different times of the day (LeBuhn et al. 2003). The contents of each bowl transect were combined into a single sample and placed in a plastic "Whirl-Pak®" bag with 70% ethanol. Bee-bowl transects were deployed on three occasions throughout the growing season (June, August, and late September/early October) in 2015, and on four times in 2016 and 2017, to collect bees species active at different times of the year. Bowls were deployed during fair weather with no rain or high winds and ideally with ambient temperatures $\geq 15.5^{o}C$. Bee specimens were brought back to the lab where they were washed, dried, pinned, labeled, and identified. Bee specimens were identified to species when possible, or to genera for species for which accurate keys are not yet available or specimens that were in poor condition. Species were identified using a variety of keys, both online (Discoverlife.org) and print (e.g., Mitchell 1962).

Lethal sampling of bees has been found to not affect the viability of wild bee populations (Gezon et al. 2015).

The streamlined protocol recorded the number of bees visiting flowers along two 30.5 m transects established at each of the 10 sites in 2015. Although this approach does not identify bees to species or provide ecological or behavioral data, it does provide a measure of bee abundance (Ward et al. 2014). Transects were monitored within a few days from the time bee bowls were deployed. During each visit the two transects were monitored for 7.5 minutes each for a total of 15 minutes per site. The number of native bees observed present on the reproductive structures of a flower for more than 0.5 seconds within 1 m of each of the two 30.5 m transects were recorded. Native bees were recorded as present, but not identified to species. Honey bees were tallied separately from native bees because their presence and abundance depend on the location of managed bee hives (Ward et al. 2014).

Results from Bee Bowls:

A total of 865 individual bees were captured in bowls from 2015-2017 representing 95 species, five families, and 21 genera. Female *Hylaeus affinis* and *H. modestus* were lumped as *Hylaeus affinis/modestus* because they cannot be distinguished as individual species with the present taxonomy. Similarly, Nomada bidentate-not maculate cannot be identified to species but were counted as a single species, althought they likely represent several species thus may underrepresent the total species count. Overall bee abundance and richness of bees captured in bowls increased each year of the study for all sites combined (Table 2). Species abundance by site and year varied, and showed a slight decline in total number of bees captures at all sites except the Bodwell/Saunders site that showed a marked increase in bees in 2017 (Figure 1).

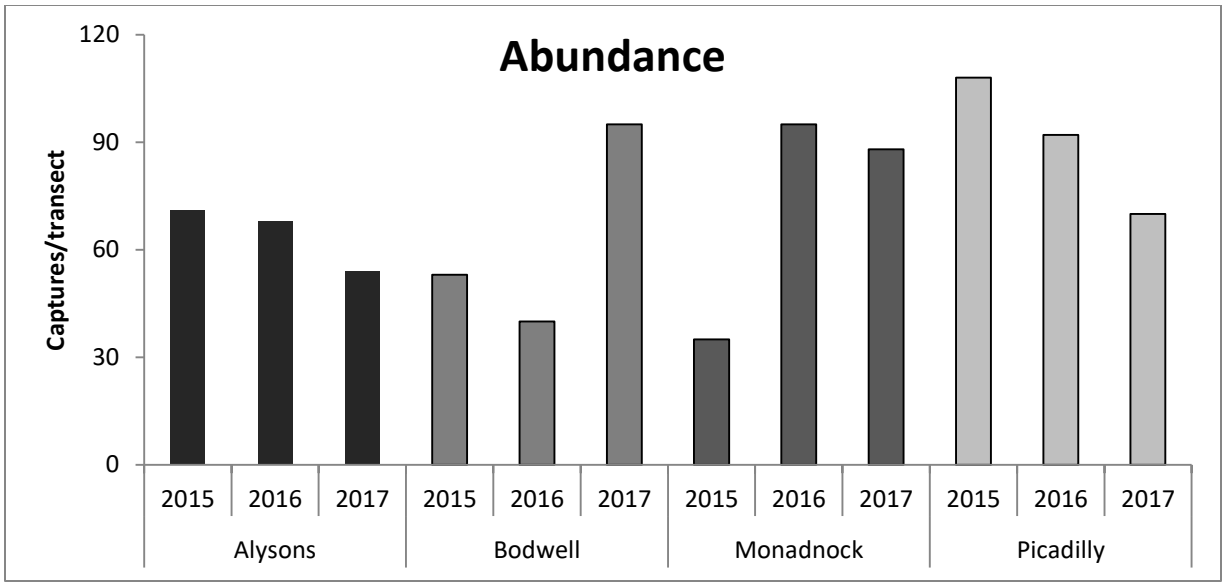

Figure 1. Total number of bees captured by site and year at four sites in Cheshire County, NH, showing a slight decrease in total captures at all sites except the Bodwell/Saunders site.

Bee species richness was slightly higher at all sites in 2016. In 2017 there was an increase in richness at Bodwell/Saunders and Picadilly Farm, and a slight decrease at Alyson's Orchard and Monadnock Berries (Figure 2). However, species richness and abundance for all sites combined increased with each year sampled (Table 2).

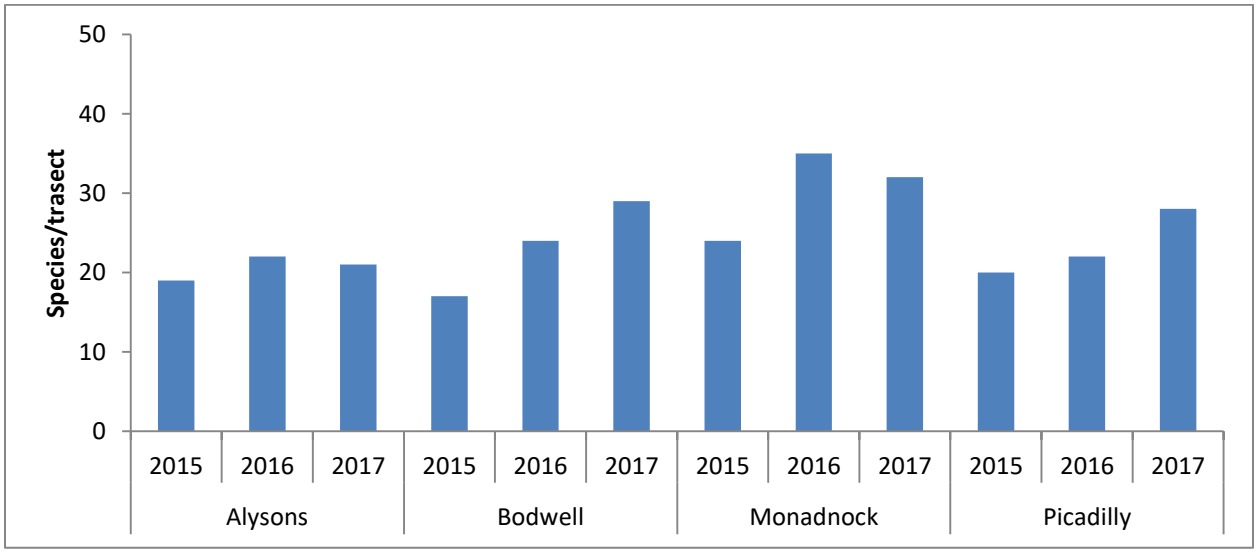

Figure 2. Bee species richness was slightly higher at all sites in 2016. 2017 saw in increase in bee richness at Bodwell/Saunders and Picadilly Farm, and a slight decrease at Alyson's Orchard and Monadnock Berries.

Bee abundance by habitat per site varied by year.

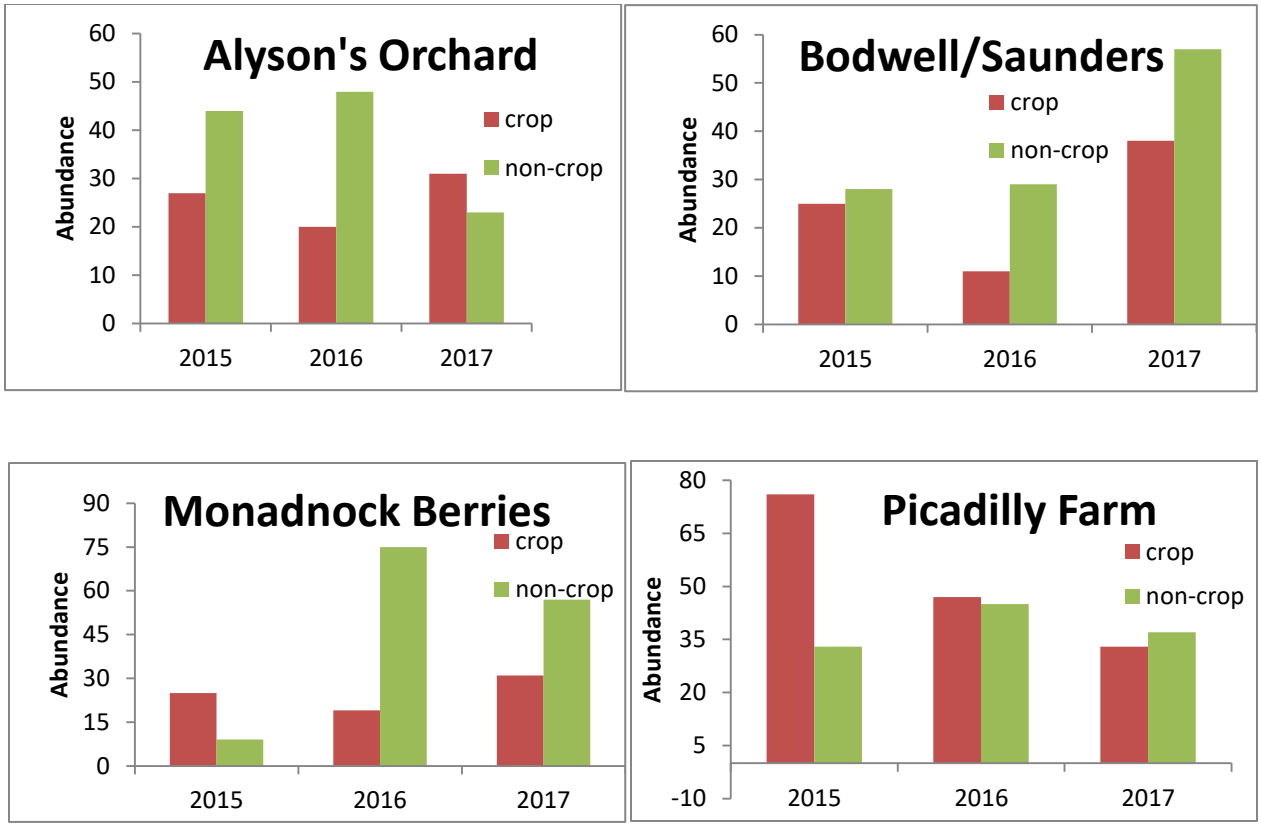

Figure 3. Abundance by habitat. Sample dates for 2015 (17-18 May, 22-23 July, 21-22 Sept); 2016 (27-28 April, 16-17 May, 21-22 July, 22-23 Sept); 2017 (3-4 May, 16-17 May, 19-20 July, 25-26 Sept). There were only three sample dates in 2015.

Results of Streamlined Monitoring

Few bees were observed on flowers during streamlined sampling until late in the season at any of the four sites. The pollinator enhancement plots established in 2015 continued to mature through 2017 at Alyson's Orchard, Bodwell/Saunders, and Monadnock Berries. The pollinator enhancement plot surveyed at Picadilly Farm looked more like a field and had few flowers. Streamlined monitoring yielded the most data along transects in September, likely because major crops had finished blooming and plants within the plots were predominantly late season bloomers such as Asters and Goldenrods (Table 3).

Discussion

Total bee species abundance and richness for all sites combined increased each year (Table 2). Estimated species richness also increased each year (2015=70.46 SE 6.80, 2015=83.0 SE 6.78, 2016=157.23 SE 24.60) driven largely by the presence of singleton species. New species were added to the total each year, and, as expected, there was considerable overlap in species composition among years. Additional sampling of these sites using hand-held insect nets on targeted flowers would likely increase the species total by site and year.

Streamlined bee monitoring efforts yielded more bee observations on flowers later in the season. Although well past blueberry bloom, Monadnock Berries had a number of native bees at the crop site visiting flowers of what looked to be late-season buckthorn. The late season pollinator enhancement sites at Alyson's Orchard, Bodwell/Saunders, and Monadnock Berries generated more bee observations on late season Aster and Goldenrods. However, there were more bee observations along the crop transect at Picadilly Farm because there were more crops in bloom than in the control site. The enhancement site at Monadnock Berries was spectacular with abundant New England Aster and Goldenrod that was visited by numerous native and honey bees. The Bodwell/Saunders planted site differed among years with 2017 dominated by profuse New England Aster (*Symphotrichum novae-angliae*) in comparison to 2016 which was dominated by Blanket Flower (*Gaillardia spp*.). The streamlined monitoring protocol records honey bees separately from native bees because their presence is an artifact of a hive established in the vicinity. The same might be applicable to the bumble bee *Bombus impatiens*. Farmers, such as Monadnock Berries, purchase commercial bumble bee hives in the spring to supplement pollination and late season bees along the streamlined transects could be bees from commercial hives.

Conclusion

The pollinator enhancement sites at Alyson's Orchard, Bodwell/Saunders, and Monadnock Berries offer important early-summer to late-fall forage for bees. In particular, late season Asters and Goldenrods were a attraction for late flying bees. Picadilly Farm could benefit from additional planting in the pollinator enhancement areas, but farm crops offered continuous

flowers from early spring (e.g. strawberries) through fall (e.g. sunflowers) that were visited by bees. Additional bee surveys will likely result in additional species at each site.

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Table 1. Flower species (n=123 species) identified by Jarrod Fowler in 2014 at four sites surveyed for pollinators in Cheshire County, NH 2015-2017.

ASSESSMENTS	Site	Alyson's Orchard	Bodwell Saunders	Picadilly Farm	Monadnock Berries
	Date	8/21/2014	8/18/2014	8/19/2014	8/19/2014
Plant	Season	.	.	.	.
Acer pensylvanica	Sp	0	1	0	0
Acer rubrum	Sp	4	3	2	0
Acer saccharinum	Sp	0	0	2	0
Acer saccharum	Sp	2	2	1	0
Achillea millefolium	Sp-Su-F	1	1	1	0
Ajuga reptans	Sp	0	0	1	0
Apocynum cannabinum	Su	0	0	0	1
Aquelligia canadensis	Sp	0	0	0	1
Arctium minus	Su	1	0	0	1
Artemisia absinthium	Su	0	0	1	0
Asclepias incarnata	Su	0	0	1	0
Asclepias syriaca	Su	3	1	1	1
Campsis radicans	Su	0	0	1	0
Catalpa speciosa	Su	0	0	1	0
Cercis canadensis	Sp	0	1	0	0
Chamaecrista fasciculata	Su	0	0	0	1
Chamaedaphne calyculata	Sp	0	1	0	0
Cichorium intybus	Su	1	0	0	0
Cirsium vulgare	Su	1	0	0	1
Clematis virginiana	Su	1	0	0	1
Convovulus arvense	Su	1	0	1	0
Coreopsis verticillata 'Moonbeam'	Su	0	1	1	1
Cotoneaster divaricatus	Sp	1	0	0	0
Dasiphora floribunda	Su	0	1	0	1
Daucus carota	Su	4	4	1	0
Digitalis purpurea	Sp	0	1	0	0
Doellingeria umbellata	Su-F	1	2	1	2
Echinacea purpurea	Su	0	1	0	1
Echinops ritro	Su	0	1	0	0
Erigeron strigosus	Su	1	1	1	0
Eupatorium perfoliatum	Su	0	0	1	4
Eurybia divaricata	Su-F	1	1	0	1
Euthamia graminifolia	Su-F	1	4	4	4
Eutrochium purpureum	Su-F	1	2	1	1

Fragaria virginina	Sp	0	0	1	0
Gaillardia pulchella	Sp-Su	0	0	0	1
Gautheria procumbens	Su	0	1	0	0
Glechoma hederacea	Sp-Su	0	0	1	0
Helianthus divaricatus	Su	0	1	0	0
Helianthus tuberosus	Su	0	0	1	0
Hibiscus syriacus	Su	0	1	1	0
Hieracium pilosella	Sp-Su	0	0	1	0
Hosta lancifolia	Su	1	1	0	0
Hydrangea macrophyllum	Su	0	0	1	1
Hydrangea paniculata	Su	1	1	1	1
Hypericum perforatum	Su	0	1	0	0
Hypochaeris radicata	Su-F	0	4	0	0
Ilex meserveae	Sp	0	1	0	1
Ilex verticillata	Su	1	1	0	1
Impatiens capensis	Su	4	1	0	1
Iris versicolor	Su	1	0	0	1
Kalmia latifolia	Sp-Su	0	0	1	0
Lamium spp.	Sp-Su	0	0	1	0
Leucanthemum vulgaris	Su-F	0	1	0	1
Leucanthemum x superbum	Su	0	1	0	0
Liatris spicata	Su	0	0	0	1
Lobelia cardinalis	Su	0	0	1	0
Lupinus perrenis	Sp	0	0	0	1
Lyonia ligustrina	Su	0	1	0	0
Lysimachia terrestris	Su	0	0	0	3
Lythrum salicaria	Su	4	0	1	0
Malus spp.	Sp	5	1	1	1
Melilotus officinalis	Su	0	0	0	1
Mentha spp.	Su	0	0	1	0
Nuttllanthus canadensis	Su	0	0	0	1
Oenothera biennis	Su	1	0	1	1
Origanum vulgare	Su	0	0	1	0
Oxalis stricta	Sp-Su-F	0	0	1	0
Penstemon hirsutus	Su	0	0	1	0
Perovskia atriplicifolia	Su-F	0	1	0	0
Plantago lanceolata	Sp-Su-F	2	2	1	0
Polygonum spp.	Su-F	0	1	1	0
Populus sp.	Sp	1	0	2	0
Potentilla canadensis	Sp	0	1	0	1
Potentilla fruticosa	Su	1	0	0	0

Prunus serotina	Sp	4	2	2	2
Prunus serrulata	Sp	0	0	1	0
Prunus sp.	Sp	3	1	1	1
Pyrus calleryana	Sp	0	0	1	0
Ranunculus sp.	Sp	1	0	0	0
Rhododendron kaempferi	Sp	1	0	1	1
Rhododendron maximum	Sp	1	1	1	0
Rhus copallinum	Su	0	0	1	0
Rhus hirta	Su	4	2	1	0
Ribes sp.	Sp	0	0	0	3
Rosa multiflora	Su	1	1	1	0
Rosa rugosa	Su	0	0	1	0
Rubus allegheniensis	Sp-Su	4	1	0	4
Rubus hispidus	Sp-Su	0	1	1	4
Rubus idaeus	Sp-Su	4	0	1	0
Rudbeckia hirta	Su	1	1	1	0
Salix alba	Sp	2	0	0	0
Salix discolor	Sp	4	2	1	0
Sambucus canadensis	Su	1	0	1	1
Sedum spectabilis	Su-F	1	0	0	1
Solanum carolinense	Su	1	0	0	1
Solanum dulcamara	Su	1	0	0	1
Solanum ptycanthem	Su	0	0	1	0
Solidago bicolor	Su-F	0	1	0	1
Solidago canadensis	Su-F	1	5	2	1
Solidago rugosa	Su-F	4	4	1	4
Solidago spp.	Su-F	1	4	1	0
Spiraea alba	Su	0	1	1	1
Spiraea japonica	Sp-Su	1	0	1	0
Spiraea tomentosa	Su	0	1	0	1
Spiraea x vanhouttei	Sp	0	0	1	0
Swida spp.	Sp	1	1	0	0
Symphyotrichum ericoides	Su-F	0	3	3	0
Symphyotrichum novae-angliae	Su-F	0	0	1	1
Symphyotrichum vimineus	Su-F	1	3	3	4
Taraxacum officinale	Sp-Su-F	4	1	2	0
Thymus sp.	Su	0	0	1	0
Trifolium hybridum	Sp-Su	0	1	1	0
Trifolium incarnatum	Su	0	0	0	1
Trifolium pratense	Sp-Su-F	4	5	2	4

Trifolium repens	Sp-Su-F	4	4	2	4
Vaccinium corymbosum	Sp	4	2	0	5
Verbascum thapsus	Su	1	0	1	1
Verbena hastata	Su	0	0	1	0
Vicia cracca	Su	1	0	1	1
Viola sp.	Sp	0	0	1	0
Vitis labrusca	Sp	1	0	0	0
Weigela florida	Sp-Su	0	0	1	0

Table 2. Total number of bee species and abundance increased with each year sampled, 2015-2017

Year	**2015**	**2016**	**2017**	**Grand Total**
Number of species	48	60	65	95
Total Abundance	**265**	**294**	**306**	**865**

Table 3. Results of streamlined monitoring at four sites in Cheshire County, New Hampshire by date and site in 2017.

2017 Rapid-transect observations.

		11-May-17	11-May-17	18-May-17	18-May-17	21-Jul-17	21-Jul-17	26-Sep-17	26-Sep-17
Alyson's Orchard		4:04-4:11.48	3:52-4:01.43	12:26.00-12:33.38	12:16-12:24.12	12:26-12:34	12:13-12:20	3:10-3:18	3:01-3:08.30
		Crop	Planted	Crop	Planted	Crop	Planted	Crop	Planted
		Partly Cloudy	Partly Cloudy	Partly cloudy	Partly cloudy	Clear	Clear	Partly cloudy	Partly cloudy
BEES OBSERVED		65 ºF	65 ºF	89 ºF !!	89 ºF	81 ºF	81 ºF	87 ºF	87 ºF
Native bees		3	0	1	0	1	25	0	14
Apis mellifera		44	2	5	0	0	0	0	3
VISUAL	SUM	47	2	6	0	1	25	0	17

		11-May-17	11-May-17	18-May-17	18-May-17	21-Jul-17	21-Jul-17	26-Sep-17	26-Sep-17
Bodwell / Sanders		2:26-2:33.45	1:28-1:35	2:09:00-2:17.	1:29-1:37	3:01-3:08.32	3:14-3:21.48	11:21.3-11:28	11:43-11:57
		Crop	Meadow	Crop	Meadow	Crop	Meadow	Crop	Meadow
		Partly Cloudy	Partly Cloudy	Partly cloudy	Partly cloudy	Clear	Clear	Partly cloudy	Partly cloudy
BEES OBSERVED		59 ºF	59 ºF	92 ºF !!	92 ºF	82 ºF	82 ºF	83 ºF	83 ºF
Native bees		0	0	0	1	8	1	37	0
Apis mellifera		0	0	0	0	0	7	98	2
VISUAL	SUM	0	0	0	1	8	8	135	2

		11-May-17	11-May-17	18-May-17	18-May-17	21-Jul-17	21-Jul-17	26-Sep-17	26-Sep-17
Monadnock Berries		12:50-12:57.30	12:11-12:18.3	3:26-3:34.40	12:03:12'3:33.30	2:10-2:18.30	1:55-2:02.43	1:34-1:42	1:18-1:26
		Crop	Planted	Crop	Planted	Crop	Planted	Crop	Planted
		Partly Cloudy	Partly Cloudy	Partly cloudy	Partly cloudy	Clear	Clear	Partly cloudy	Partly cloudy
BEES OBSERVED		63 ºF	63 ºF	91 ºF	91 ºF	81 ºF	81 ºF	83 ºF	83 ºF
Native bees		23	1	3	0	3	1	12	61
Apis mellifera		0	0	0	0	2	0	3	38
VISUAL	SUM	23	1	3	0	5	1	15	99

		11-May-17	11-May-17	18-May-17	18-May-17	21-Jul-17	21-Jul-17	26-Sep-17	26-Sep-17
Picaddilly Farm		5:14-5:22	5:04-5:12	11:03-11:10.30	11:17-11:24.30	10:52.30-11:00	10:39.3	4:24-4:32	4:35-4:42.3
		Crop	Planted	Crop	Planted	Crop	Planted	Crop	Planted
		Partly Cloudy	Partly Cloudy	Partly cloudy	Partly cloudy	Clear	Clear	Partly cloudy	Partly cloudy
BEES OBSERVED		64 ºF	64 ºF	89 ºF	89 ºF	78 ºF	78 ºF	86 ºF	86 ºF
Native bees		1	0	1	3	2	2	3	2
Apis mellifera		0	0	0	0	0	1	9	0
VISUAL	SUM	1	0	1	3	2	3	12	2