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Pollinator habitat: A cooperative project between the landfill industry and blueberry growers

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Bee decline is a threat worldwide. An extension project was initiated to make the general public, industry, and municipalities aware of this problem. This study demonstrated pollinator habitat suitable for Maine farms by developing cooperation between the Maine wild blueberry industry and a regional commercial waste landfill. The reason for involving the landfill industry was to demonstrate and encourage non-farm enterprises to become involved in pollinator conservation. This project arose from previous research of ours on pollinator reservoirs in the Maine (USA) wild blueberry agro-ecosystem with the objectives of: (1) comparing three seed mixes, (2) providing demonstration areas where farmers and the general public can see such gardens, and (3) encouraging others to plant for pollinators. The methods involved planting two types of gardens in 2015, one that contained three different commercially available pollinator forage seed mixes, and one that contained shrubs and some perennials that are visited by pollinators early and late in the season, but that are not readily grown in a wildflower meadow. For all three seed mixes, at least some plant species produced flowers that were visited by bees, but there were also gaps in flowering and some species on which we saw few bees. We observed more bees coming to flowers of corn poppy, tall yellow clover, oxeye daisy, black-eyed Susan, anise hyssop, and bergamot. Ox-eye daisy and black-eyed Susan were not in any of the seed mixes but were allowed to grow among the sown plants. More than 600 people came through the booth or toured the gardens at four open houses in 2015 and 2016, and many people know of the project through presentations we have given. The stakeholders and public learned about bees and floral resources. Several municipalities and farmers have planted pollinator reservoirs since this project was initiated.

Key words: Pollinator reservoirs, wildflower seed mix, demonstration, landfill, wild blueberry.

INTRODUCTION

Pollinator decline is a major problem worldwide (Potts et al., 2010, Lever et al., 2014), especially for the most important pollinators, the bees (Garibaldi et al., 2009). Decline of pollinators has significant implications not just for crop pollination, but for the reproduction of most wild angiosperm plants that are the basis of natural

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landscapes (Dibble et al., 2017). They could be impacted by pesticides, natural enemies, diseases, habitat degradation (through invasive plant encroachment), habitat fragmentation, and climate change (Brown and Paxton, 2009; Goulson et al., 2015; Kerr et al., 2015). In the northeastern United States, there is evidence that most species of bees have maintained their historical abundances over several decades, or even increased, although some species have declined (Bartomeus et al., 2013). Therefore, in Maine where a large economically significant obligate bee pollinated crop is grown, wild blueberry, there is much concern.

Many believe that conservation and enhancement of bee habitat is one strategy that might reduce risk to threatened bee species in the northeastern U.S. (Dibble et al., 2018). Pollinator habitat improvements have been an emphasis supported by the USDA Natural Resources Conservation Service (NRCS) as of the 1990s and early 2000s. Over the past ten years, several studies have shown that habitat modification (Venturini and Drummond, 2018) and pollinator plantings or reservoirs can increase bee community abundance for both crop and native wild flower pollination (Venturini et al., 2017a; Dibble et al., 2018). We have been researching plantings to enhance pollinators in Maine wild blueberry (*Vaccinium angustifolium* Aiton) production. Native bees are an important component of blueberry pollination (Drummond, 2016; Asare et al., 2017; Qu and Drummond, 2017) and bee communities respond to planting of floral resources adjacent to wild blueberry fields and wildflower field edges with the result of increased yield (Venturini et al., 2017b; Drummond et al., 2017). The seed mix that we have tested in wild blueberry is described in a Maine Cooperative Extension factsheet (Venturini et al., 2015). Improving pollinator habitat has many benefits, not least of which is to improve pollinator services for crops, and to meet habitat requirements for the 268 species of native bees documented for Maine (Dibble et al., 2017). For most of these bee species, specific habitat requirements are incompletely known, but geographic areas with poor floral resources have low bee diversity and abundance (Groff et al., 2016; Dibble et al., 2018). To aid wild blueberry growers in determining if their fields are in need of higher bee abundance via pollinator plantings we have provided a video tutorial on estimating wild blueberry fruit set and bee pollinator strength (Skinner et al., 2014) and a tool (BeeMapper, https://umaine.edu/beemapper/, Du Clos et al., 2017) for them to locate their field and obtain estimates of native bee abundance.

To increase habitat for native bees beyond the neighborhood of wild blueberry fields, we obtained funding through a USDA/NRCS Conservation Innovation Grant to engage the landfill industry in a cooperative effort with blueberry growers to enhance flowering resources needed by bees. Our project was designed to demonstrate potential for pollinator habitat on a large scale, e.g., larger than a single farm. The project duration was 3 years, September 1, 2014 - August 31, 2017.

MATERIALS AND METHODS

Sites

In 2015, two types of plantings were installed at each of two sites, and in 2016 another garden was established at a third site. We were hosted by our cooperators, Casella Waste Systems in 2015 at the Pine Tree Landfill (hereafter "PTLF"), in Hampden, ME and in 2016 at Juniper Ridge Landfill (hereafter, "JRLF") in Alton, ME, and by G. M. Allen and Son, Wild Blueberries Inc., on Rte 15 in Orland, ME (headquarters unit), hereafter "GMAS", in both years.

Planting herbaceous plants

The first planting type was a pollinator strip or wildflower meadow about 30 m long and 10 m wide, for which we purchased seed mixes available from Applewood (the blueberry pollinator seed mix for Maine; Venturini et al., 2015, 2017b), Ernst Conservation Seeds (mix for Northeastern Pollinators, minus tall lupine, which is invasive in Maine), and Johnny's Selected Seeds (pollinator mix). We divided the total length of the pollinator strip into three sections, each about 10 m long by 10 m wide. The second planting type was a perennial/shrub border about 10 m by 5 m, with plants grown at the University of Maine or purchased from local nurseries. Plant species for the pollinator strip are listed in Appendix A, and purchase information and site preparation notes are in Appendix B. Species grown in the perennial/shrub border at three sites are listed in Appendix C.

Perennial shrub planting

In the perennial/shrub border we demonstrated plants not suitable for a seed mix, but that contribute important floral resources from early spring (willow) to late in the growing season. In June 2015, we installed two perennial/shrub borders. At GMAS, this second planting was located near the gift shop. At PTLF, it was located near the railroad track as no woody plants can be planted on the landfill where they might compromise the water-proof cap beneath a layer of soil. The third site, JRLF in Alton, Maine, was planted in July 2016 in a planting ringed with boulders and filled with compost; this was about 15 m × 5 m in area. Plants are listed in Appendix C.

Site preparation

Site preparation for the pollinator strip was in October 2014 at GMAS, continued in June 2015, and at PTLF in June 2015 (Figure 1). This consisted of rototilling by tractor, application of commercial compost (at GMAS), and raking by hand. At PTLF, a tractor was used to prepare the site at the top of the landfill. At GMAS, a tractor was used to spread a commercial compost mix contributed by Casella Waste Systems. In June 2015, at both sites, seed was mixed with Vermiculite and applied by hand broadcasting, then the seedbed was rolled with a water-filled roller, and a layer of straw was applied. The number of people who worked on raking, sowing, rolling, and spreading straw varied from seven at PTLF to nine at GMAS, and took about 5 h at each site (35 - 45 person-hours, not including machinery operations).

Measures of floral and bee abundance

In 2016, we made repeated observations and photos from the same

Figure 1. Site preparation at one of the GMAS blueberry fields. Photo shows delivery of Casella Organics GroMax® and Nutrimulch® at the pollinator strip site, which was roto-tilled in mid October and again in June the following year before planting.

vantage points to track changes in abundance of flowers and bees in the three seed mixes. We also inventoried bees on flowers starting in September 2014 and throughout the growing season in 2015 using insect sweep nets and small cups. We continued to collect bees and had their identifications confirmed by bee taxonomists. The specimens are housed at the Maine State Museum.

RESULTS AND DISCUSSION

Year 1: Plant response

At GMAS, rainy weather in June and early July 2015 led to a surge of weeds from the soil seed bank that overtook all three seed mixes despite an application of Poast© by Judith Collins of the University of Maine in early July. Lamb's quarters or pigweed (*Chenopodiium album*), common ragweed (*Ambrosia artemisiifolia*), and witch grass or quack grass (*Elymus repens*), grew densely and as tall as five feet in some parts of the pollinator strip, but sunflowers in the Applewood flower mix offered important floral resources to bees. Perennials emerged in sufficient abundance that it seemed worthwhile to hand weed the following season to create openings for the perennials. The pollinator strip was mowed by GMAS to a height of less than 20 cm in October 2015.

At PTLF, the pollinator strip was overtaken by Canada thistle (*Cirsium canadense*), lamb's quarters (*C. album*), and quack grass (*E. repens*). No herbicides can be used on the capped landfill. During the growing season in 2015 we weeded by hand with help from students but the weeds quickly grew back. The pollinator strip at this site was abandoned, though the perennial/shrub border was successful, producing an abundance of flowers all season, and allowed documentation of a European wool-carder bee that frequented flowers of anise hyssop (Table 1).

Year 2: Plant response

We maintained the three seed mixes by hand weeding once every two weeks, and fertilizing them once (June) with Osmocote™, a slow-release fertilizer. Several plant species that were visited by pollinators, including oxeye daisy, yarrow, and black-eyed-Susan, were not in the seed mixes. To replace the demonstration at PTLF, Casella Waste Systems chose to install a new garden next to the landfill at JRLF. The new garden was successful at having an abundance of ironweed, Joe pye-weed, oregano, white borage, and other plants in flower into early October 2016.

Bee abundance

At both sites there were already many bees present

Table 1. Thirty bee species documented at GMAS (blueberry field) and PTLF (landfill) from September 2014 through October 2015, 1 denotes presence.

Family	Species	GMAS	PTLF
Andrenidae	*Andrena wilkella*	1	1
Andrenidae	*Andrena carlini*	1	
Andrenidae	*Andrena crataegi*		1
Andrenidae	*Andrena milwaukeensis**		1
Andrenidae	*Andrena miserabilis*		1
Andrenidae	*Andrena sigmundi*		1
Andrenidae	*Andrena virginiana*	1	
Andrenidae	*Andrena wheeleri*		1
Andrenidae	*Andrena wilkella†*	1	1
Andrenidae	*Pseudopanurgus andrenoides*	1	
Apidae	*Apis mellifera†*	1	1
Apidae	*Bombus bimaculatus*	1	
Apidae	*Bombus impatiens*		1
Apidae	*Bombus sandersoni**		1
Apidae	*Bombus ternarius*	1	
Apidae	*Bombus vagans*	1	
Apidae	*Ceratina calcarata*		1
Apidae	*Ceratina dupla**		1
Apidae	*Melissodes illata**		1
Apidae	*Nomada luteoloides**	1	
Colletidae	*Colletes simulans*		1
Colletidae	*Hylaeus affinis**	1	
Halictidae	*Halictus confusus*		1
Halictidae	*Halictus ligatus*		1
Halictidae	*Lasioglossum leucocomum**	1	
Halictidae	*Lasioglossum nigroviride**		1
Halictidae	*Lasioglossum versans**		1
Megachilidae	*Anthidium manicatum†*		1
Megachilidae	*Coelioxys rufitarsus**		1
Megachilidae	*Megachile latimanus*	1	1
Totals		**13**	**21**

† denotes exotic bee species (n=3); * denotes unusual in context to other bee collecting sites in Maine, 2000 – 2015 (Dibble et al., 2017) (n=10).

before we began the habitat improvement activities, and this could reflect lack of pesticides and relative abundance of bees under existing conditions. During 2014 and 2015 we documented 30 bee species total, with 13 species at GMAS and 21 species at PTLF (Table 1). Eleven of these are somewhat unusual compared to historical data and our other recent collections (Dibble et al., 2017; Bushmann and Drummond, 2015; Drummond et al., 2017), though none are known to be truly rare and might be temporarily less abundant than they have been in the past. Half of the diversity was comprised of digger bees (Andrenidae) and sweat bees (Halictidae). This was consistent with Bushmann and Drummond (2015). One of the most noteworthy is Sanderson's bumble bee (*Bombus sandersoni*).

Assessing seed mixes, based on the pollinator planting at GMAS

Photo documentation provided adequate information for assigning ranks according to the abundance of flowers in the three seed mixes (Figure 2). We also had sufficient observations on plants to rank relative visitation rate by bees (Figure 3). We documented flowering periods of the most visited plants (Figure 4). Each seed mix had strengths and weaknesses through the flowering season. All were successful in that pollinators were observed visiting each of the plots. Many other insect pollinators and beneficial insects were observed (Figure 5), suggesting that these pollinator plantings play a multifaceted role near crops.

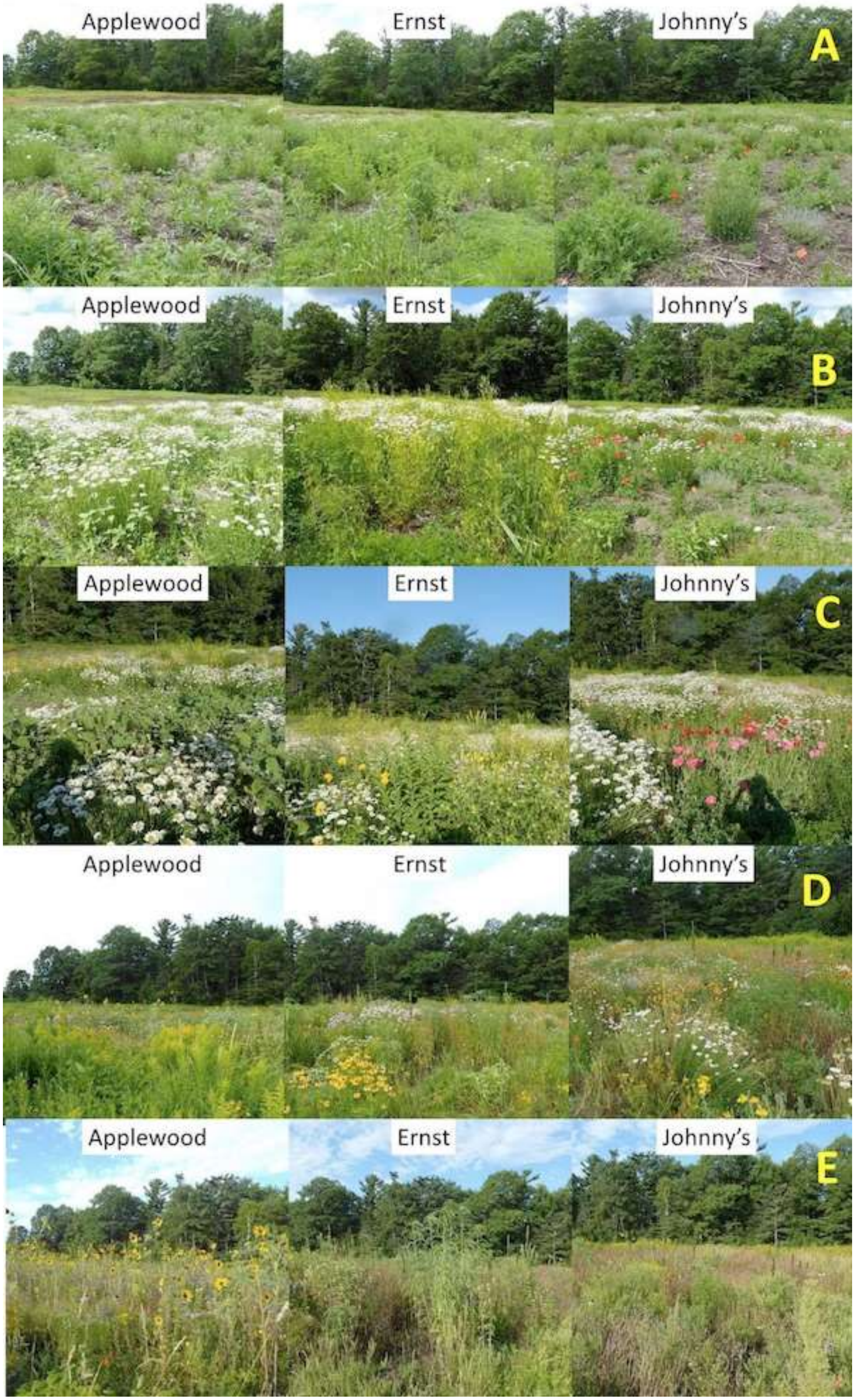

Figure 2. Views of 2016 GMAS (blueberry field pollinator planting) three pollinator seed mixes on 5 dates: A) 14 June, B) 30 June, C) 13 July, D) 29 July, and E) 25 August.

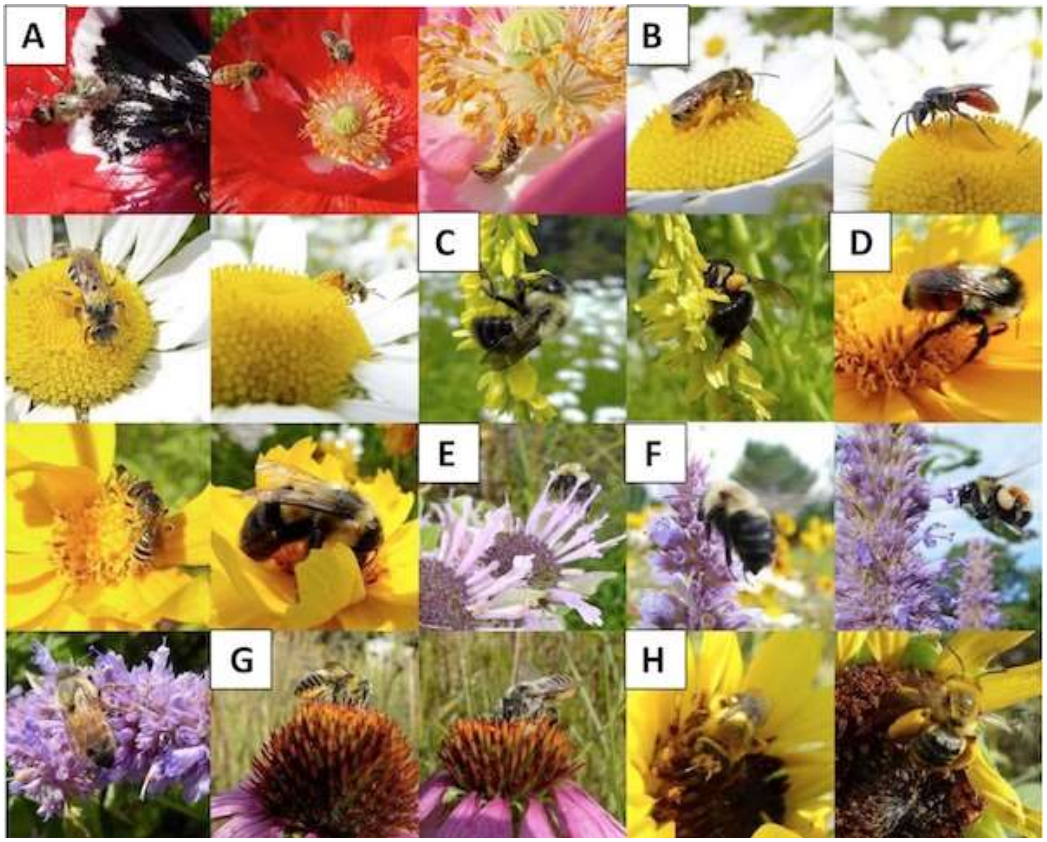

Figure 3. Top plant species growing in pollinator strips according to insect visitation: A) Corn Poppy, B) Ox-eye Daisy, C) Tall Yellow Clover, D) Lance leaf Coreopsis, E) Wild Bergamot, F) Anise Hyssop, G) Purple Cone Flower, H) Wild Sunflower.

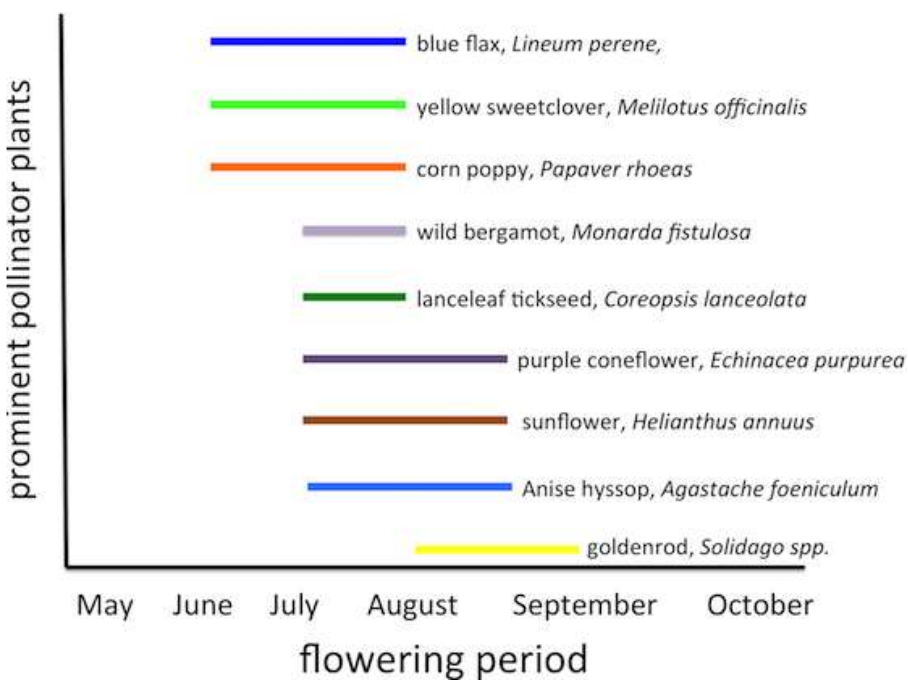

Figure 4. Flowering period for some of the most prominent pollinator plants in the pollinator strips at GMAS in 2016.

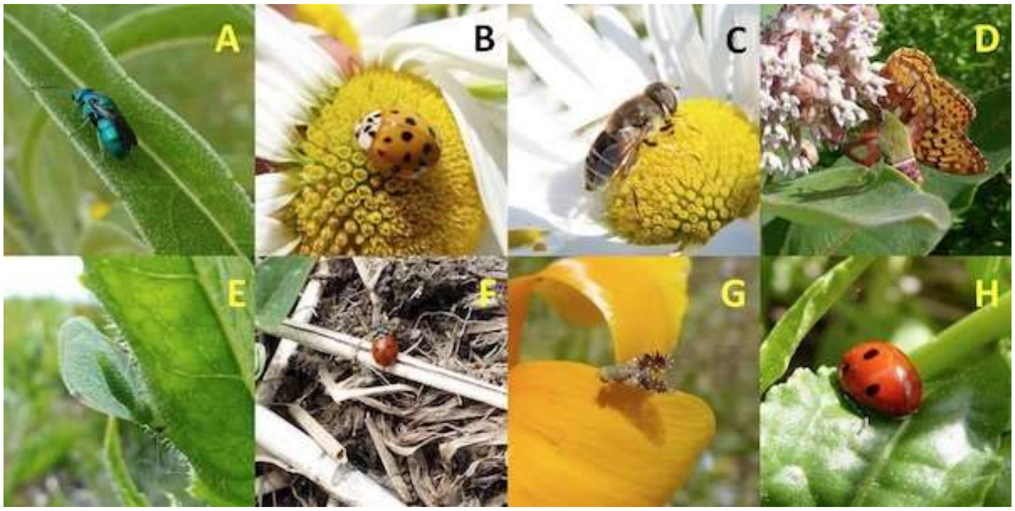

Figure 5. (A) Bees, (B, F, H) ladybeetles, (C) flower flies, (D) butterflies, (E) lacewings, and (G) picture wing flies were observed in the pollinator plantings.

Early season

The earliest flowering plants from the seed mixes were forget-me-not (starting in late May), blue flax, and various poppy varieties (middle of June). All of the earliest flowering plants were in the Johnny's plot. These were followed by tall yellow clover, lanceleaf coreopsis, and a mustard plant species. All of these flowers were present in the Ernst seed mix at the highest density, the Applewood and Johnny's seed mix had lanceleaf coreopsis as well but at a much lower density. The beginning of bloom for these flower mixes was the end of June.

Mid-season

From the end of June through the end of July none of the mixes contained a large abundance of flowers from any one species. Milkweed flowered at a high density just outside the pollinator strip at GMAS. Milkweed seed was included in the Ernst mix but few flowered in the plot, and might develop in subsequent years. From early July into September, black-eyed Susan was present in the surrounding landscape and also in the plots. Plant species that bloomed in late July included plains coreopsis, anise hyssop, purple coneflower, tidy tips and wild bergamot. All except plains coreopsis and tidy tips were included in the three seed mixes; plains coreopsis was not included in the Ernst seed mix. Tidy tips were included only in the Johnny's seed mix.

Late season

All three seed mixes produced adequate abundance of flowers through late season. Tall sunflowers were abundant in the later part of the growing season, with lesser abundance of New England aster and purple coneflower.

Top plants

The plants with the highest abundance were corn poppy, tall yellow clover, oxeye daisy, black-eyed Susan, anise hyssop, and wild bergamot. These plants flowered between the beginning of June and early September, and each began and ended their flowering period at different dates (Figure 4).

Bee visitation

Overall, the plants with the highest bee visitation were corn poppy, tall yellow clover, oxeye daisy, black-eyed Susan, anise hyssop, and wild bergamot. These plants flowered between the beginning of June and early September, and each began and ended their flowering period at different dates (Figure 4). In 2016, the Applewood mix produced no flowers from the planted seed mix until late June when lanceleaf coreopsis bloomed.

Applewood plants flowered later and were mostly unavailable to early pollinators. Plants present in the plots with low bee visitation were globe gilia, fleabane, and Siberian wallflower, all of which were in the Johnny's seed mix. That same mix had flowers from late May through August. Ernst had abundant flowers later in the season. In the perennial/shrub borders, Northern blue violet, yarrow and Rudbeckia 'Goldsturm' appeared to attract few insects.

Figure 6. Open house at (A) GMAS blueberry field and (B) Juniper Ridge landfill.

Technology transfer and outreach

In 2015, open houses and garden tours were held at GMAS and PTLF in September. We learned that a Friday afternoon is a difficult time to get people to come out to a blueberry farm (GMAS). The 2015 tour of PTLF was much better attended, but this landfill is not open to the public so only one event was scheduled there. In 2016, the open house for the public at GMAS was on a Saturday and the people who came were keen to see both gardens (Figure 6). Our best-attended event was at JRLF with its established open house each first Saturday in October. More than 180 people came to our booth (Figure 6), and many more enjoyed the garden itself.

Numerous bees, especially bumble bees, visited the garden. In all, we estimate that about 600 people saw the gardens and had a chance to take handouts we prepared.

SUMMARY AND CONCLUSION

Use of two types of gardens was successful in this demonstration. The shrubs and perennials in the border at both GMAS and PTLF did surprisingly well, and covered the very early and late seasons for pollinator forage. They were attractive and because they were heavily mulched thanks to Casella's contribution of bark mulch, were not overrun with weeds. The shrub/perennial border was an important part of the demonstration as it provided pollinators with resources that were not otherwise available. Landowners who hosted these two gardens at GMAS and PTLF were pleased with the appearance and function of the gardens. Shrubs that attract beneficial insects have an important place in the list of resources valuable to pollinators, but they are not suitable for some pollinator strips. By making a place for these on the landscape, we allowed for the contribution such plants can make.

Based on what we learned in this demonstration project, pollinator strips will be most successful if there is sufficient weed control before planting the wildflower mixes. This was already known, but our experience reinforced the point. We were following a method used successfully in another study, but we probably should have anticipated the emergence of weeds in a wet season. We then had to take a post-facto instead of preventive approach. Farmers will not want to take the time to weed around the perennials as we did at GMAS in 2016, and should be encouraged to put extra resources into controlling weeds 1-2 years ahead of sowing the expensive wildflower mixes. At GMAS, weed pressure in all three seed mixes was high but hand weeding in 2016 made a considerable difference in countering this, and was successful in allowing for emergence of intended subject plants. We might have mis-identified a few plants from the mixes and pulled them unknowingly, but there was sufficient germination and emergence to overcome this. When hand weeding plots, we suggest waiting until the first true leaves have developed before making a decision to pull or not. It is also important to note that flowering plants not included in the mixes (e.g., ox-eye daisy, black-eyed Susan) but allowed to remain were important to the three plots, especially in the Applewood mix where few other plants bloomed in the earlier part of the season (later, sunflower and coreopsis, along with anise hyssop, were available). The weed pressure was greatly reduced in the Ernst seed mix due to tall yellow clover ground coverage. This reduced the need for weeding and allowed bees to forage on the many other flowering plant species present in the section.

We recognize a need for development of weed control methods that should be implemented before planting wildflower seed. Presumably each site differs in the soil seed bank that could be present, and a one-size-fits-all approach might be inadequate. Weed control on organic and conventional farms could include repeated shallow tilling every few weeks through the growing season prior to planting. Some combination of cover crops with repeat tilling could be effective. Producers will want to allow sufficient budget to cover the garden maintenance, as we found this to be a necessary labor -- an estimated 1-2 h per week will help keep a perennial/shrub border that is 5 m x 10 m in size deadheaded, weeded, watered, and looking its best, thus offering maximum forage for bees.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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