Native Meadow Trial at the Hudson Valley Farm Hub

Botany Report for the first three seasons: 2017-2019

by Claudia Knab-Vispo (Hawthorne Valley Farmscape Ecology Program)

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SUMMARY

In 2017, a trial was initiated in three trial areas totaling 4.5 acres of former corn fields to

- document the establishment and maintenance of native meadows without the use of herbicides
- test the performance of 22 insect-pollinated wildflowers and 8 grasses native to northeastern North America seeded into farmland in the mid Hudson region
- monitor the development of the plant composition of meadows derived from two different seed mixes and spontaneously establishing themselves in fallow fields
- assess the value of these seed mixes for supporting insect biodiversity and beneficial invertebrates.

The meadows were successfully established and required approximately 11 person-hours of labor per acre during each of the first two years, and 6 person-hours/acre during the third year.

Although some of the seeded experimental plots were overrun by Crabgrass in the first year, the seeded wildflowers and native grasses asserted themselves in the second year, and by the third year, most seeded plots were composed of more than 90% of native plants. While all but one seeded species did establish at least some seedlings during the first two years, only half of the originally seeded species really "took off" and made up the bulk of the vegetation in the seeded meadows in 2019.

The seeded meadows produced very few flowers in the first year, but by the second year (2018), both seed mixes (flower-rich Mix A and grass-rich Mix B) resulted in a large amount of yellow flowers (Black-eyed Susan) in mid July. Mix A continued to provide flowers of diverse species into October, while flower abundance in Mix B declined rapidly at the end of July. In the third year, yellow flowers again dominated the meadows in mid July, but they were not as abundant as in the second year. While this peak of yellow July flowers was higher in Mix B than in Mix A, it was again the only flush of flowers in Mix B. The peak of yellow in July was not as impressive in Mix A, but the meadows derived from this flower-rich seed mix did continue to provide abundant and diverse flowers through the end of September.

From the insect research (Vispo et al. 2020; Allen 2019), we learned that the flower-rich Mix A resulted in a meadow that attracted more butterflies, native bees, and hover flies, but did not seem to support beneficial parasitoid wasps as well as the fallow control.

The insights from the first three years of the native meadow trials guided us to design a modified native meadow seed mix which contains the wildflower species that provide the bulk of flowers in Mix A and additional species with flowers easily accessible to the small parasitoid wasps. This new mix has been seeded in the fall of 2019 on a 10 acre field and its success (and challenges) in establishment and its attractiveness to the insect community will be monitored in the coming years.

We also plan to continue the monitoring of the vegetation composition, flower abundance, and insect community, as well as any management action in the native meadows, for several more years and to maintain them as a well-documented demonstration sites of seeded native meadows in the mid Hudson Valley. This will also allow us to assess the “longevity” of such meadows.

Introduction

The Hudson Valley Farm Hub is a non-profit, organic farm located on 1,200 acres of prime farmland in the floodplain of the Esopus Creek, between the Catskills and the Hudson River. It strives to contribute to a resilient food system for the Hudson Valley and is committed to strengthening the synergies between farming and wild nature. The Farm Hub is a production farm that also serves as a resource for education, demonstration, and research.

One area of research is the establishment and monitoring of on-farm habitats to support beneficial invertebrates and other wildlife. In 2017, we established a native meadow trial on former corn fields that had been taken out of tillage because of their exposure to infrequent but severe flooding.

Objectives of the Native Meadow Trial

Our overall objective for the native meadow trial is to understand what seed mixes and management regimes can produce good herbaceous habitat for beneficial insects and other wildlife at the Farm Hub. Specifically, we hope to learn and document the following:

- What does it take (in terms of equipment, labor, and cost of seeds) to establish permanent meadows composed mostly of native grasses and wildflowers on former cornfields? Is that possible without the use of herbicides and with techniques that are potentially practical to other farmers?
- Which plant species seem most suitable as components of permanent meadows here at the Farm Hub and so, perhaps, elsewhere in the region?
- Which invertebrates are attracted to the experimental plots of the native meadow trial? What is the balance between beneficial insects and pests? The ultimate agroecological question is: What is the net effect of such wildflower plantings on crop production?
- What role might these native meadows play for birds?

- How do soil conditions evolve in the native meadow trial plots compared to neighboring hayfields and tilled soil?

The native meadow trial plots are intended to serve as well-documented demonstration areas and inspiration for other farmers. They will also help inform future management decisions at the Farm Hub itself, as it explores opportunities for conservation biological control, pollinator conservation, and options for productive permanent cover of flood-prone fields.

Methods

The Native Meadow Trial consists of three rectangular trial areas of 320 x 200 feet (NMT1, NMT2, and NMT3; Figure 1), each of which has been subdivided into three experimental plots (A, B, C) of 100 x 200 feet, separated by 10 foot wide strips of mowed grass/clover.

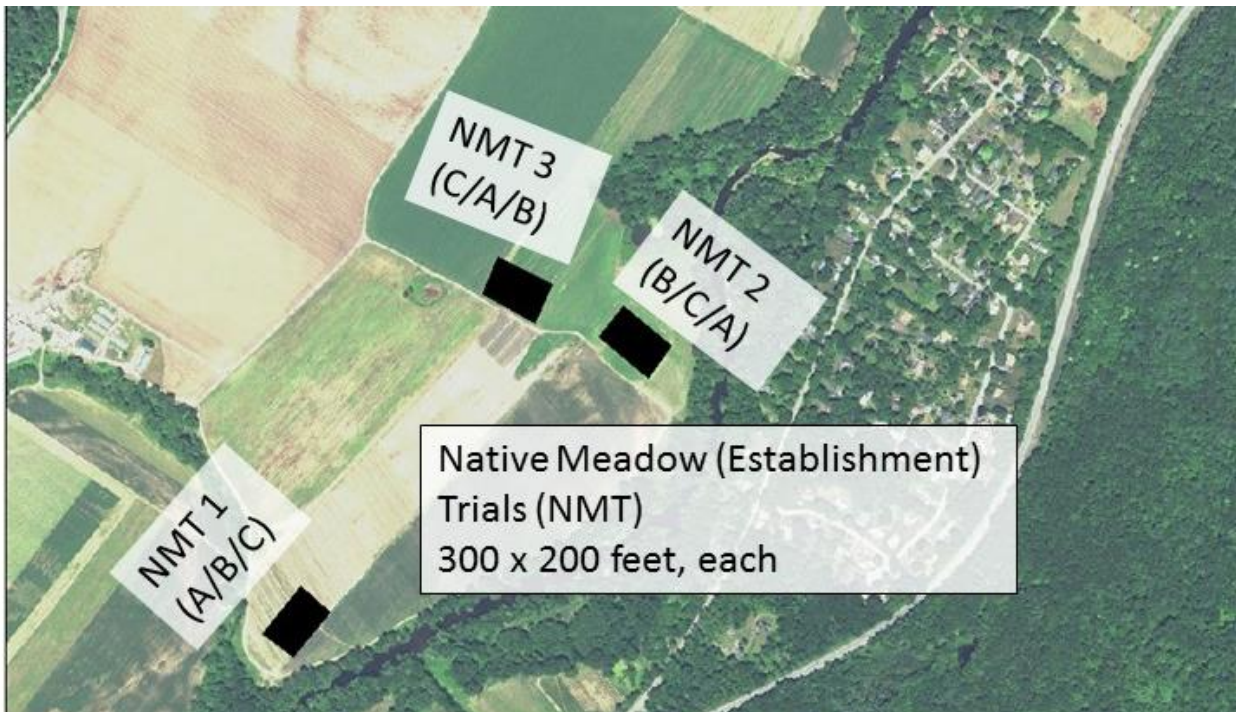

Figure 1: Map of Native Meadow Trial Areas at the Hudson Valley Farm Hub

Soil Types: The trial areas were located on different soil types. NMT1 is on Tioga fine sandy loam, NMT2 on Suncook loamy fine sand, and NMT3 on Unadilla silt loam. The soil characteristics are described in more detail in the results section below.

Crop History: All three trial areas were planted in Sweet Corn (preceded and followed by Rye) in 2013. In 2014, they all had a cover crop of Crimson Clover. In 2015, NMT1 was planted in mixed vegetables and NMT2&3 were in Wheat, all followed by Rye. In 2016, all three trial areas were planted in Rye, followed by Oat—in preparation for the seeding with native meadow seed mixes the following year.

Site Preparation: The decision to dedicate these particular areas to the native meadow trial was only made in the summer of 2016, when they were all in Rye. We decided to plan for a spring 2017 seeding, realizing that this would not allow for the recommended year-long site preparation. The trial areas were seeded with Oat in fall 2016, which was expected to winter-kill and leave bare soil for seeding the following spring. Although the Oat was winter-killed, the Rye volunteered in most of the experimental areas in early spring 2017. Therefore, the experimental areas were harrowed three times in the spring of 2017 with a Perfecta II Harrow with S-tines equipped with duck feet in order to uproot the rye and to prepare a weed-free seedbed for the native meadow mixes. Each harrowing pass over the entire 4.5 acre trial area took 2 hours. According to Jean-Paul Courtens (then one of the farmers at the Farm Hub), disking would have accomplished the same; however a Perfecta Harrow with points (rather than duck feet) would not have been effective at uprooting the Rye.

Seed Mixes and Seeding: With the help of Kelly Gill (Xerces Society), we created two customized seed mixes for this trial. Meadow Mix A (see Table 2 and Figure 2) is an ideal (but expensive) pollinator mix, rich in wildflowers native to North America, most of them native to the Northeast (including 22 species which should provide ample flower resources to pollinators throughout the seasons) and with one species of native bunch grass (Little Bluestem).

The cheaper Meadow Mix B (see Table 3 and Figure 3) has a variety of native bunch grasses, but also contains six native wildflowers, which likewise were selected to provide floral resources throughout the seasons.

The seeds were sourced from three different suppliers, as indicated in Tables 2 and 3. Please also refer to these tables for scientific names of the plant species referred to in the text by common names. In addition to the perennial species listed as “official” components of the seed mixes, seeds from annual Blanketflower (*Gaillardia* sp.) and Phacelia (*Phacelia tanacetifolia*), which had been left over from annual insectary seedings elsewhere on the farm, were added to both seed mixes (approximately 1 lb of each species to each seed mix).

On May 19, 2017, we used a Great Plains No-till Seeder to seed experimental plots A and B in each of the three trial areas with Meadow Mix A and Meadow Mix B, respectively. For unknown reasons, we did not quite accomplish the recommended seeding rates, and seeds were left over after the first pass of the seeder. To correct this, the leftover seeds were broadcast by hand on May 25th (before the next rain, to maximize soil seed contact and minimize the danger of the seeds getting blown away by the wind) to approximate the recommended seeding rates. Seeds of each species in the seed mixes were seeded on May 19th into pots in the greenhouse to serve as a reference. This enabled us to photographically document seedling morphology and to monitor seed germination, both in the greenhouse and in the field.

Experimental plot C in each of the three trial areas was left fallow as a control and allowed to develop a plant community from the seed bank in the soil and from naturally dispersed seeds. These were cut and weeded on the same schedule as the seeded trial areas.

*Table 1: Species list for Seed Mix A, which is rich in wild flowers. Seeds from annual Blanketflower (*Gaillardia *sp.) and Phacelia (*Phacelia tanacetifolia*) were added to this mix, approximately 1 lb each.*

Native Meadow Mix A				
Common Name	Scientific Name	Percent of mix by volume (seed/ft2)	Final Mix Total pounds (lb) for 1.5 acres	Supplier
Blackeyed Susan	Rudbeckia hirta	6.5%	0.19	Ernst Seeds
Browneyed Susan	Rudbeckia triloba	2.2%	0.18	Ernst Seeds
Butterfly Milkweed	Asclepias tuberosa	1.1%	0.73	Ernst Seeds
Common Milkweed	Asclepias syriaca	1.1%	0.73	Ernst Seeds
Dense Blazingstar	Liatris spicata	1.1%	0.51	Ernst Seeds
Early Goldenrod	Solidago juncea	3.2%	0.06	Ernst Seeds
Joe Pye Weed	Eupatorium purpureum	1.0%	0.07	Prairie Moon
Lance Leaved Coreopsis	Coreopsis lanceolata	8.6%	1.84	Ernst Seeds
Lavender Hyssop	Agastache foeniculum	8.6%	0.27	Ernst Seeds
Little Bluestem	Schizachyrium scoparium	19.4%	4.59	Ernst Seeds
Mistflower	Eupatorium coelestinum	6.5%	0.20	Ernst Seeds
Narrowleaf Mountainmint	Pycnanthemum tenuifolium	3.8%	0.03	Prairie Moon
New England Aster	Aster novae-angliae	2.1%	0.09	Ernst Seeds
Ohio Spiderwort	Tradescantia ohiensis	2.2%	0.81	Prairie Nursery
Partridge Pea	Chamaecrista fasciculata	2.2%	1.57	Ernst Seeds
Purple Coneflower	Echinacea purpurea	4.3%	1.76	Ernst Seeds
Purple Prairie Clover	Dalea purpurea	2.2%	1.27	Ernst Seeds
Roundhead Lespedeza	Lespedeza capitata	1.1%	0.19	Prairie Moon
Showy Goldenrod	Solidago speciosa	2.3%	0.08	Ernst Seeds
Slender Lespedeza (added)	Lespedeza virginiana	2.1%	1.27	Ernst Seeds
Smooth Blue Aster	Aster laevis	2.1%	0.10	Ernst Seeds
Tall White Beardtongue	Penstemon digitalis	9.7%	0.25	Pinelands Nursery
Wild Bergamot	Monarda fistulosa	6.7%	0.25	Pinelands Nursery
	TOTALS:	100.0%	17.04 lbs	

*Table 2: Species list of Seed Mix B, which is rich in grasses; Seeds from annual Blanketflower (*Gaillardia *sp.) and Phacelia (*Phacelia tanacetifolia*) were added to this mix, approximately 1 lb each.*

Native Meadow Mix B				
Common Name	**Scientific Name**	**Percent of mix by volume (seed/ft2)**	**Final Mix Total pounds (lb) for 1.5 acres**	Supplier
Autumn Bentgrass	*Agrostis perennans*	15.0%	0.09	Ernst Seeds
Big Bluestem	*Andropogon geradii*	6.4%	2.12	Ernst Seeds
Blackeyed Susan	*Rudbeckia hirta*	6.3%	0.19	Ernst Seeds
Canada Wildrye	*Elymus canadensis*	10.7%	4.47	Ernst Seeds
Indiangrass	*Sorghastrum nutans*	6.7%	1.82	Ernst Seeds
Lance Leaved Coreopsis	*Coreopsis lanceolata*	3.2%	0.69	Ernst Seeds
Little Bluestem	*Schizachyrium scoparium*	16.0%	3.82	Ernst Seeds
Partridge Pea	*Chamaecrista fasciculata*	1.1%	0.78	Ernst Seeds
Purple Coneflower	*Echinacea purpurea*	5.3%	2.20	Ernst Seeds
Purple Lovegrass	*Eragrostis spectablis*	1.3%	0.06	Prairie Moon
Purple Prairie Clover	*Dalea purpurea*	2.1%	1.27	Ernst Seeds
Purpletop	*Tridens flavus*	16.4%	1.69	Ernst Seeds
Slender Lespedeza	*Lespedeza virginiana*	1.1%	0.65	Ernst Seeds
Switchgrass	*Panicum virgatum*	8.5%	1.57	Ernst Seeds
	TOTALS:	**100.00%**	**21.42 lbs**	

Figure 2: Images of plants included in Seed Mix A (first row: Lavender Hyssop, Dense Blazingstar, Black-eyed Susan, Smooth Blue Aster, Purple Prairie Clover, New England Aster; second row: Little Bluestem, Early Goldenrod, Brown-eyed Susan, Tall White Beardtongue, Round-headed Lespedeza, Ohio Spiderwort; third row: Mistflower, Joe-Pye-Weed, Butterfly Milkweed, Showy Goldenrod, Partridge Pea, Purple Coneflower; fourth row: Narrow-leaved Mountain-mint, Lance-leaved Coreopsis, Common Milkweed, Wild Bergamot, Slender Lespedeza); Pictures were copied from on-line seed catalogues, mostly by Prairie Moon

Figure 3: Images of plants included in Seed Mix B (first row: Autumn Bentgrass, Big Bluestem, Black-eyed Susan, Canada Wildrye, Indiangrass; second row: Lance-leaved Coreopsis, Little Bluestem, Partridge Pea, Purple Coneflower, Purple Lovegrass; third row: Purple Prairie Clover, Purpletop, Slender Lespedeza, Switchgrass).

Management:

First Season (2017): All experimental plots (those seeded with seed mixes A & B, as well as the control plots) were mowed to approximately 6-7 inches height three times during the first season. This was necessary to reduce shading of the slow-growing seedlings of the perennial native plants by the fast-growing annual weeds that had germinated from the seed bank and to limit the production of new weed seeds. The mowing was done on:

- 6-10 July 2017: with flail mower (6 hours total for 4.5 acres)
- 26/28 July 2017: with flail mower (6 hours total for 4.5 acres)
- 15/16 Aug 2017: with rotary mower (3 hours total for 4.5 acres)

No management occurred during the rest of the season and the vegetation was left standing into the winter.

Second Season (2018): By Spring of the second year, the native perennials had established dense stands and were not threatened by competition for light by early-season annual weeds any more. However, the perennial and non-native Red Clover, Hairy Vetch, Mugwort, Curly and Broad-leaved Dock, and Wild Carrot were growing vigorously in the experimental plots, and were reduced by selective weeding/string trimming in all nine experimental plots, including the control plots (50 hours total for 4.5 acres between 25 May and 15 June 2018). During the summer, we noticed young Cottonwood trees colonizing some of the experimental plots, most densely in NMT1C, and to a lesser degree in NMT1A, NMT3A, and NMT3C. Because five of the nine experimental plots had basically no colonization with Cottonwood, we decided to try to selectively pull out/cut the Cottonwood in those plots where it was getting common the following spring. Thus, the vegetation was again left standing into the winter in all experimental plots.

Third Season (2019): On May 6th of the third year, we selectively cut (and pulled where still possible) the young Cottonwood trees (20 person hours total; most of them applied to NMT1 C). No other selective weeding was necessary that spring. In late summer, we selectively cut most (but did not get to all) Mugwort patches that had persisted in the experimental plots. This took 7 person hours total. Once more, the vegetation was left standing into the winter in all experimental plots. The young Cottonwood trees had regrown to a height of up to 8 feet by the end of the season.

Monitoring Methods:

Vegetation Development:

Photographic Documentation: We documented the development of the vegetation in all nine experimental plots with a series of images taken from standard locations at monthly intervals.

Quantitative Vegetation Inventories: Twice a year (July & September), we documented the vegetation in ten evenly-spaced samples along two transects in each of the nine experimental plots. In ten square-shaped samples of one square foot, we recorded the % cover and maximum height of each plant species present. In ten larger circular samples of 3 feet radius (which included the square samples), we recorded the presence of all additional plant species.

Flower Abundance: We documented quantitatively the seasonal flower abundance by species. In each experimental plot, we counted or estimated the number of open flowers of each species in ten circular, three-foot radius samples spaced evenly along two transects. Species-specific flower abundance in each sample was calculated by multiplying the number of flowers by their average size (=flower or inflorescence area in mm^2). We then extrapolated this value to average % cover by each flower species within each experimental plot. Flower abundance was monitored twice in 2017 (Aug 10 and Sept 8; the newly seeded plants were slow to produce flowers in the first year, therefore, we only began documenting flower abundance later in the summer) and four times in 2018 (June 12, July 10, Aug. 9, Sept. 21) and 2019 (June 12, July 15, Aug. 14, Sept. 10) to represent the duration of the flowering period.

General Insect Monitoring: We documented the presence and abundance of insects in the experimental plots three times in 2017 (May, Aug., Oct.) and four times in 2018 and 2019 (in June, July, Aug., and Sept.). In each of the nine plots, insects were sampled over a 24-hour period with a variety of traps. For a detailed description of the insect monitoring methods, please see the entomology research report by Vispo et al. (2020).

Monitoring of Flower-Visiting Insects: Flower-visiting insects were documented in the nine experimental plots every two weeks from June through September 2018 with standardized visual surveys conducted by Erin Allen as part of her graduate work at SUNY Albany (Allen 2019).

Soil Conditions: Three composite soil samples (composed of 10 samples each) were taken from each of the nine experimental plots annually in the spring (May 2, 2017; May 7, 2018; May 22, 2019) and analyzed at the Cornell Soil Health Lab for their chemical, physical, and biological characteristics.

Labor and Equipment: We keep records of all management actions to document the labor and equipment used to establish and maintain these wildflower meadows.

Monitoring Results and Discussion

Vegetation Development:

Appendices 1.1 through 9.3 are the photographic documentation of each of the nine experimental plots during the first three years. Appendices 10.1 through 12.3 show side-by-side photographic comparisons during the first three years for all plots organized by treatment, while Appendices 13.1 through 15.3 show the same images organized by trial area.

Figures 4 & 5 illustrate the results from the quantitative vegetation inventories in experimental plots seeded with Seed Mix A during the first three years. Figure 4 shows percent cover of *seeded* species and Figure 5 that of *wild-growing* species. Figures 6 & 7 show the same for experimental plots seeded with Seed Mix B. Figure 8 illustrates percent cover by *wild-growing* plants in the control plots.

There was a marked difference in vegetation development during the first season between the trial areas. In trial area NMT1 (Fig. 1), both seeded plots (A1 and B1) had better establishment of the seeded plants (reaching 44% and 26% cover respectively; Fig. 4 & 6) by September 2017 than the same treatments in NMT2 and 3 (reaching at the most 15% and 5% cover, respectively; Fig. 4 & 6). This might have been in part due to the different crop history of NMT1, which had been in mixed vegetables in 2015 and consequently seemed to have a different weed seed bank. NMT2 has the sandiest soil and lowest water holding capacity of the trial areas, and there might have been less germination success and higher seedling mortality due to the relative dryness in this trial area. NMT3A has the highest heterogeneity of soil conditions within any of the experimental plots, including a large area (approximately 20% of the plot) that often has standing water after rains, but also dries to a hard pan during dry periods. Germination of seeded plants was low in this intermittently-waterlogged area of NMT3A during the first year.

During the second season, the seeded plants “took off” in all experimental plots (including in the intermittently waterlogged area of NMT3A), reaching between 80% and 95% cover in those seeded with Mix A (Fig. 4), and between 60% and 80% cover in those seeded with Mix B (Fig. 5). The density of seeded plants in NMT1A compared to NMT2A and NMT3A remained somewhat higher, but the difference became much less striking (Fig. 4). Although at the end of the 2017 season and into early 2018, NMT2A was densely covered with a mulch of Crabgrass stalks (App. 4.1 and 4.2), the seeded wildflowers eventually pushed through and reached almost the same density as in NMT3A (Fig. 4). The initial difference in percent cover by seeded plants between the three experimental plots seeded with Mix B did not persist into the second season (Fig. 6).

During the third season, the seeded plants in the plots seeded with Mix A became more diverse (Fig. 4). Black-eyed Susan, which was predominant in all three plots in July 2018, diminished in abundance, to be partly replaced by Wild Bergamot, Partridge Pea, New England Aster, and a number of less common species. At the same time, the plots seeded with Mix A continued to diverge from each other in terms of their plant composition. For example, the different species of seeded plants were most similar in their abundance in NMT1 A, while Wild Bergamot and Lance-leaved Coreopsis were most abundant in NMT2 A, and Partridge Pea was most abundant in NMT 3A.

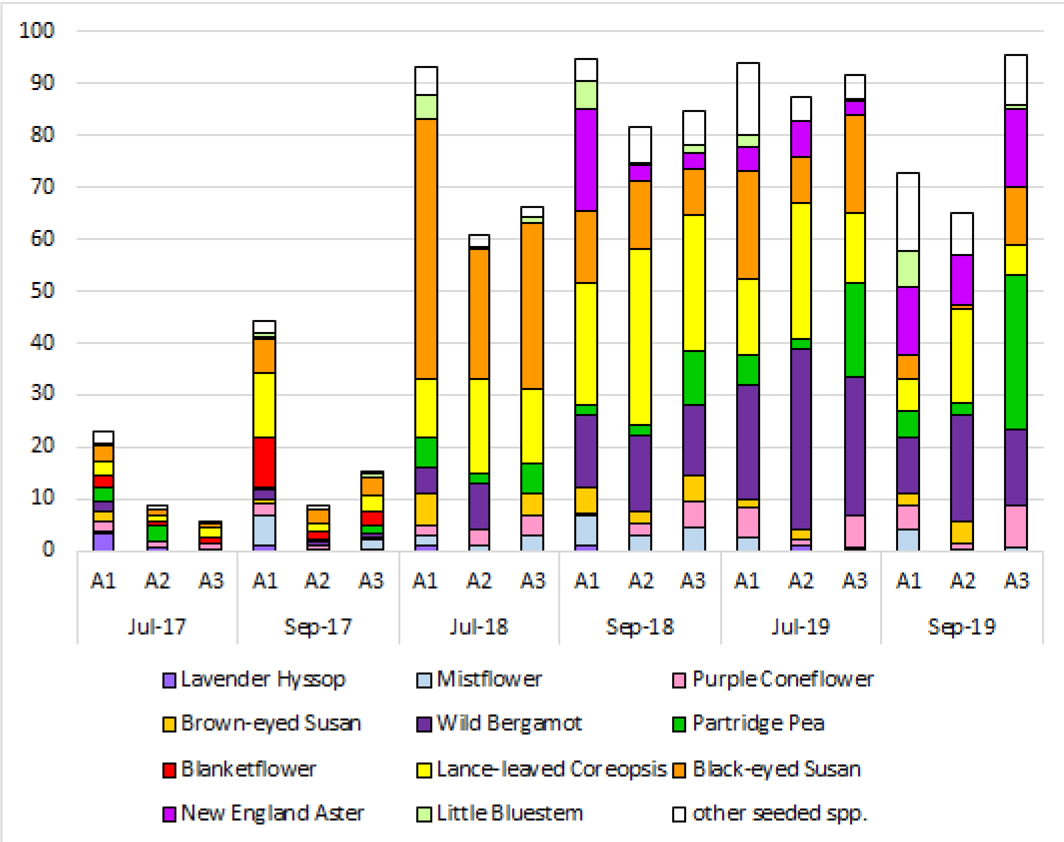

Figure 4: Development of Vegetation Composition (% cover of seeded species only) in Experimental Plots seeded with Seed Mix A (please note that A1, A2, and A3 refer to experimental plots NMT1A, NMT2A, and NMT3A, respectively)

In all three plots seeded with Mix B, the native grasses asserted themselves during the third season, at the expense of Black-eyed Susan and Lance-leaved Coreopsis, which nevertheless continued to be important components of the vegetation in these plots. In all three plots of this treatment, Purple Coneflower also increased in abundance. The wild-growing plants were clearly more abundant in NMT2A and 3A than in NMT1A at the end of the first season (Fig. 5), with Crabgrass covering 85% and 65% of NMT2A and NMT3A, respectively (App. 10.1). Crabgrass was also the dominant wild-growing plant in all other experimental plots at the end of 2017 (Figs. 5, 7, and 8). During the following seasons, wild-growing plants declined markedly in all experimental plots that had been seeded with Seed Mix A (reaching, at the most, 25% cover in 2018 and 7% cover in 2019). By midsummer 2018, wild-growing plants were still somewhat more abundant in NMT2A and NMT3A compared to NMT1A, but that difference became much less prominent by September 2018 and had disappeared by 2019 (Fig. 5). The most common wild-growing plants in NMT1A and NMT3A in 2019 were Cottonwood seedlings.

Wild-growing plants were also more abundant in NMT2B and NMT3B (hovering around 90% cover), compared to NMT1B (between 60 and 70% cover) in the first season, but this difference had also disappeared by 2019, when none of the plots seeded with Mix B had more than 15% cover of wild-growing plants (Fig. 7). Annual plants were the most common wild-growing plants in these plots during the first two seasons (Pigweed, Crabgrass, and Galinsoga in 2017, Horseweed in 2018). By 2019, the biennial Wild Carrot was the most common wild-growing plant in these plots (Fig. 7).

The species in Seed Mix A did not all establish evenly. Although, during 2017, we found young plants of 19 of the 22 seeded wildflowers and of Little Bluestem in at least one of the experimental plots, some species established themselves more quickly and abundantly. During the first season, these were Black-eyed Susan, Lance-leaved Coreopsis, Partridge Pea, Purple Coneflower, and Blanketflower (an annual, which had been added to the seed mixes as an afterthought) and, to a lesser degree, Mistflower, Wild Bergamot, Lavender Hyssop, and Phacelia (another annual, which also had been added to the seed mixes) (Fig. 4).

In 2018, Lance-leaved Coreopsis and Black-eyed Susan became very common in the experimental plots that had been seeded with Seed Mix A (Fig. 4), but many other seeded species, such as Partridge Pea, Purple Coneflower, Brown-eyed Susan, Wild Bergamot, Lavender Hyssop, Mistflower, and—to a lesser degree--Dense Blazingstar, New England and Smooth Aster, Showy and Early Goldenrod, and Butterfly Milkweed increased in abundance, and even a few individuals of Narrowleaf Mountainmint and Ohio Spiderwort, which had not been seen during the first season, began to appear. In 2019, Black-eyed Susan and Lance-leaved Coreopsis became less common, while most of the other species increased in cover. Roundhead and Slender Lespedeza, Purple Priarie Clover, as well as Common Milkweed persisted through 2019 in small numbers. The only species that has not been detected at all during the first three seasons is Joe-Pye-Weed. Blanketflower and Phacelia, the two annual species which had been added to the seed mixes, flowered in 2017 but did not reappear in 2018 or 2019.

In the experimental plots seeded with Seed Mix B, the dominant species during the first season were Black-eyed Susan, Lance-leaved Coreopsis, and Blanketflower (Fig. 6). The last did not persist into the second season. Of the native grasses, Little Bluestem and Canada Wildrye were most noticable in 2017. Native grasses increased in abundance in 2018 (up to 20% cover) and continued to do so (up to 50% cover) in 2019. In 2019, all seeded native grass species were present, but Switchgrass, Indian Grass, Canada Wildrye, and Little Bluestem were the most abundant. Black-eyed Susan and Lance-leaved Coreopsis peaked in abundance in 2018 and became less (although they both remained prominent) in 2019. Purple Coneflower steadily increased during the first three years, although it has not exceeded 10% cover. Partridge Pea persisted in very low densities through 2018 and 2019, while Slender Lespedeza and Purple Prairie Clover were not observed during the first three seasons in any of the experimental plots seeded with Seed Mix B.

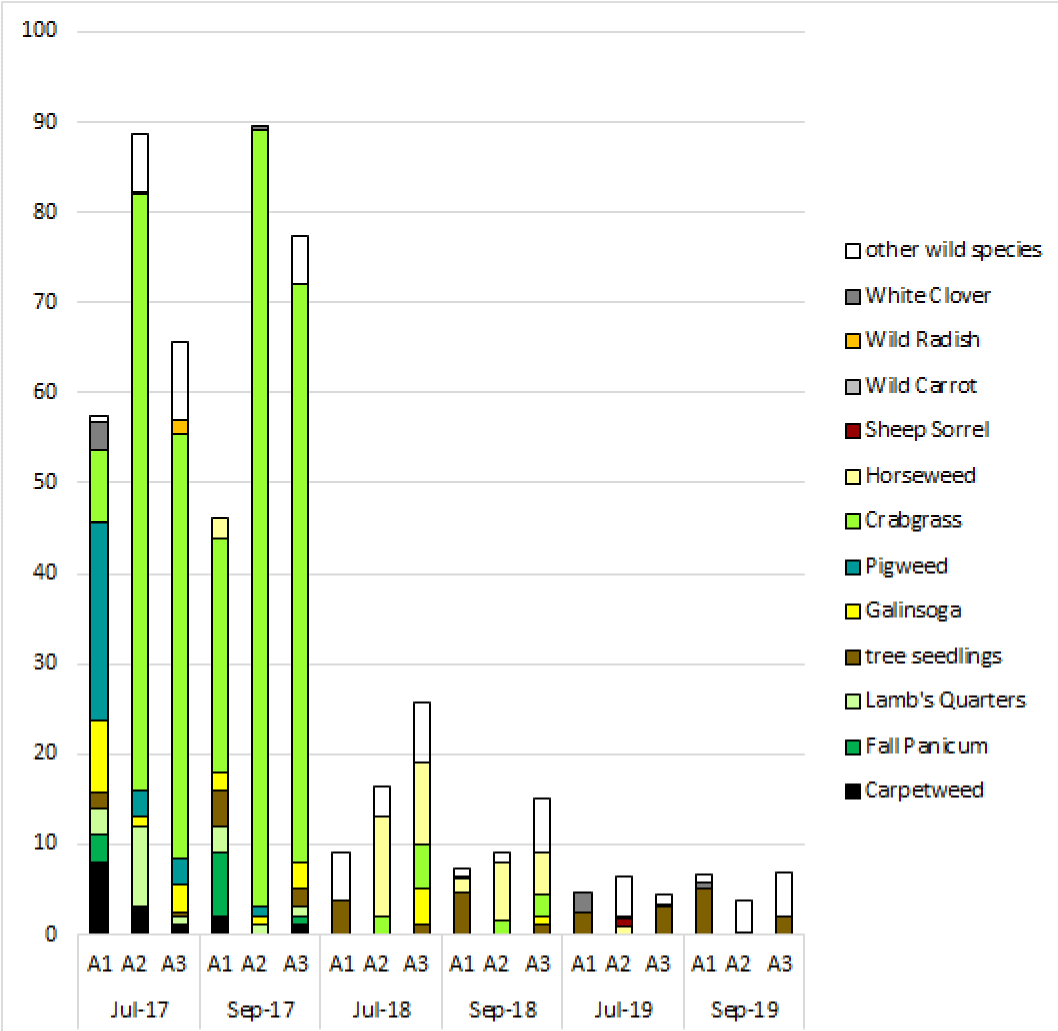

Figure 5: Development of Vegetation Composition (% cover of wild-growing species only) in Experimental Plots seeded with Seed Mix A (please note that A1, A2, and A3 refer to experimental plots NMT1A, NMT2A, and NMT3A, respectively)

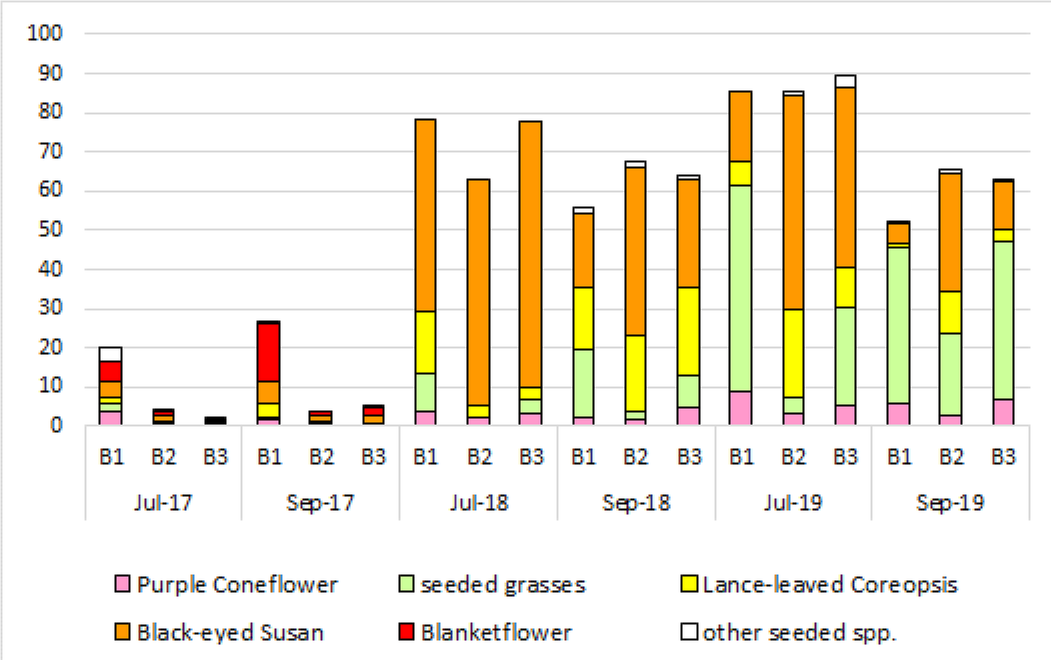

Figure 6: Development of Vegetation Composition (% cover of seeded species only) in Experimental Plots seeded with Seed Mix B (please note that B1, B2, and B3 refer to experimental plots NMT1B, NMT2B, and NMT3B, respectively)

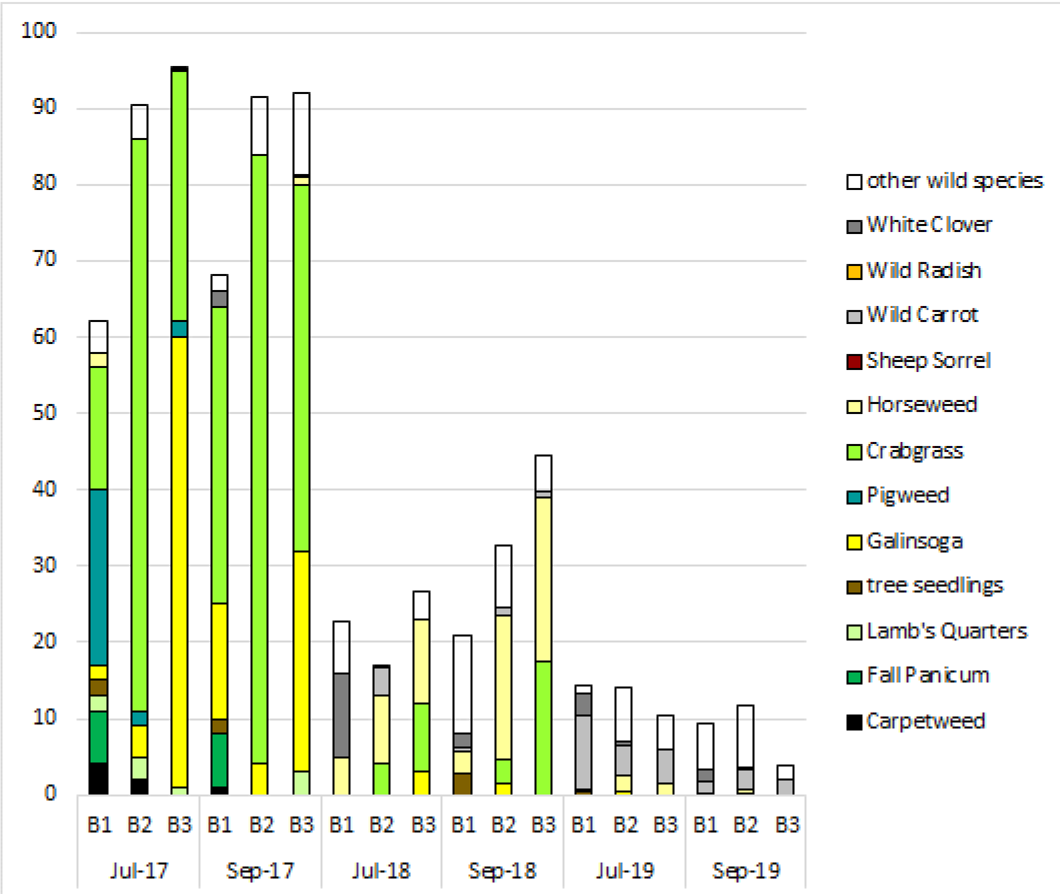

Figure 7: Development of Vegetation Composition (% cover of wild-growing species only) in Experimental Plots seeded with Seed Mix B (please note that B1, B2, and B3 refer to experimental plots NMT1B, NMT2B, and NMT3B, respectively)

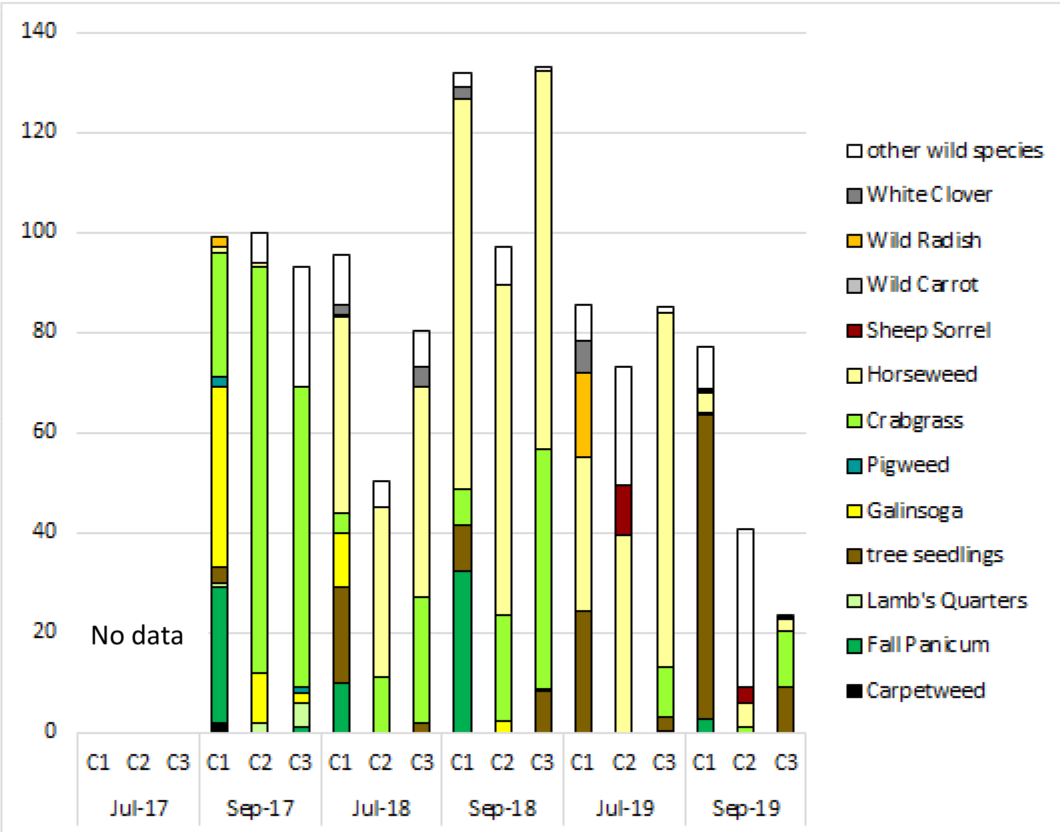

Figure 8: Development of Vegetation Composition in Control Plots; Horseweed reached approximately 80% cover, creating a canopy above a layer of shorter plants in Experimental Plots C1 and C3 in September 2018; consequently, the total % cover added to more than 100% in these plots (please note that C1, C2, and C3 refer to experimental plots NMT1C, NMT2C, and NMT3C, respectively)

The control plots were dominated by Crabgrass and Galinsoga during the first season, and by Horseweed in 2018 and 2019. Tree seedlings (mostly Cottonwood) also became abundant especially in NMT1C in 2018 and—after selectively cutting them in May 2019—grew right back (to a height of 8 feet in one season!) and were even more abundant in the fall of 2019 (Fig. 8).

<u>Flower Abundance</u>:

Figures 9.1 and 9.2 show the average seasonal flower abundance (quantified as percent of the experimental plot covered by flowers at four dates during the 2018 and 2019 growing season, respectively) of the most common flowers (all species with a flower abundance of at least 1% during any of the surveys) in the three plots seeded with Seed Mix A. Figures 10.1 and 10.2 shows the equivalent data for the three plots seeded with Seed Mix B and Figures 11.1 and 11.2 for the three control plots.

Figures 12.1 and 12.2 compare the cumulative seasonal flower abundances at the same four dates in 2018 and 2019, respectively, in the three experimental plots seeded with Seed Mix A, Seed Mix B, and the control plots.

Figures 13.1 and 13.2 compares the average diversity (quantified as species richness) of seeded and wild-growing plant species, respectively, in flower in the experimental plots throughout the first three seasons.

While Lance-leaved Coreopsis flower abundance during the second year (2018) had a small peak in June (Fig. 9.1) and suffused the Seed Mix A plots with some light yellow (see App. 1.2 for NMT1A, App. 4.2 for NMT2A, and App. 7.2 for NMT3A), Black-eyed Susan flowers became very abundant in July (Fig. 9.1) and created a stunning visual display of a warm yellow. By August, most of the Black-eyed Susan flowers had wilted, and Wild Bergamot was the most abundant flower, covering more area than Lance-leaved Coreopsis in June, but only 1/10th of the area covered by Black-eyed Susan in July. Although total flower abundance was substantially less in August compared to July, flower diversity was twice as high in August (Fig. 13.1), with Wild Bergamot, Black-eyed Susan, Brown-eyed Susan, and Partridge Pea providing most flowers (Fig. 9.1). By mid-September, total flower abundance increased again (Fig. 9.1) and the diversity of seeded plants in bloom continued to increase (Fig. 13.1), as the remaining Black-eyed Susan flowers and the increasing Brown-eyed Susan flowers were joined by those of New England Aster and a number of less abundant flowers from seeded plants.

In 2019, flower abundance in the Seed Mix A plots was distributed more evenly throughout the growing season. While Black-eyed Susan flowers still dominated the plots in July, their abundance was less than a quarter of that in the prior year. In turn, Wild Bergamot tripled in abundance compared to the year before. While we did not quantify the flower abundance in late September, we did observe another peak, composed mostly of New England Aster, after Sept. 10, 2019. Like in 2018, the diversity of seeded plants in bloom increased from month to month during the 2019 season (Fig. 13.1), but the total number of seeded plants observed in bloom in our standardized sampling throughout the year was the same (13 species) in 2018 and 2019 (Fig. 14). However, the number of wild-growing species observed throughout the year in the Seed Mix A plots fell from 22 in 2018 to 13 in 2019.

Figure 10.1 illustrates that Seed Mix B resulted in a much lower peak of Lance-leaved Coreopsis (barely reaching 1% cover) in June of the second year (2018), with only approximately a quarter of the flower abundance observed in Seed Mix A at the same time (and see App. 13.2, 14.2, and 15.2 for side-by-side comparisons of Mix A and B in NMT1, 2, and 3, respectively). This was to be expected, because the seeding rate for Lance-leaved Coreopsis in Mix B was less than half that in Mix A. White Clover (not seeded!) also contributed some flowers (just above 1%) in June in the experimental plots seeded with Seed Mix B. In July, Seed Mix B was even more dominated than Seed Mix A by the flowers of Black-eyed Susan. Also present were small amounts of flowers of Lance-leaved Coreopsis, as well as White Clover and Wild Carrot (the last two not seeded). In August, there were still some Black-eyed Susan flowers, accompanied by Wild Carrot. By September, there were very few flowers left in Seed Mix B. As shown in Figure 10.2, a similar pattern repeated itself in the Seed Mix B plots in 2019, but—as in the Seed Mix A plots—the July peak of Black-eyed Susan was markedly lower than the year before. The seeded

Purple Coneflower (*Echinacea*) reached just above 1% flower cover in August, while White Clover did not reach 1% in flower cover at any point in 2019.

While the control plots had a markedly higher diversity of wild-growing plants in bloom throughout 2019 than the plots seeded with Seed Mix A or B (Fig. 14), very few species reached a flower abundance of at least 1% cover. In 2018, Annual Fleabane reached it in July and Horseweed in August and September (Fig. 11.1). In 2019, only Wild Radish flowers reached more than 1% cover in the control plots in June (Fig. 11.2). This result was somewhat surprising, because Horseweed plants were very abundant in the control plots in both years (Fig. 8) and flowered profusely. However, the individual flower heads of this species are very small and our calculation of the total percent cover of these flower heads (based on our estimate of the number of flower heads in the samples) gave very low results, which might be an underrepresentation of Horseweed flower abundance.

Figures 12.1 and 12.2 compare the average overall flower abundance (summed for all species) in the three treatments in 2018 and 2019, respectively. While Seed Mix B in both years had a higher peak of flowers in July, Seed Mix A continued to produce flowers into the fall. Especially in 2019, flowers were present in appreciable numbers in Seed Mix A throughout the growing season. The control plots had a comparatively low flower abundance throughout both of these years. (But see above comment about a possible underestimation of Horseweed flowers with the method we used to calculate flower abundance.)

It is interesting to note in Fig. 14 how the diversity of wild-growing plants with insect-pollinated flowers, which we observed throughout each year in the three treatments, was quite similar during the first two years (2017/18), but diverged markedly in 2019. Compared to 2018, wild-growing plants became less diverse in the plots with Seed Mix B and—even more markedly—in the plots with Seed Mix A, while they increased in diversity in the control plots. As expected, the diversity of seeded plants in bloom throughout the year was consistently higher in Seed Mix A than in Seed Mix B or the control plots. However, after an increase from 7 to 13 species during the first two years, the diversity of seeded plants in bloom in Seed Mix A did not increase further and remained at 13 species in 2019. Note that a couple of species seeded in neighboring experimental plots in 2017 found their way into control plots and contributed to the flower diversity in 2018 and 2019.

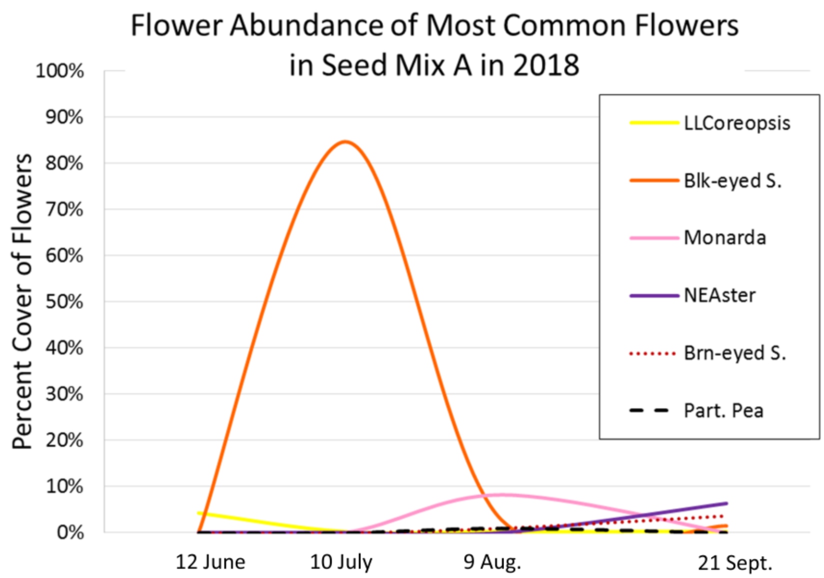

Figure 9.1: Average flower abundance of the most common flowers throughout 2018 in the three plots seeded with Seed Mix A.

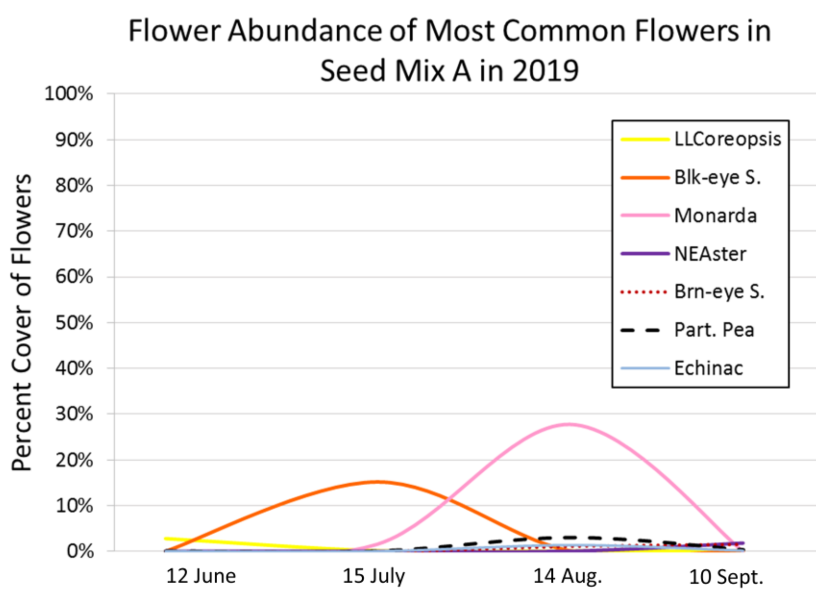

Figure 9.2: Average flower abundance of the most common flowers throughout 2019 in the three plots seeded with Seed Mix A.

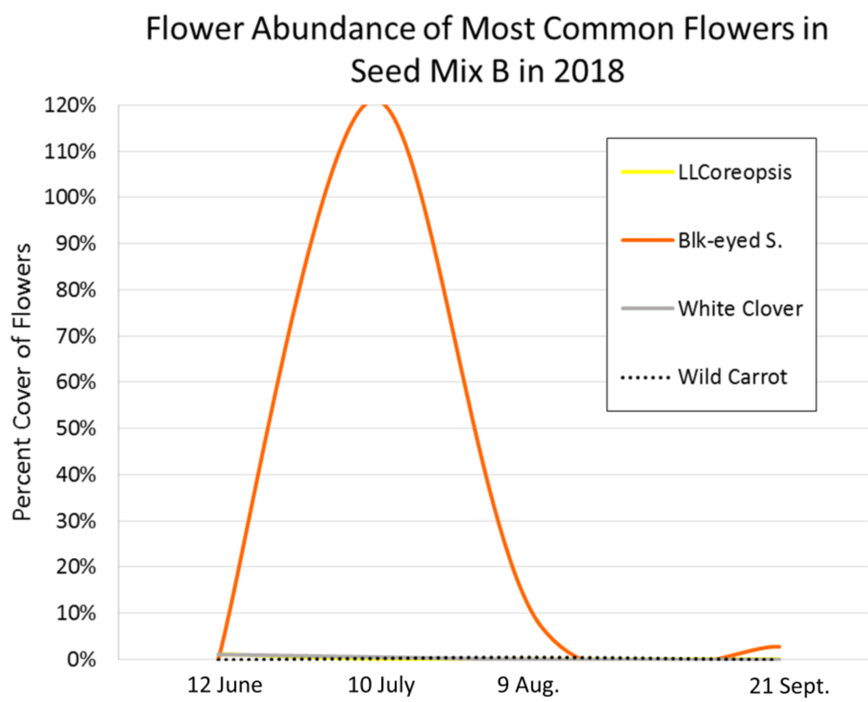

Figure 10.1: Average flower abundance of the most common flowers throughout 2018 in the three plots seeded with Seed Mix B.

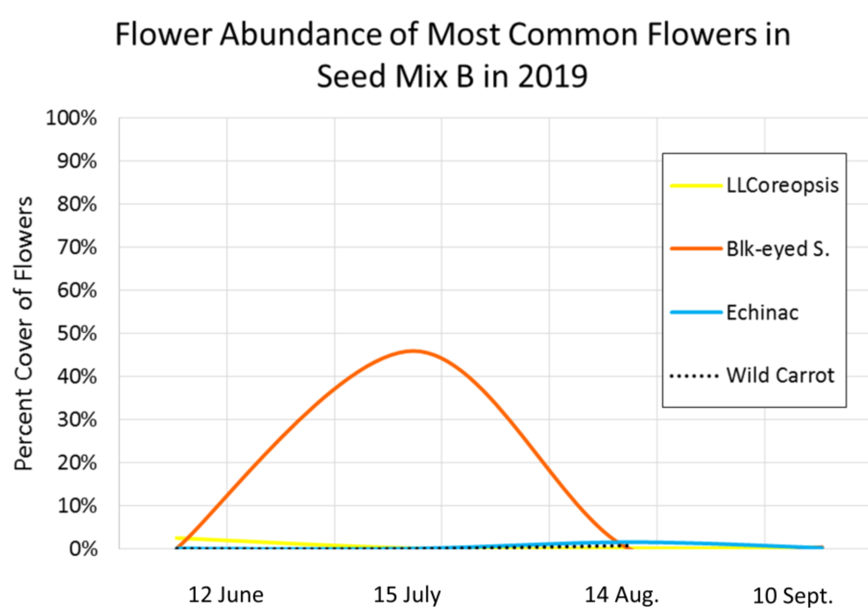

Figure 10.2: Average flower abundance of the most common flowers throughout 2019 in the three plots seeded with Seed Mix B.

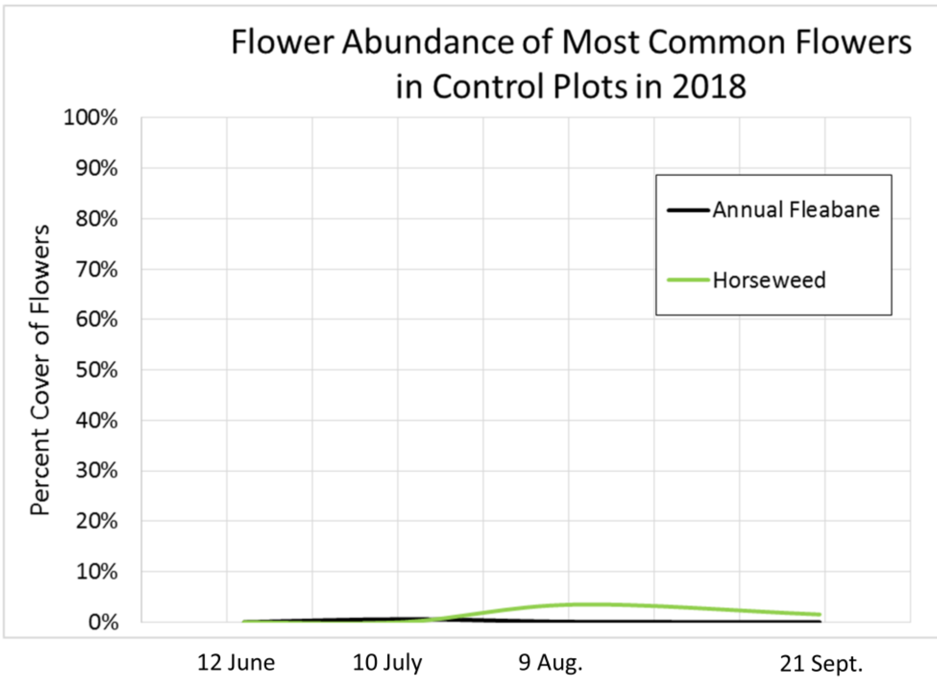

Figure 11.1: Average flower abundance of the most common flowers throughout 2018 in the three control plots.

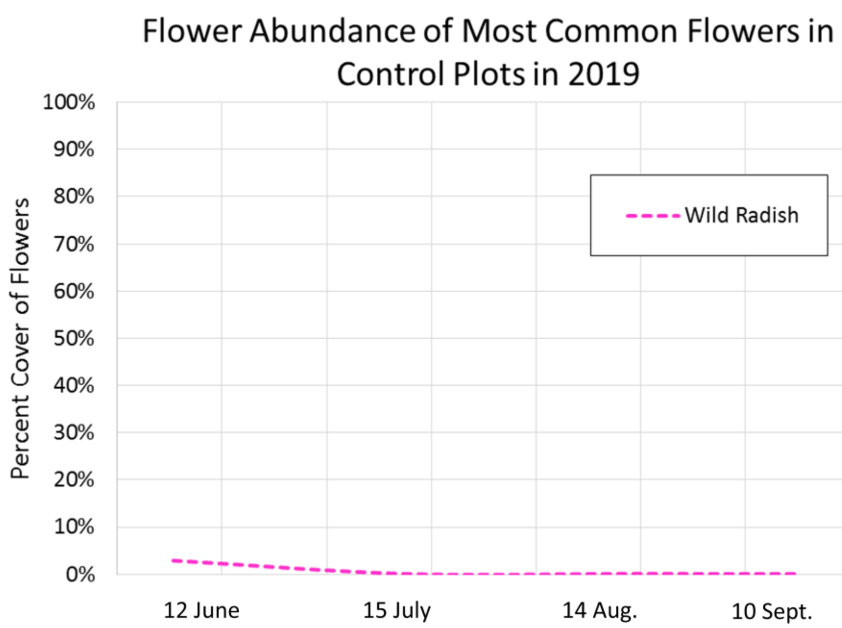

Figure 11.2: Average flower abundance of the most common flowers throughout 2019 in the three control plots.

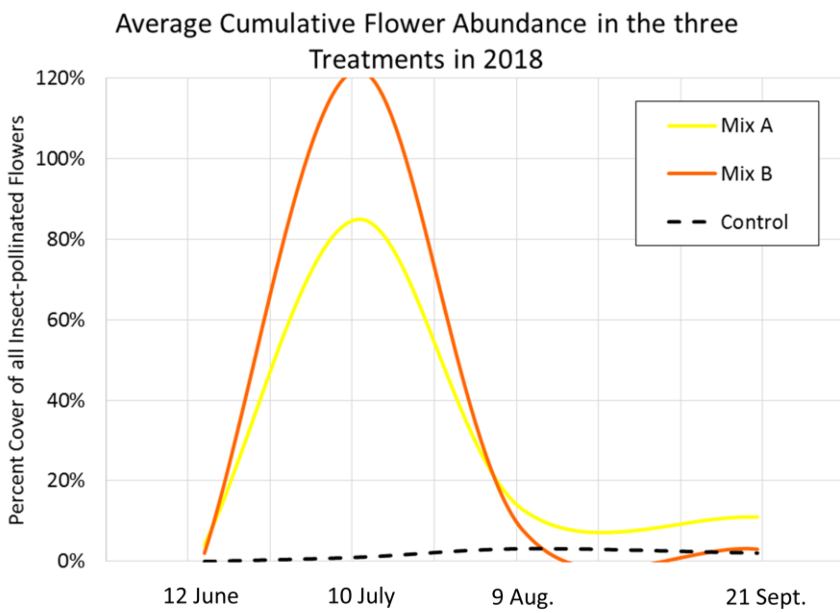

Figure 12.1: Average cumulative flower abundance (adding the flowers of all species) in the three treatments in 2018.

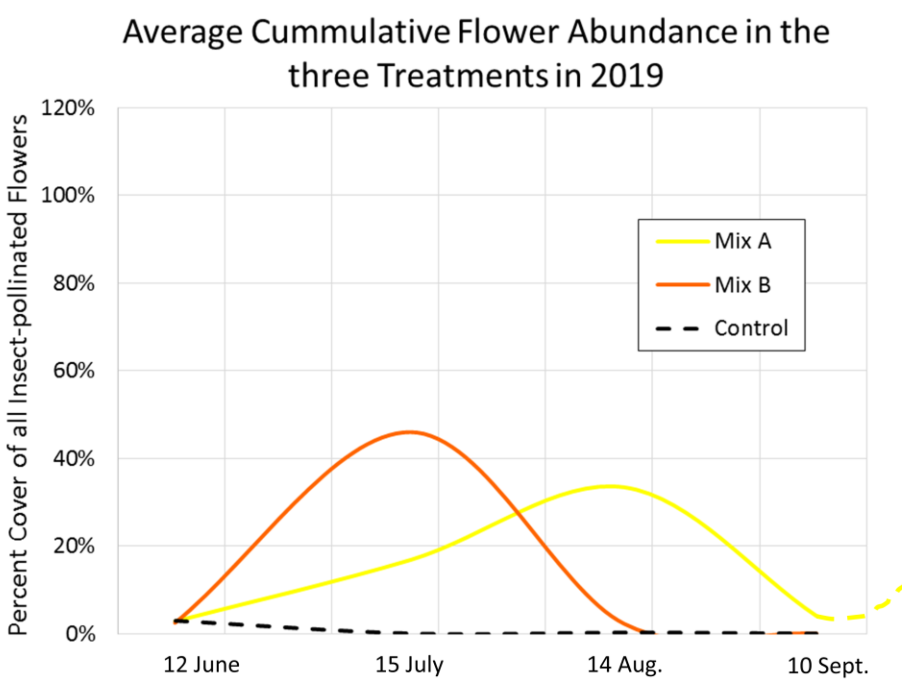

Figure 12.2: Average cumulative flower abundance (adding the flowers of all species) in the three treatments in 2019. We did not quantify flower abundance in late September this year, but noticed a peak in New England Aster flowers (indicated by yellow stippled line).

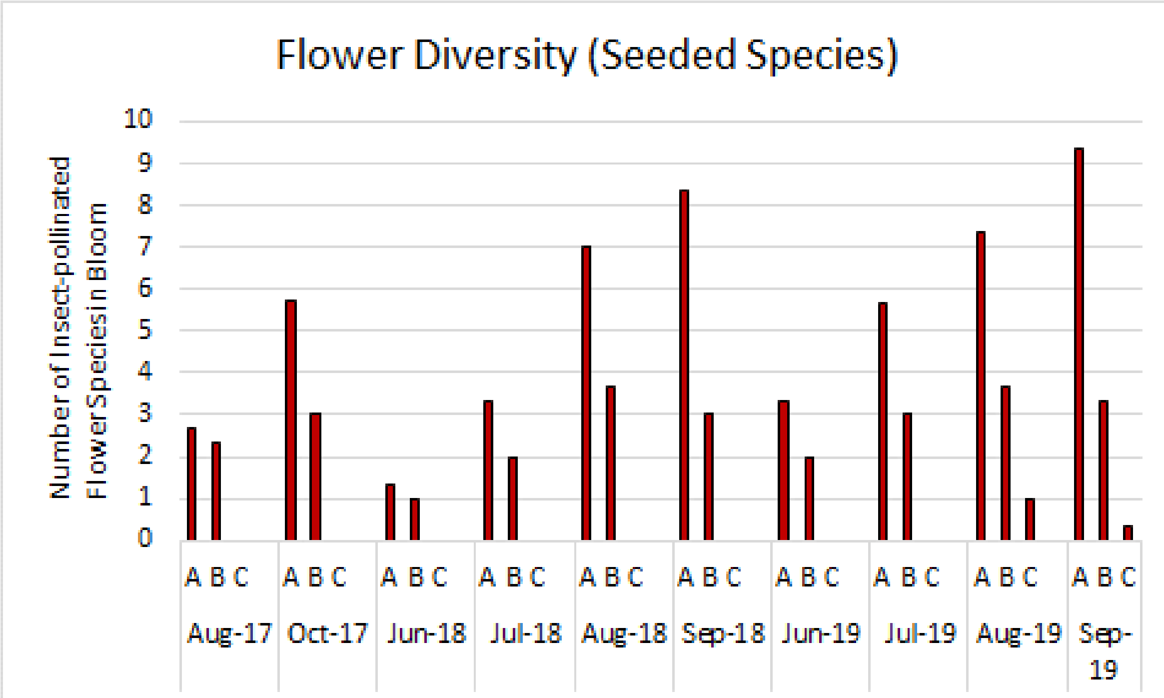

Figure 13.1: Average number of seeded plant species in bloom in the experimental plots during the first three seasons.

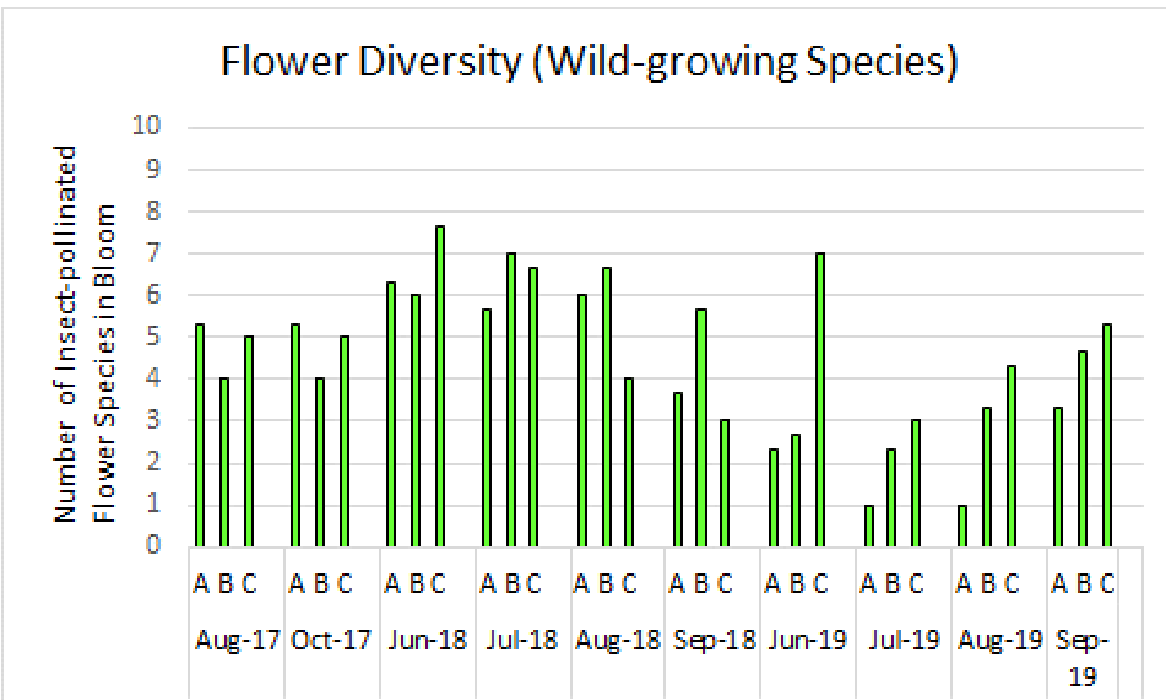

Figure 13.2: Average number of wild-growing plant species in bloom in the experimental plots during the first three seasons.

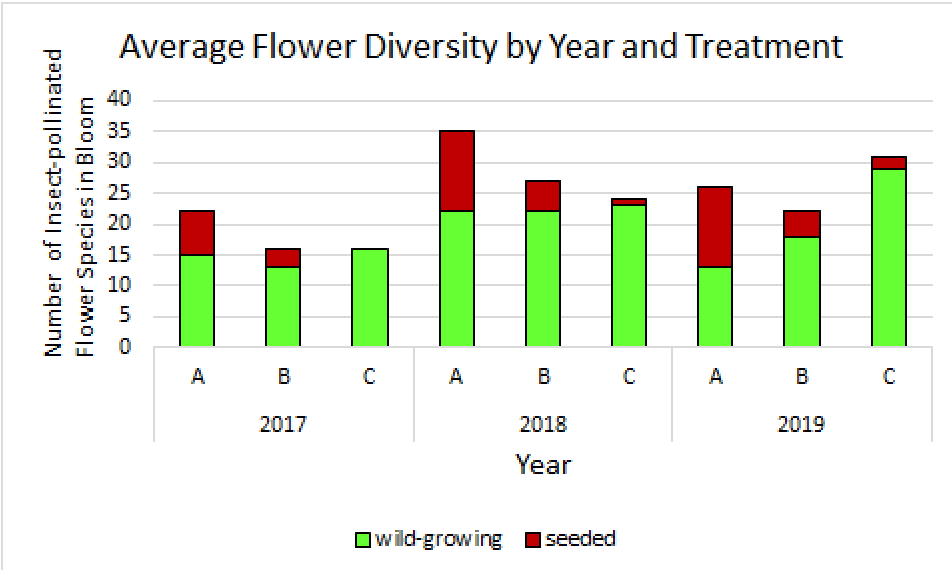

Figure 14: Average number of insect-pollinated plants (seeded species in red; wild-growing species in green) in bloom in each treatment across the first three years.

General Insect Monitoring:

The results from the insect monitoring in the native meadow trials are summarized in the entomology reports by Vispo (2018) and Vispo et al. (2020).

Monitoring of Flower Visiting Insects:

The results from the monitoring of flower visiting insects are presented in Allen (2019), Vispo (2018), and Vispo et al. (2020).

Soil Conditions:

The soil samples taken in spring of 2017 (before the plots were seeded) and in spring of the second and third year (2018 and 2019) were analyzed by the Cornell Soil Health Lab. As part of the Soil Health Lab report, the values for the different soil variables were ranked by comparing them to a comprehensive database of agricultural soils throughout the US and beyond.

For the 2017 (pre-seeding) soil samples, this ranking indicated a good pH range and high-to-excessive phosphorous values in all experimental plots. Potassium was ranked perfect for trial areas NMT1 and NMT3, but low for NMT2. Organic matter, active soil carbon, soil protein, subsurface hardness and even surface hardness were ranked low in all trial areas. Aggregate stability also ranked very low overall, only experimental plot NMT2A ranked slightly better. Soil respiration ranked overall low, but worst in experimental plot NMT2A. Root pathology was very variable across the experimental plots, with NMT2A ranking worst and NMT1A pretty good. Water holding capacity was ranked high in trial areas NMT1 and 3, but only intermediate in NMT2 (worst in NMT2A and B).

Figure 15 illustrates the differences in soil texture between the experimental plots in 2017. Trial area NMT2 has the sandiest soils (classified as sandy loam to loamy sand), while NMT3 has the siltiest (classified as sandy loam, loam, and silt loam). The soils of trial area NMT1 are intermediate in their soil texture (classified as sandy loam and loam).

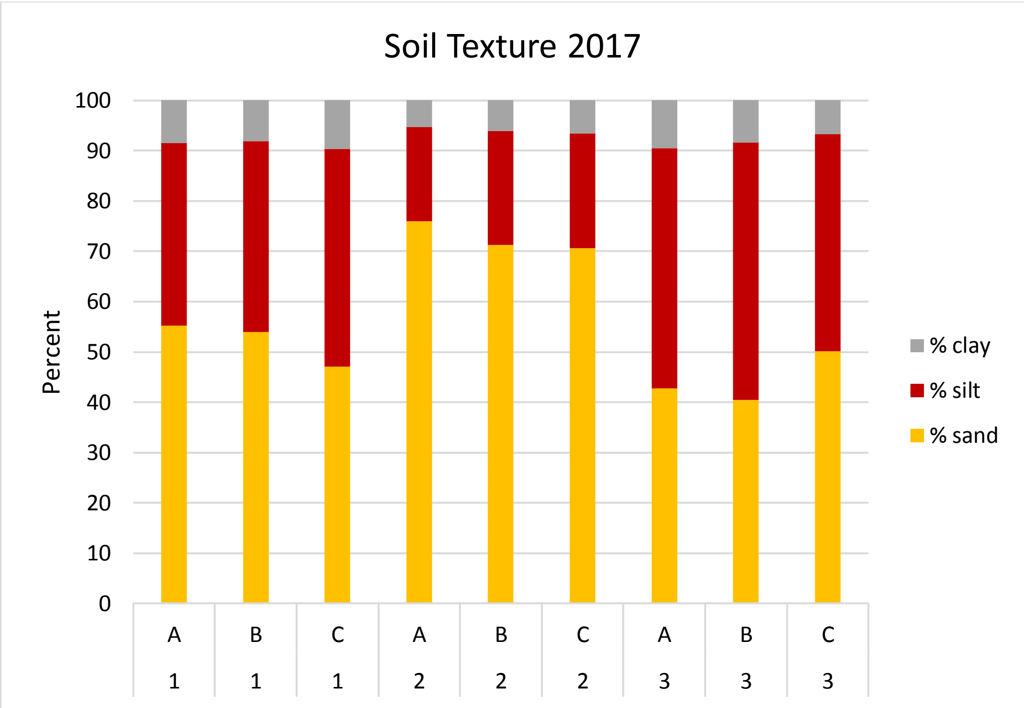

Figure 13: Soil texture of the experimental plots according to the 2017 soil samples (please note that 1A, 1B, 1C, etc. refers to experimental plots NMT1A, NMT1B, NMT1C, etc., respectively).

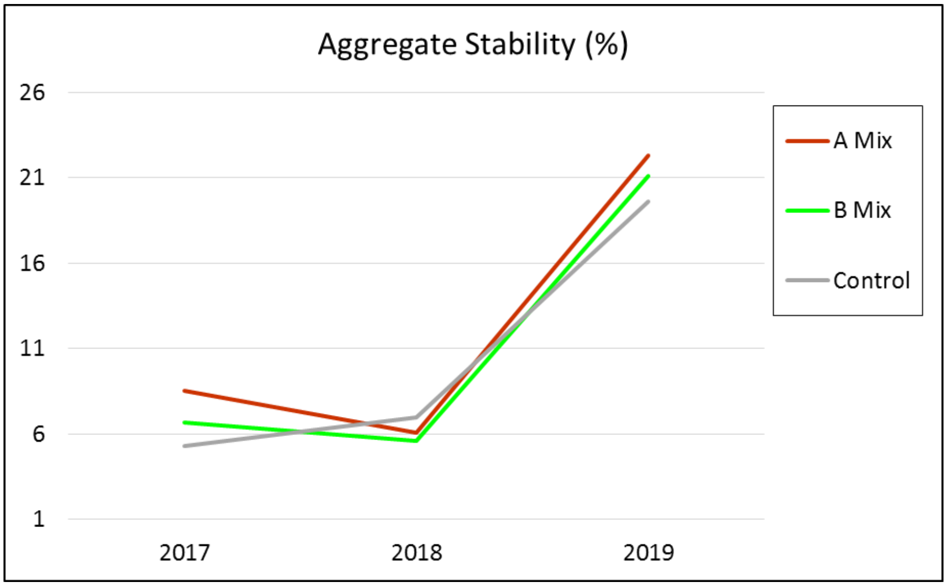

Figure 14: Comparison of average aggregate stability in the three treatments over the first three years.

The 2018 and 2019 test results showed no consistent trends over time or between treatments in some variables, such as waterholding capacity, soil respiration, and root pathogens. Other variables changed in all treatments over time. For example, the somewhat excessive phosphorous values in 2017 became less and were evaluated as ideal across the experimental plots in 2018 and 2019. Potassium showed a similar trend of diminishing values across all experimental plots. On the other hand, aggregate stability, while not changing much between May 2017 and May 2018, had increased markedly in all three treatments by May 2019 (Fig. 14)

While some of the soil variables changed over time across treatments, most did not show any consistent differences in the development of the soils due to experimental treatments (Mix A, Mix B, or control) between 2017 and 2019. However, organic matter might be an exception. While percent organic matter increased in all treatments between 2017 and 2018, the 2019 data might indicate the beginning of a trend for a differentiation between the treatments (Fig. 15), with organic matter continuing to increase in the experimental plots seeded with Mix A and Mix B, but decreasing in the control plots. Time will tell, whether these 2019 data are part of an overarching trend towards faster accumulation of organic matter in the seeded plots.

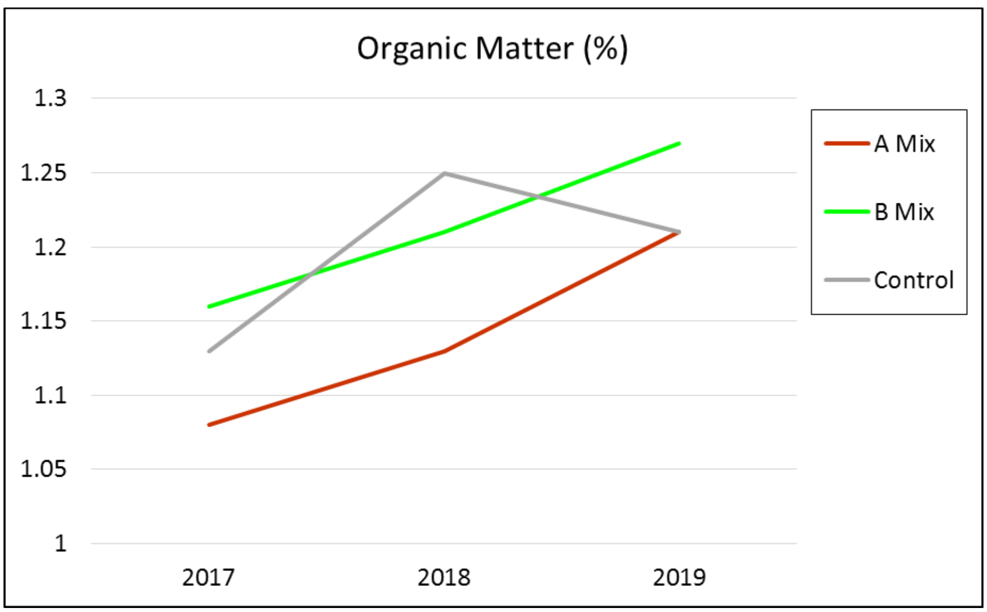

Figure 15: Development of Percent Organic Matter in the three treatments over the first three years.

__Labor and Equipment__:

Starting with the site preparation in early Spring 2017, Table 3 lists the management actions taken to date in the Native Meadow Trials in chronological order, specifies the equipment used, and the time spent (in person-hours per acre).

Table 3: List of Management Activities in the Native Meadow Trials

Year	Timing	Action	Labor (person hrs/acre)	Equipment
2017	April to mid May	1st Harrowing	0.5	Perfecta II Harrow with S-tines equipped
	April to mid May	2nd Harrowing	0.5	Perfecta II Harrow with S-tines equipped
	April to mid May	3rd Harrowing	0.5	Perfecta II Harrow with S-tines equipped
	May 19	Seeding	5.0	Great Plains No Till Seeder
	May 25	Seeding	1.0	by hand
	July 6-10	Mowing	1.3	Flail Mower
	July 26-28	Mowing	1.3	Flail Mower
	Aug. 15/16	Mowing	0.7	Rotary Mower
2018	late May to mid Jun	Selective Weeding/ Mowing	11.0	String Trimmer; by hand
2019	May	Selective Weeding/ Cutting	4.5	by hand; Clippers; String Trimmer
	Aug/Sept.	Selective Weeding	1.5	Clippers

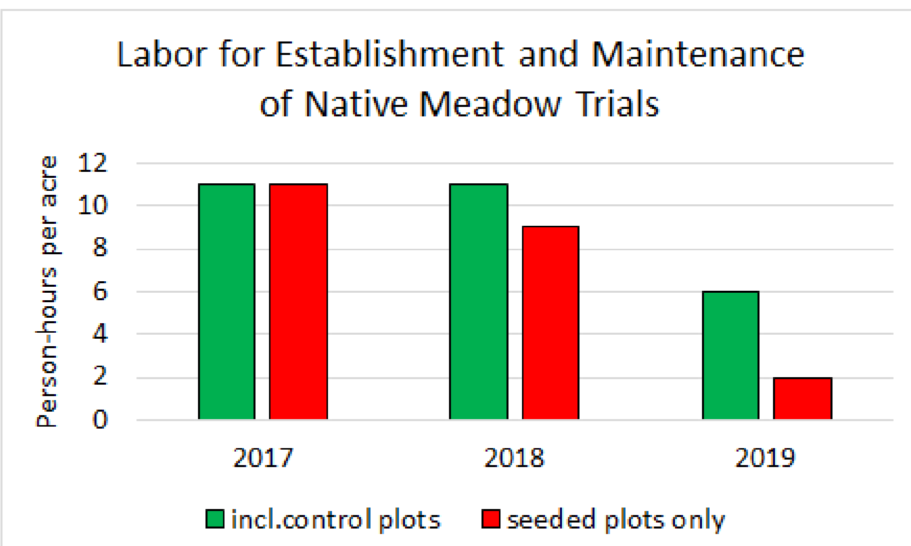

Figure 16: A summary of the labor applied to the establishment and maintenance of the native meadow trials during the first three years. The green bars represent the labor applied across all treatments, including the control plots. The red bars represent the labor applied only in the seeded native meadows.

Conclusions

We successfully established two types of native meadows (plus a fallow field control) in three 1.5-acre trial areas on former corn fields at the Hudson Valley Farm Hub. This was accomplished without the use of herbicides, but required repeated shallow harrowing to prepare a weed-free seed bed. After seeding, the maintenance effort during the first two seasons of the meadows was approximately 11 person-hours per acre per year, the third year this dropped to 6 person-hours per acre. The more diverse seed mix resulted in more flowers and the presence of flowers throughout the second and third seasons (June through October) and, as detailed in the accompanying and past *entomology reports* (Vispo 2018, Vispo et al. 2020), attracted more pollinators (butterflies, bumblebees, and possibly hover flies, Honey Bees, and other bees) than the less diverse seed mix or the unseeded control. We were encouraged by the fact that certain pest insects (Tarnished Plant Bugs, weevils, and flea beetles) appeared to be less common in the seeded meadows than in the weedy control plots. However, wasps as a group (most of which are considered beneficial), did not seem to be particularly attracted to the seeded meadows, and may even have favored the control. In addition, some pests (such as leafhoppers and aphids) were more widely distributed, occurring in high numbers in both native meadows and the control.

We are looking forward to another year of sampling to see if the patterns in insect distributions persist and how the vegetation of the seeded meadows and the fallow fields continue to evolve. Based on what we have learned from the native meadow trials so far, we have included more shallow-flowered plants into a new meadow seeding to try to attract more beneficial wasps, as well as pollinators.

Acknowledgements

I thank Kelly Gill of the Xerces Society for her advice and patience in answering all my questions; the farmers at the Farm Hub for all their help with the preparation, establishment, and management of the test plots; Erin Allen, Brenna Bushey, Dylan Cipkowski, Jackie Edgett, Molly Fava, Kenny Fowler, Julia Meyer, Rosa Villegas, and Conrad Vispo for their assistance with the data collecting and analyzing; and Anne Bloomfield for helping coordinate it all.

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Allen, Erin E. (2019): “Butterflies as charismatic indicators: Can study of impact of on-farm habitat enrichment on butterfly populations provide insight about habitat quality for other insects?” MS Thesis, SUNY Albany, 137p.

Vispo, C. (2018): Native Meadow Trial: 2018 Entomology Report

Vispo, C. et al. (2020): “Agroecological hoarding and sharing: The role of wildflower patches in augmenting beneficials & evidence of invertebrate flows into crops.” Entomology Report of the 2019 season for the Hudson Valley Farm Hub.