Native Meadow Trial at the Hudson Valley Farm Hub

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February 2019

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 cornfields, which 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 it 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?
- 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.

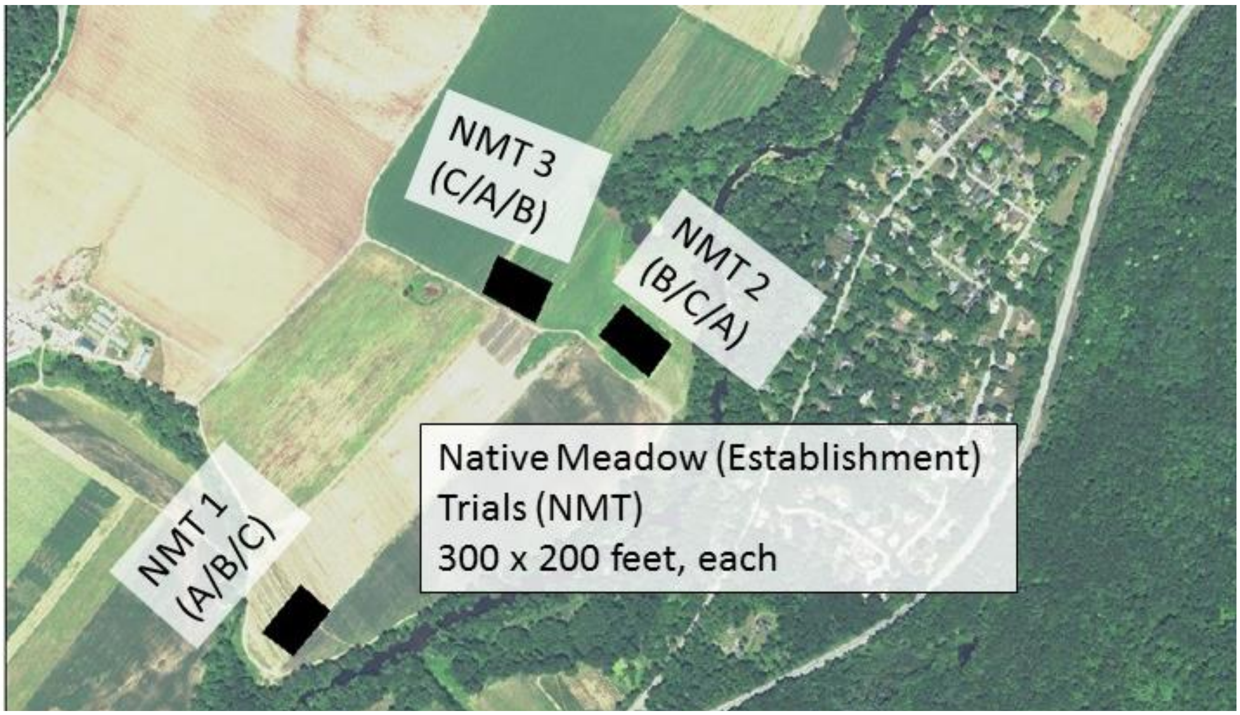


Figure 1: Map of Native Meadow Trial Areas at the Hudson Valley Farm Hub

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 plots C in each of the three trial areas were 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, Roundheaded Lespedeza, Ohio Spiderwort; third row: Mistflower, Joe-Pye-Weed, Butterfly Milkweed, Showy Goldenrod, Partridge Pea, Purple Coneflower; fourth row: Narrowleaf 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-leaf 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). Other than that, no mowing was necessary in the experimental plots during the second season, and the vegetation was again left standing into the winter.

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; 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 (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 separate report, entitled "*Native Meadow Test Plots: 2018 Entomology Report*" by Conrad Vispo (14 Feb. 2019).

Monitoring of Flower-Visiting Insects: Flower-visiting insects were documented in the nine experimental plots every two weeks from June through September with standardized visual surveys conducted by Erin Allen as part of her graduate work at SUNY Albany. Again, a more detailed description of the specific methods is provided in a separate report, entitled "*Native Meadow Test Plots: 2018 Entomology Report*" by Conrad Vispo (14 Feb. 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 and May 7, 2018) 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 1.9 are the photographic documentation of each of the nine experimental plots during the first two years. Appendices 2.1 through 2.3 show side-by-side photographic comparisons during the first two years for all plots organized by treatment, while. Appendices 3.1 through 3.3 show the same 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 two 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 40% and 25% cover respectively) by September 2017 than the same treatments in NMT2 and 3 (reaching at the most 15% and 10% 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.

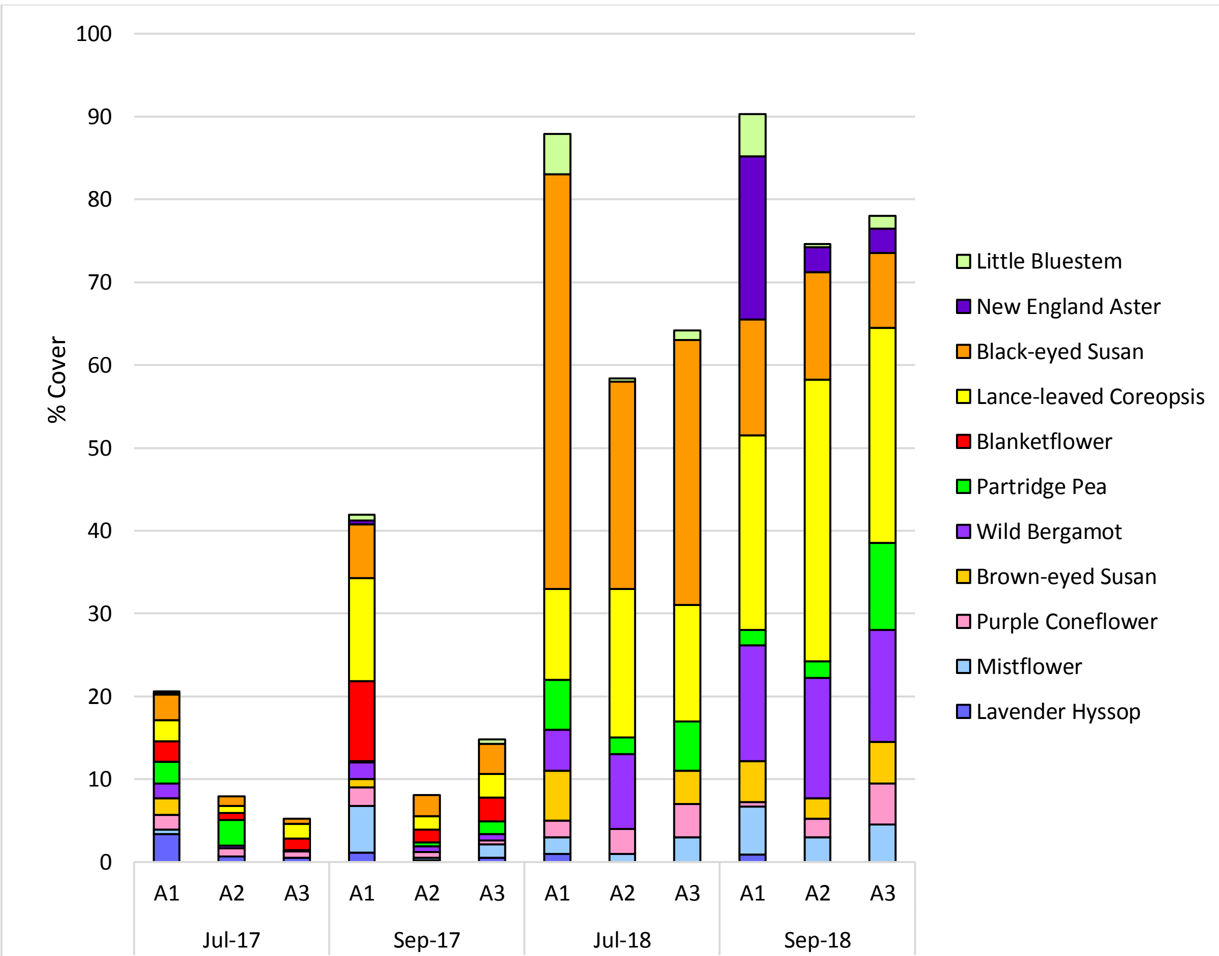


Figure 4: Development of Vegetation Composition (% cover of seeded species only) in Experimental Plots seeded with Seed Mix A (please note that A1, A2, and A3 refer to experimental plots NMT1A, NMT2A, and NMT3A, respectively)

During the second season, the seeded plants "took off" in all experimental plots (including in the intermittently waterlogged area of NMT3A), reaching between 70% and 90% 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.

2.1), 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).

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 90% and 70% of NMT2A and NMT3A, respectively (App. 2.1). Crabgrass was also the dominant wild-growing plant in all other experimental plots at the end of 2017. During the second season, wild-growing plants were markedly less common in all experimental plots that had been seeded with Seed Mix A or B, and Horseweed replaced Crabgrass as the dominant wild-growing plant. 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 (Fig. 5). The most common wild-growing plants in NMT1A by that time were Cottonwood seedlings. Wild-growing plants were also more abundant in NMT2B and 3 B, compared to NMT1B and this difference persisted through both seasons, although the abundance of wild-growing plants in all three experimental plots seeded with Mix B decreased in 2018 (Fig. 7). While Crabgrass and Galinsoga were the dominant wild-growing plants in these three plots during the first season, Horseweed became more abundant in 2018 (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, we did not discover any young plants of Narrowleaf Mountainmint, Ohio Spiderwort, and probably also Joe-Pye-Weed (early records of this species from our plots were in retrospect most likely all misidentified young Mistflower plants). The seeded species that established themselves most abundantly and evenly during the first season were Black-eyed Susan, Lanceleaf 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, Lanceleaf 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. Roundhead and Slender Lespedeza, Purple Priarie Clover, as well as Common Milkweed persisted through both seasons in small numbers. The only species that has not been detected during the first two seasons is Joe-Pye-Weed. Blanketflower and Phacelia, the two annual species which had been added to the seed mixes, flowered in 2017 but were absent in 2018.

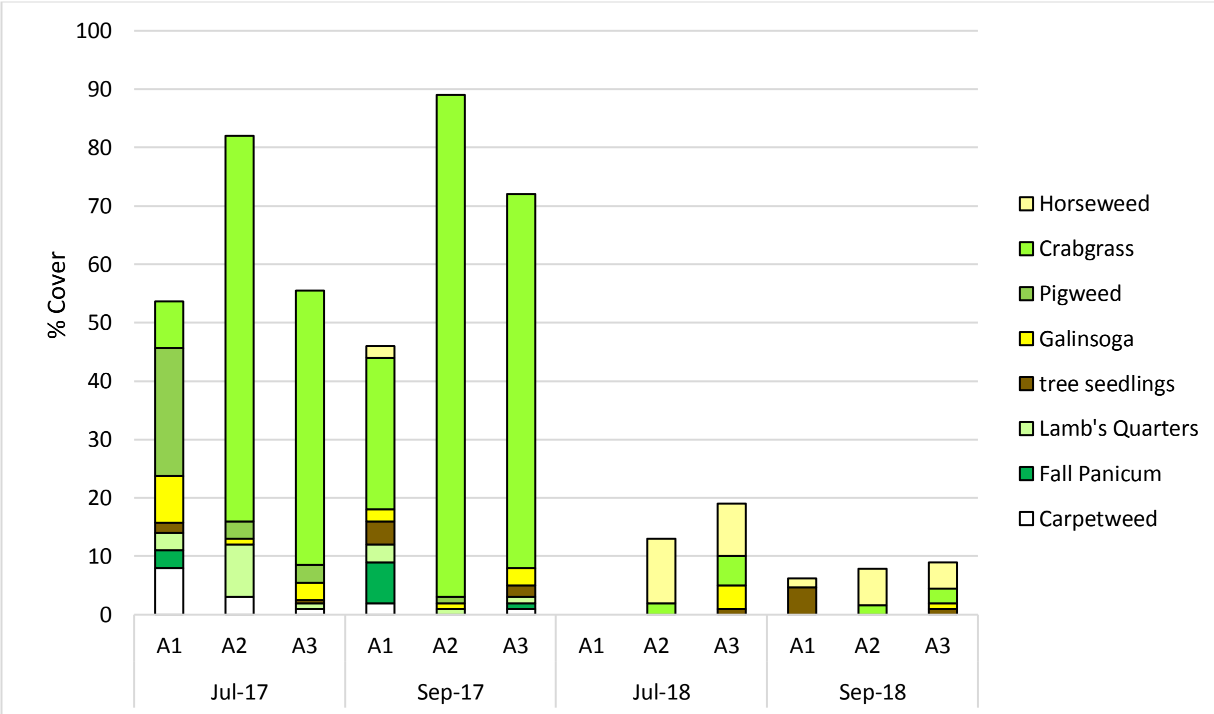


Figure 5: Development of Vegetation Composition (% cover of wild-growing species only) in Experimental Plots seeded with Seed Mix A (please note that A1, A2, and A3 refer to experimental plots NMT1A, NMT2A, and NMT3A, respectively; note also that we did not find any wild-growing species in our vegetation samples of NMT1A in July 2018!)

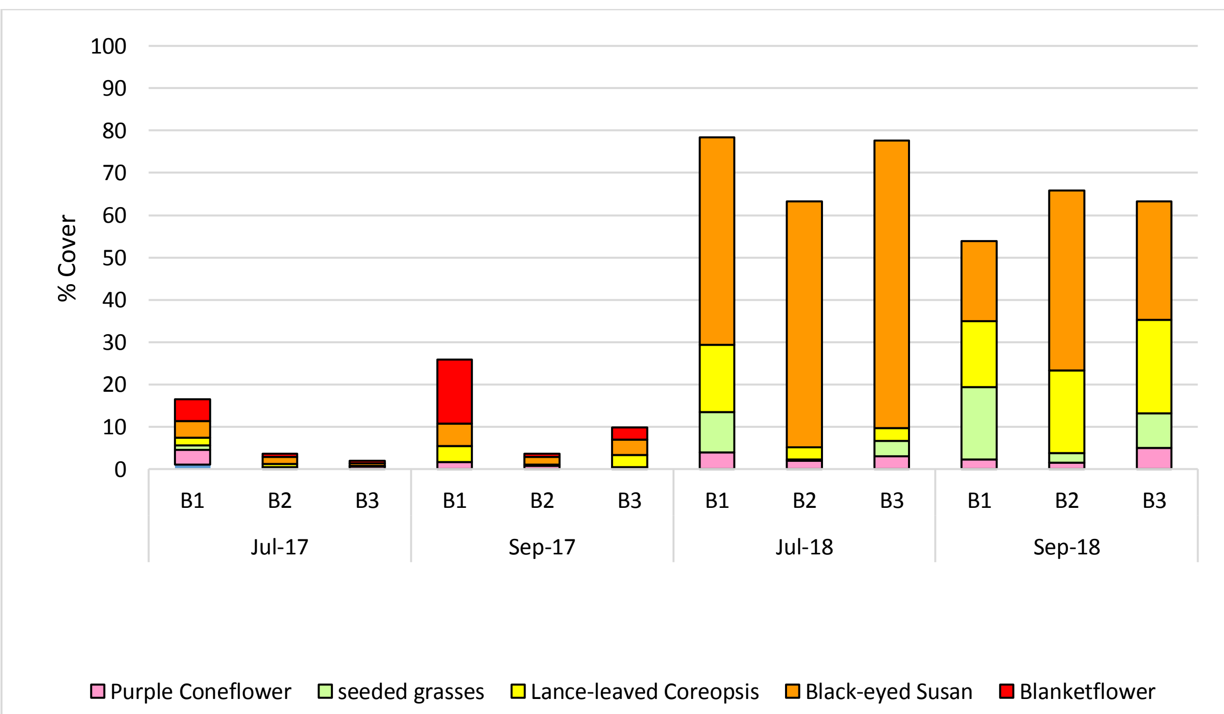


Figure 6: Development of Vegetation Composition (% cover of seeded species only) in Experimental Plots seeded with Seed Mix B (please note that B1, B2, and B3 refer to experimental plots NMT1B, NMT2B, and NMT3B, respectively)

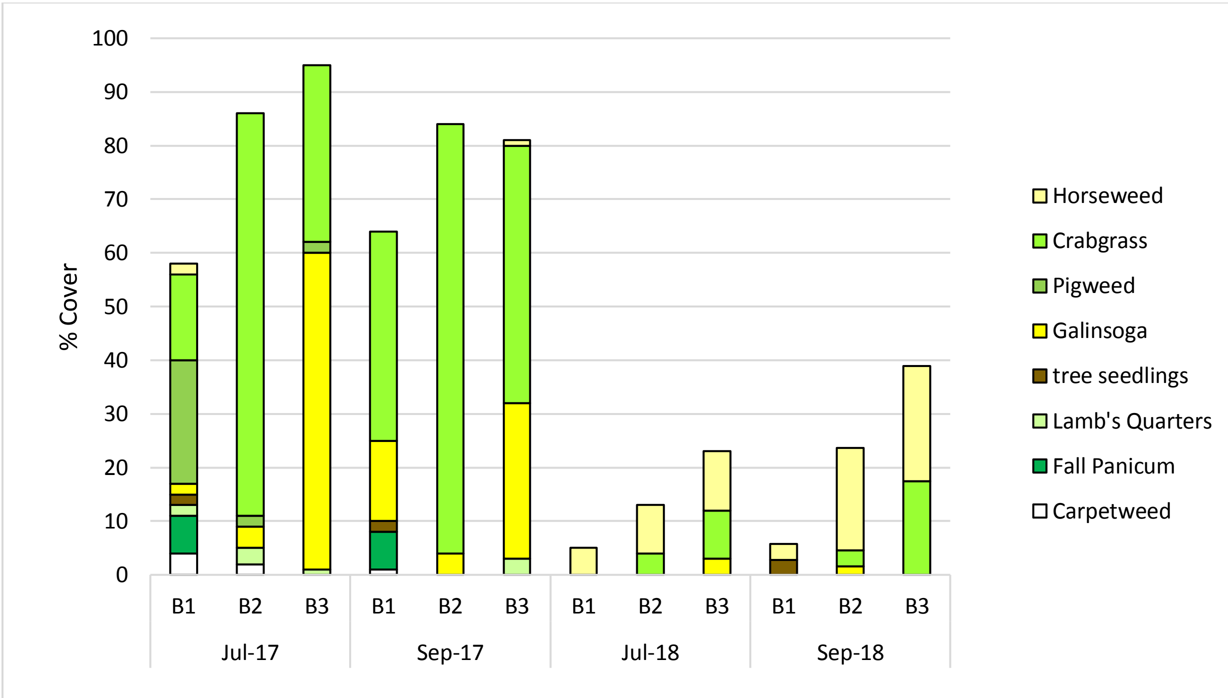


Figure 7: Development of Vegetation Composition (% cover of wild-growing species only) in Experimental Plots seeded with Seed Mix B (please note that B1, B2, and B3 refer to experimental plots NMT1B, NMT2B, and NMT3B, respectively)

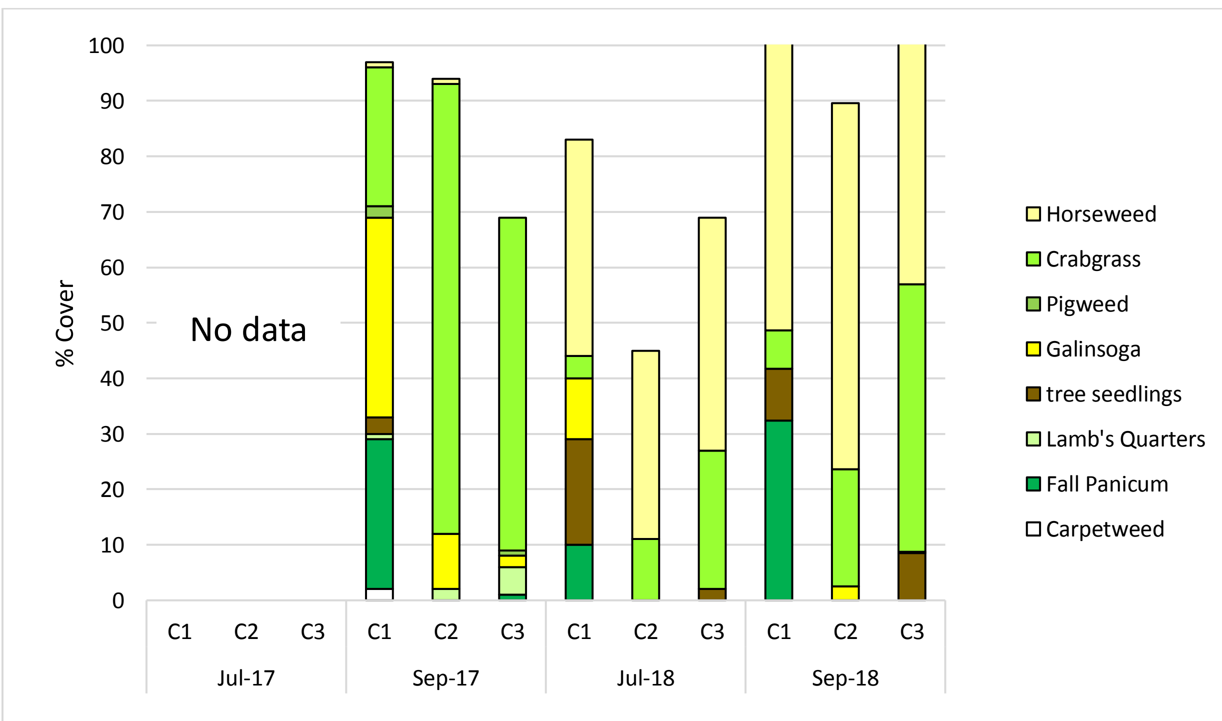


Figure 8: Development of Vegetation Composition in Control Plots; Horseweed reached approximately 80% cover, creating a canopy above a layer of shorter plants in Experimental Plots C1 and C3 in September 2018; consequently, the total % cover added to more than 100% in these plots (please note that C1,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

In the experimental plots seeded with Seed Mix B, the dominant species during the first season were Black-eyed Susan, Lanceleaf 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. In 2018, we documented all seeded native grasses except Purple Lovegrass. Black-eyed Susan and Lanceleaf Coreopsis continued to be abundant, but Purple Coneflower was also quite common (Fig. 6). Partridge Pea persisted in low density through both years, while Slender Lespedeza and Purple Prairie Clover were not observed during the first two seasons in any of the experimental plots seeded with Seed Mix B.

The control plots were dominated by Crabgrass and Galinsoga during the first season, and by Horseweed in 2018. Tree seedlings (mostly Cottonwood) also became quite abundant in 2018 (Fig. 8).

<u>Flower Abundance</u>:

Figure 9 shows the average flower abundance (quantified as percent of the experimental plot covered by flowers) of the most common flowers in the three plots seeded with Seed Mix A.

Figure 10 compares the average flower abundances in the three experimental plots seeded with Seed Mix A, Seed Mix B, and the control plots, scaling the vertical axes even more to amplify the differences in flower abundance between 0 and 5% cover of the experimental plot.

Figure 11 compares the average diversity (quantified as species richness) of seeded and wild-growing plant species in flower in the experimental plots throughout the first two seasons.

While Lance-leaved Coreopsis flower abundance peaked in June (Fig. 9) and suffused the experimental plots with some light yellow (see App. 1.1 for NMT1A, App. 1.4 for NMT2A, and App. 1.7 for NMT3A), Black-eyed Susan flowers became very abundant in July (Fig. 9) and created a stunning visual display of a warm yellow (see App. 1.1 for NMT1A, App. 1.4 for NMT2A, and App. 1.7 for NMT3A). By August, most of the Black-eyed Susan flowers had wilted, and Wild Bergamot (*Monarda fistulosa*) 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 highest in August (Fig. 11), with Wild Bergamot, Black-eyed Susan, Brown-eyed Susan, and Partridge Pea providing most flowers (Fig. 9). By mid-September, total flower abundance increased again (Fig. 9) and flower diversity stayed high (Fig. 11), 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.

Seed Mix B resulted in a much lower peak of Lance-leaved Coreopsis in June, with only approximately 25% of the flower abundance observed in Seed Mix A at the same time (Fig. 10 and see App. 3.1, 3.2, and 3.3 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 an appreciable amount of flowers 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 (App. 3.1 – 3.3). Also present were small amounts of flowers of Lance-leaved Coreopsis, as well as White Clover, Wild Carrot, and Annual Fleabane (the last three not seeded). In August, there was still a considerable amount of Black-eyed Susan flowers, accompanied by Wild Carrot and Horseweed. By September, there were very few flowers left in Seed Mix B, and they were mostly of Black-eyed Susan. Throughout the 2018 season, Mix B had—as expected-- a lower diversity of flowers than Seed Mix A. However, the lack of diversity in the seed mix was compensated for by a higher diversity of wild-growing flowers (Fig. 11).

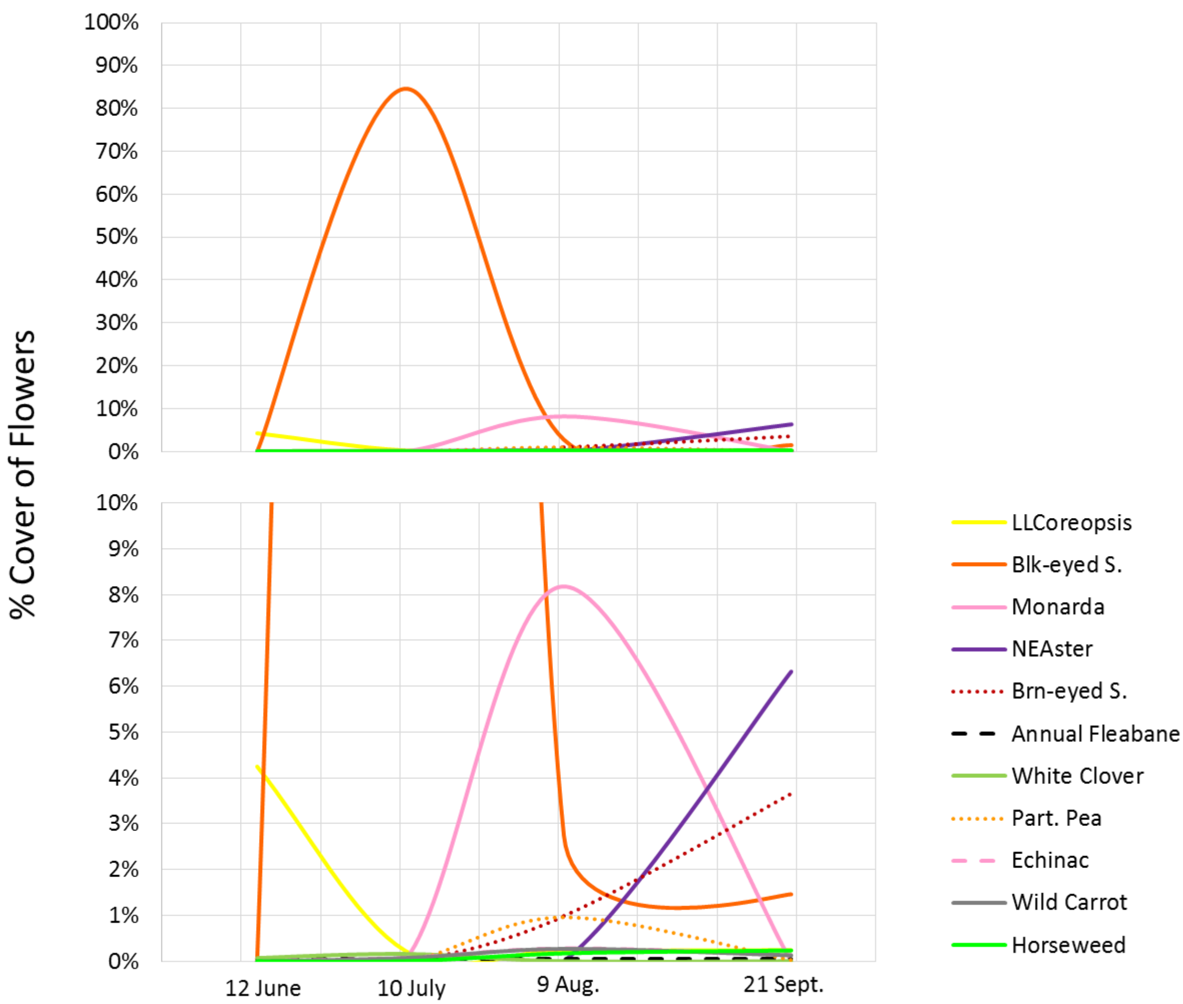


Figure 9: Average flower abundance of the most common flowers throughout 2018 in the three plots seeded with Seed Mix A. Both charts show the same data, but the vertical axis ranges from 0 to 100% (of the plot's area covered by flowers) in the upper chart and from 0 to 10% in the lower chart in order to magnify the pattern in this lower range.

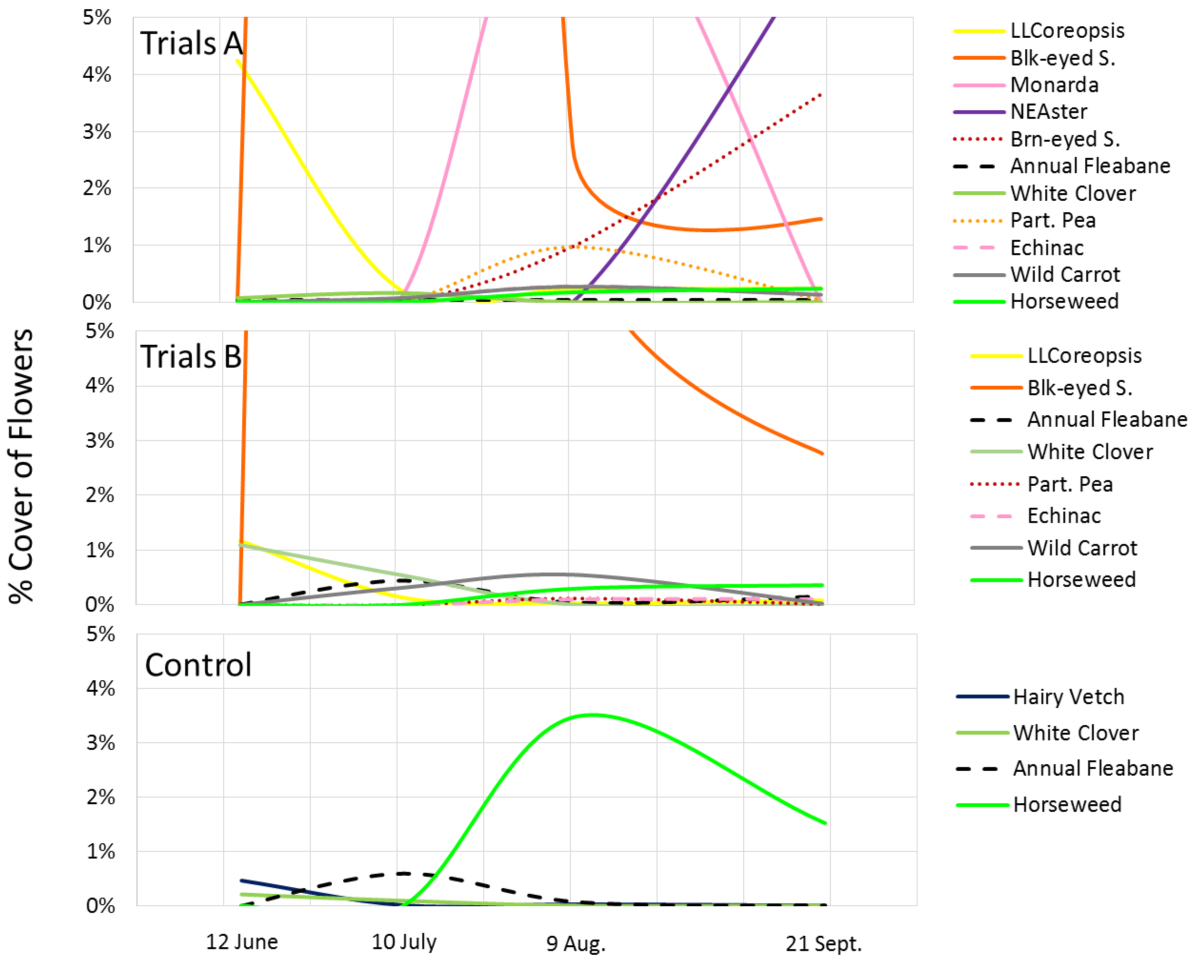


Figure 10: Comparison of Average Flower Abundance in the three plots seeded with Seed Mix A (top), Seed Mix B (middle), and the three control plots (bottom). Note that all three vertical axes are scaled to represent a range from 0 to 5% flower cover. Consequently, the Black-eyed Susan flower peaks in July in Trials A and B, as well as the Monarda *peak in August and the New England Aster peak in September in Trials A, are off the charts.*

The control plots had very little Hairy Vetch and White Clover flowers in June, a small peak of Annual Fleabane Flowers in July, and an abundance of Horseweed flowers in August. By September, there were also very few flowers left in the control plots, and these were mostly of Horseweed (Fig. 10). Figure 11 illustrates a steady decline of flower diversity in the control plots throughout the 2018 season. Early successional weeds of tilled ground provided a variety of flowers--although not in large abundance—early in the season, but seemed to have gotten largely crowded out by the dense growth of Horseweed that developed in the control plots throughout the summer.

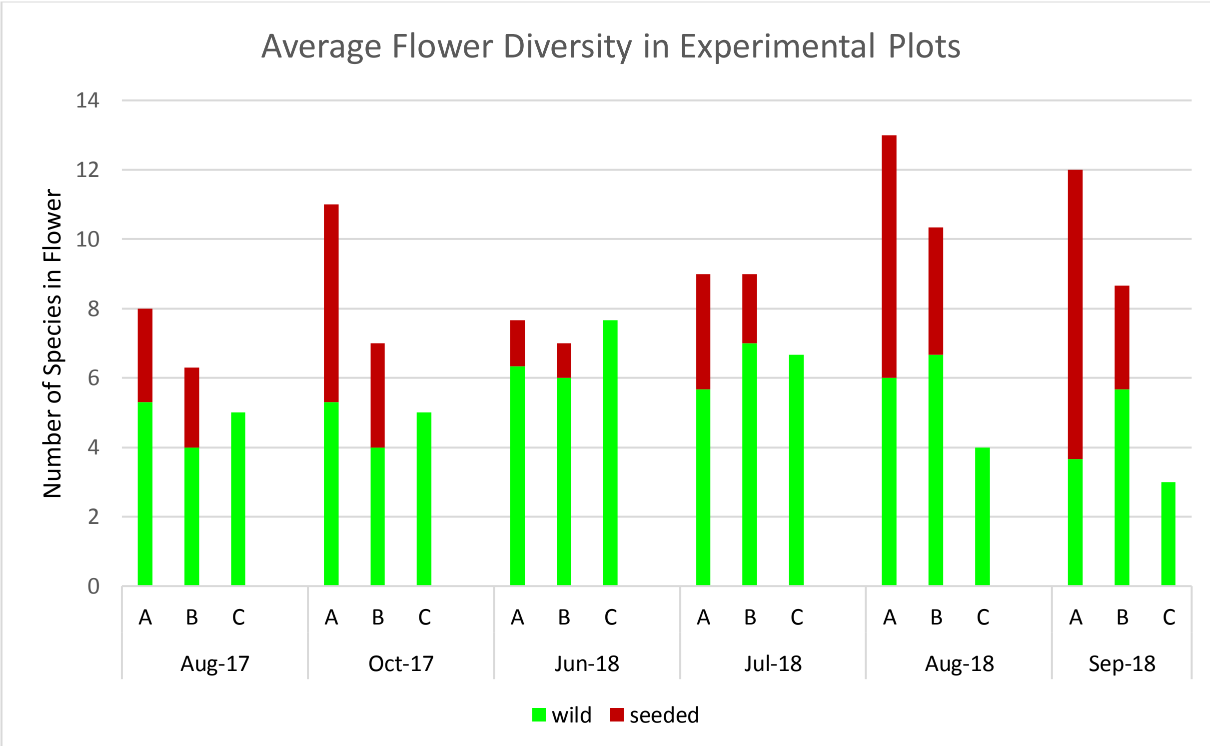


Figure 11: Average number of flowering species present in the experimental plots during the first two seasons. The green bars represent wild-growing species in flower, the red bars represent species in flower that had been seeded.

General Insect Monitoring: The results from the general insect monitoring are summarized in a separate report, entitled "*Native Meadow Test Plots: 2018 Entomology Report*" by Conrad Vispo (14 Feb. 2019).

Monitoring of Flower Visiting Insects: The results from the monitoring of flower visiting insects are currently being analyzed by Erin Allen as part of her graduate work at SUNY Albany and will be presented fully in her thesis in May 2019. Some of these data are included in "*Native Meadow Test Plots: 2018 Entomology Report*".

Soil Conditions: The soil samples taken in spring of 2017 (before the plots were seeded) and in spring of 2018 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. 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 12 illustrates the differences in soil texture between the experimental plots. 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).

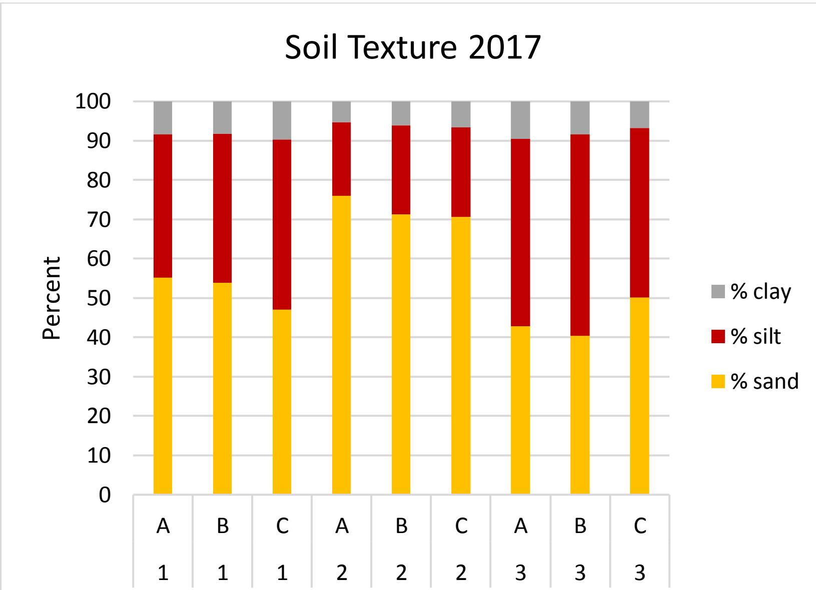


Figure 12: Soil texture of the experimental plots according to the 2017 soil samples (please note that 1A, 1B, 1C, etc. refers to experimental plots NMT1A, NMT1B, NMT1C, etc., respectively).

The 2018 test results indicated that across all experimental plots, the soils seem to have changed somewhat since 2017. This is not surprising, because—after years of frequent tillage—the soils in all experimental plots had been left untilled for an entire year between the testing dates. However, there was no indication of any consistent differences in the soils due to experimental treatments (Mix A, Mix B, or control).

Across all experimental plots, there was a 40% increase in organic matter (from an average of 1.1% in 2017 to 1.5% in 2018), a 50% increase in active carbon (from an average of 184ppm in 2017 to 278ppm in 2018), and a 30% increase in soil respiration (from an average of 0.35 mg CO_2/g dry matter in 2017 to 0.45 mg CO_2/g dry matter in 2018). While this seems to be a considerable improvement, due most likely to the fact that between the two testing dates permanent vegetation got established on all experimental plots (there was no tilling and no plant material was removed), it is important to note that the 2018 samples were still rated quite low by the Cornell Soil Health Lab in respect to their organic matter and active carbon (average scores 20 of 100), as well as soil respiration (average score 30 of 100).

Water holding capacity showed a very slight increase in most experimental plots and an appreciable increase in NMT2A & B. Root pathology also might have improved slightly across all experimental plots.

Aggregate stability, soil protein and pH showed no appreciable change during the first year of the trial across the experimental plots.

The somewhat excessive phosphorus levels from 2017 came down to what the Cornell Soil Health Lab considers close to ideal levels in 2018 in all experimental plots.

The potassium levels, which were rated as quite good by the Cornell Soil Health Lab in 2017 improved even further and were ideal across all experimental plots in 2018.

Potentially mineralizable nitrogen decreased by approximately 20% across all experimental plots (from an average of 7.0 µgN/g dry matter/week in 2017 to 5.6 µgN/g dry matter/week in 2018).

Labor and Equipment: Starting with the site preparation in early Spring 2017, Table 4 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). Not counting the site preparation work (seeding to Rye and then to Oats) completed in 2016, the site preparation for the actual seeding (starting with a cover of winter-killed Oats and some volunteer Rye growing back in (see the images from April 12, 2017 in Appendices 1.1 through 1.9) took a total of 1.5 person-hours per acre. The seeding itself (including the mixing of the seeds and calibration of the seeder) took 6 person-hours per acre. Mowing during the first season required a total of 3.3 person-hours per acre. Selective weeding/mowing during the second season required a total of 11 person-hours per acre.

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

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

Conclusions:

We successfully established two types of native meadows (plus a 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 more diverse seed mix resulted in more flowers and the presence of flowers throughout the second season (June through October) and, as detailed in the accompanying "*Entomology Report*", 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, at least in 2018, 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 distribution persist and if any of the seeded native plants might yet get established. We will also try to include more shallow-flowered plants into future native meadow/nectary seed mixes to try to attract more beneficial wasps, as well as the 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, Julia Meyer, Rosa Villegas, and Conrad Vispo for their assistance with the data collecting and analyzing; and Anne Bloomfield for helping coordinate it all.

Appendix 1.1 Photographic documentation of the experimental plots: Native Meadow Trial 1A

NMT 1A through its first year (2017)


12-April-2017 (3 harrowings)


18-May-2017 (day before seeding)


8-June-2017


3-July-2017 (mowed 6 July)


11-July-2017 (mowed 28 July)


4-Aug-2017 (mowed 15 August)


8-Sep-2017 (after 3 cuts)


3-Nov-2017


14-Dec-2017

NMT 1A through its second year (2018)


27-April-2018


25-May-2018 (selectiveweeding)


19-June-2018


10-July-2018


9-Aug-2018


13-Sept-2018


24-Sept-2018


23-Oct-2018

Appendix 1.2 Photographic documentation of the experimental plots: Native Meadow Trial 1B

NMT 1B through its first year (2017)


12-April-2017 (3 harrowings)


18-May-2017 (day before seeding)


8-June-2017


3-July-2017 (mowed 6 July)


11-July-2017 (mowed 28 July)


4-Aug-2017 (mowed 15 August)


8-Sep-2017 (after 3 cuts)


3-Nov-2017


14-Dec-2017

NMT 1B through its second year (2018)


27-April-2018


25-May-2018 (selectiveweeding)


19-June-2018


10-July-2018


9-Aug-2018


13-Sept-2018


24-Sept-2018


23-Oct-2018

Appendix 1.3 Photographic documentation of the experimental plots: Native Meadow Trial 1C

NMT 1C through its first year (2017)

12-April-2017 (3 harrowings)

18-May-2017 (day before seeding)

8-June-2017

3-July-2017 (mowed 6 July)

11-July-2017 (mowed 28 July)

4-Aug-2017 (mowed 15 August)

8-Sep-2017 (after 3 cuts)

3-Nov-2017

14-Dec-2017

NMT 1C through its second year (2018)

27-April-2018

25-May-2018 (selectiveweeding)

19-June-2018

10-July-2018

9-Aug-2018

13-Sept-2018

24-Sept-2018

23-Oct-2018

Appendix 1.4 Photographic documentation of the experimental plots: Native Meadow Trial 2A

NMT 2A through its first year (2017)


12-April-2017 (3 harrowings)


18-May-2017 (day before seeding)


8-June-2017


3-July-2017 (mowed 6 July)


11-July-2017 (mowed 28 July)


4-Aug-2017 (mowed 15 August)


8-Sep-2017 (after 3 cuts)


3-Nov-2017


14-Dec-2017

NMT 2A through its second year (2018)


27-April-2018


25-May-2018 (selectiveweeding)


19-June-2018


10-July-2018

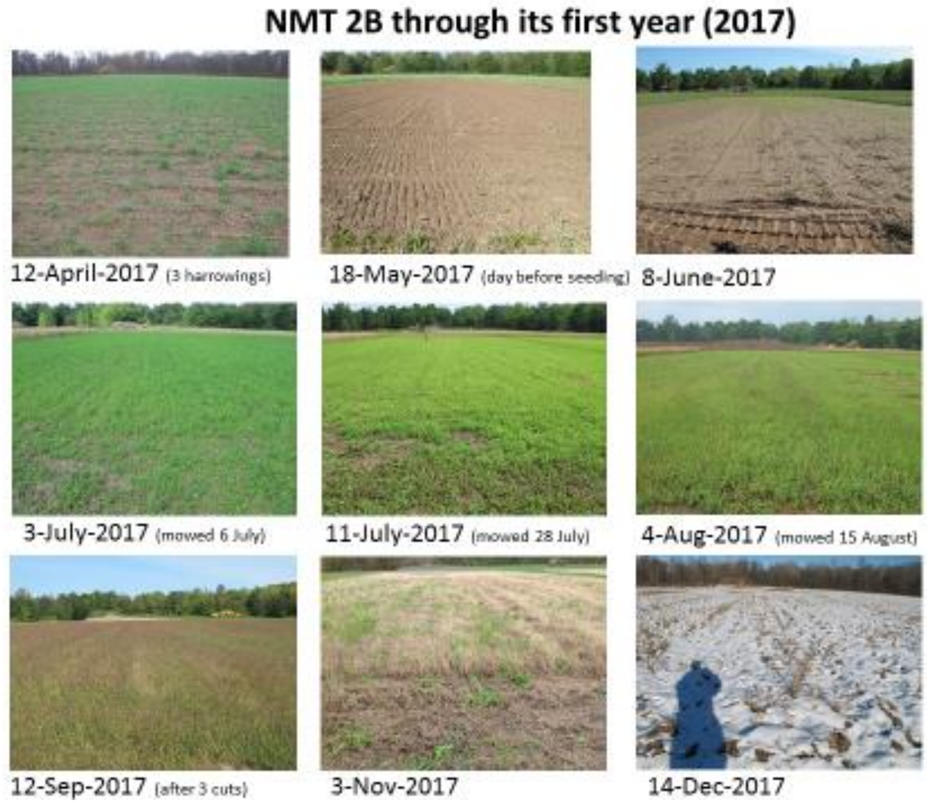

9-Aug-2018

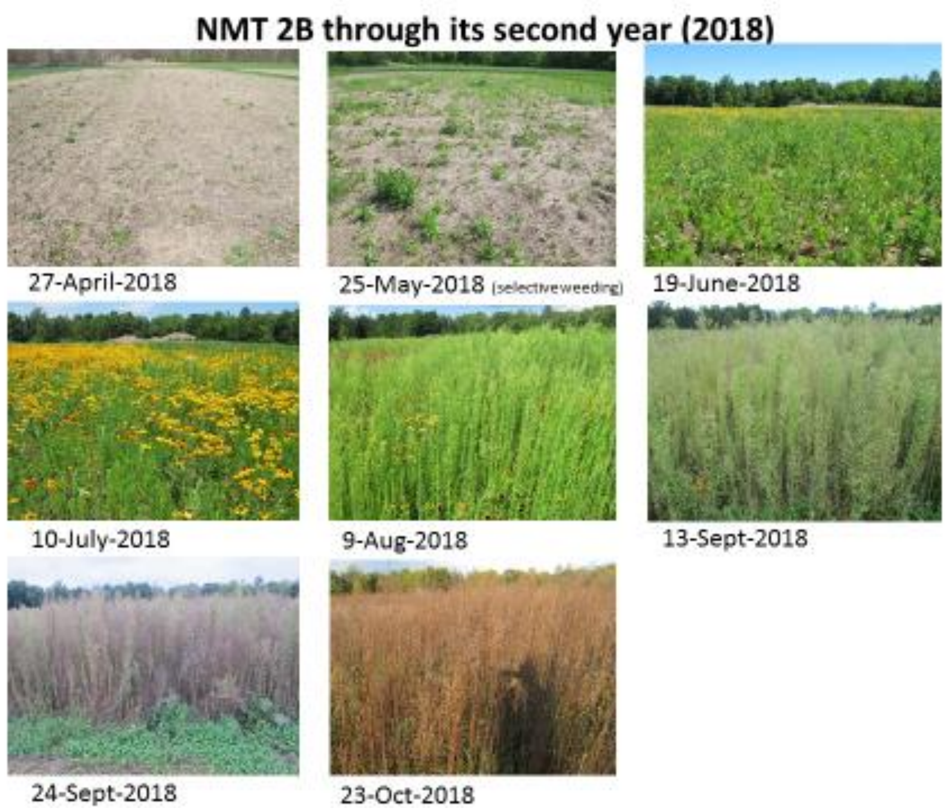

13-Sept-2018


24-Sept-2018


23-Oct-2018

Appendix 1.5 Photographic documentation of the experimental plots: Native Meadow Trial 2B





Appendix 1.6 Photographic documentation of the experimental plots: Native Meadow Trial 2C

NMT 2C through its first year (2017)

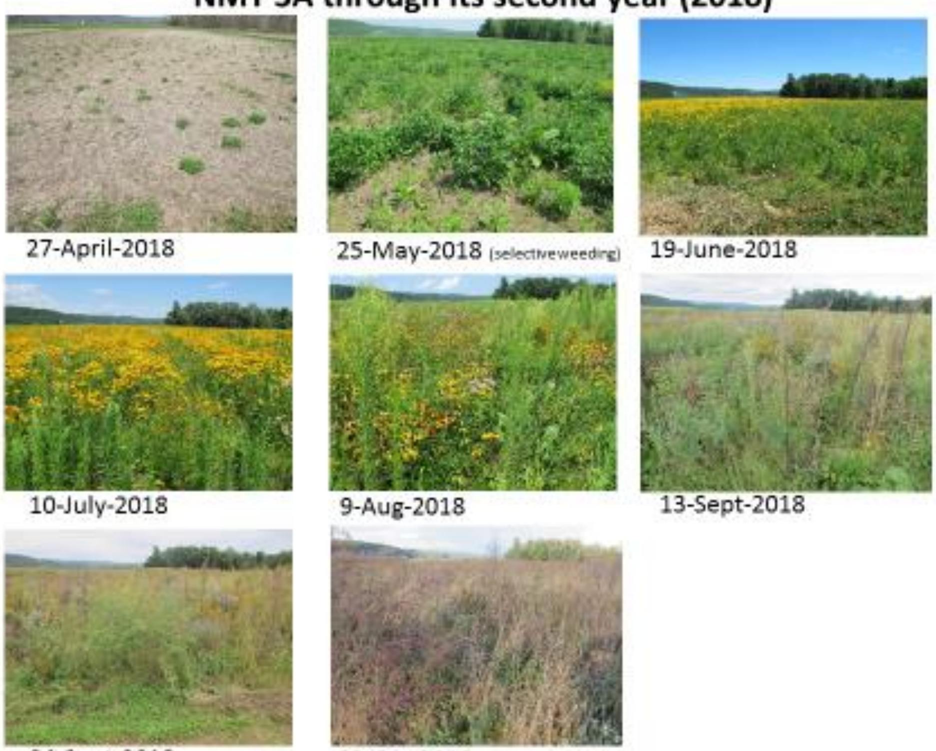
NMT 2C through its second year (2018)

Appendix 1.7 Photographic documentation of the experimental plots: Native Meadow Trial 3A

NMT 3A through its first year (2017)

12-April-2017 (3 harrowings)
18-May-2017 (day before seeding)
8-June-2017
3-July-2017 (mowed 6 July)
11-July-2017 (mowed 28 July)
4-Aug-2017 (mowed 15 August)
12-Sep-2017 (after 3 cuts)
3-Nov-2017
14-Dec-2017

NMT 3A through its second year (2018)



27-April-2018
25-May-2018 (selectiveweeding)
19-June-2018
10-July-2018
9-Aug-2018
13-Sept-2018
24-Sept-2018
23-Oct-2018

Appendix 1.8 Photographic documentation of the experimental plots: Native Meadow Trial 3B

NMT 3B through its first year (2017)


12-April-2017 (3 harrowings)


18-May-2017 (day before seeding)


8-June-2017


3-July-2017 (mowed 6 July)


11-July-2017 (mowed 28 July)


4-Aug-2017 (mowed 15 August)


12-Sep-2017 (after 3 cuts)


3-Nov-2017


14-Dec-2017

NMT 3B through its second year (2018)


27-April-2018


25-May-2018 (selectiveweeding)


19-June-2018


10-July-2018


9-Aug-2018


13-Sept-2018


24-Sept-2018


23-Oct-2018

Appendix 1.9 Photographic documentation of the experimental plots: Native Meadow Trial 3C

NMT 3C through its first year (2017)


12-April-2017 (3 harrowings)


18-May-2017 (day before seeding)


8-June-2017


3-July-2017 (mowed 6 July)


11-July-2017 (mowed 28 July)


4-Aug-2017 (mowed 15 August)


12-Sep-2017 (after 3 cuts)


3-Nov-2017


14-Dec-2017

NMT 3C through its second year (2018)


27-April-2018


25-May-2018 (selectiveweeding)


19-June-2018


10-July-2018

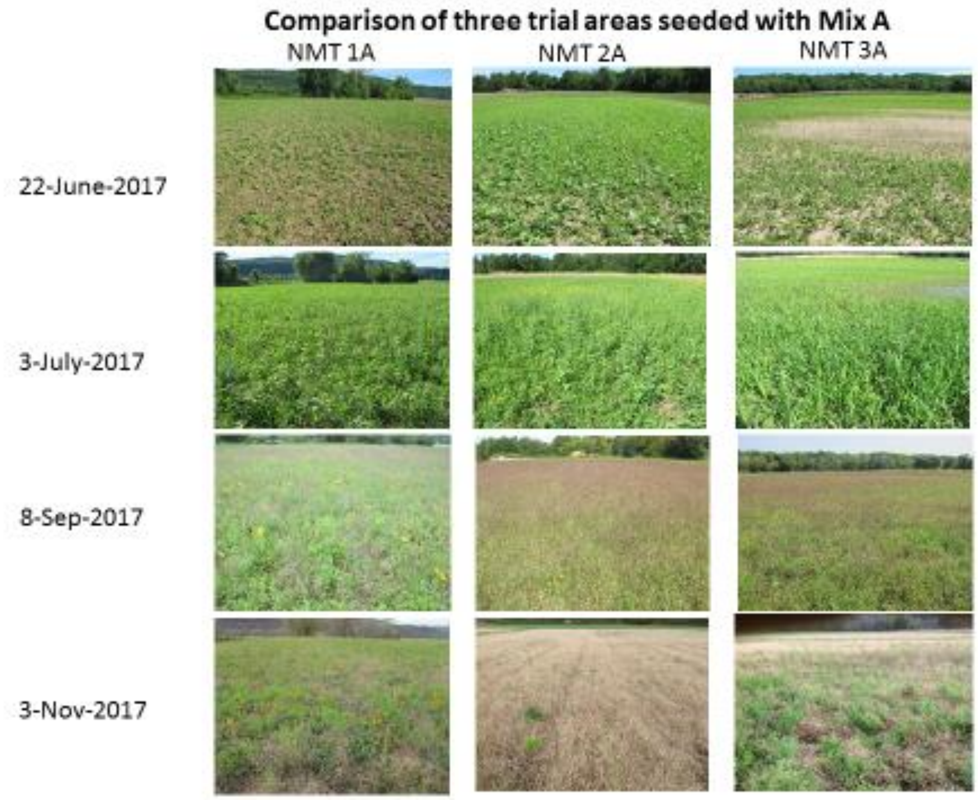

9-Aug-2018

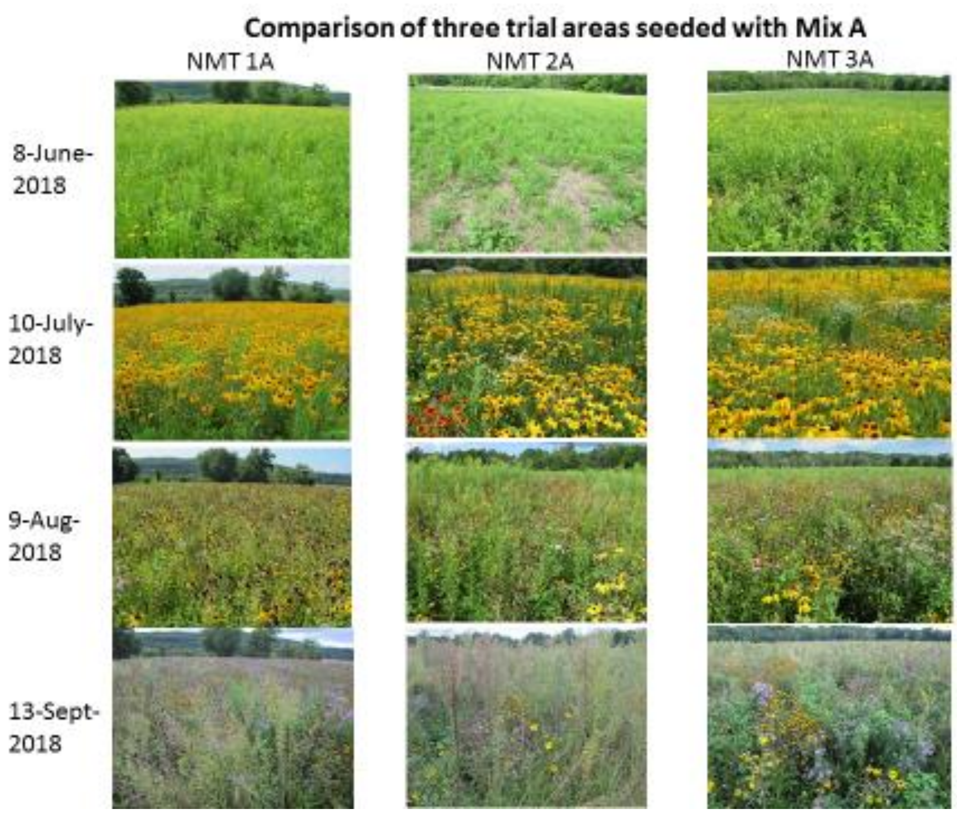

13-Sept-2018


24-Sept-2018

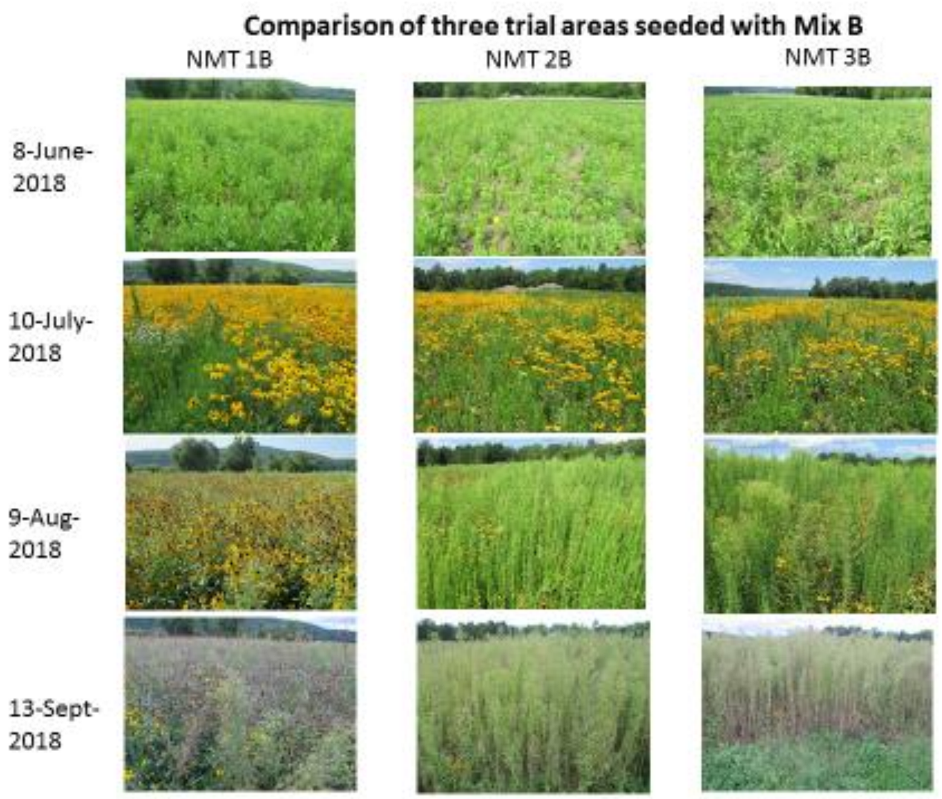

23-Oct-2018

Appendix 2.1 Photographic comparison of the three experimental plots seeded with Seed Mix A

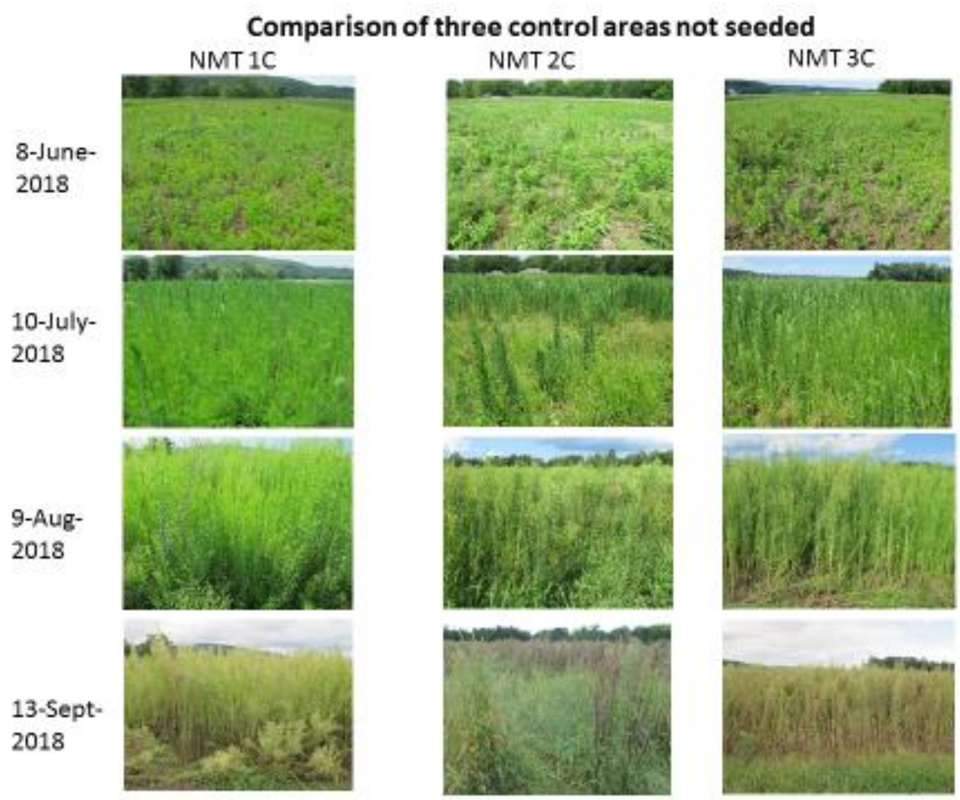




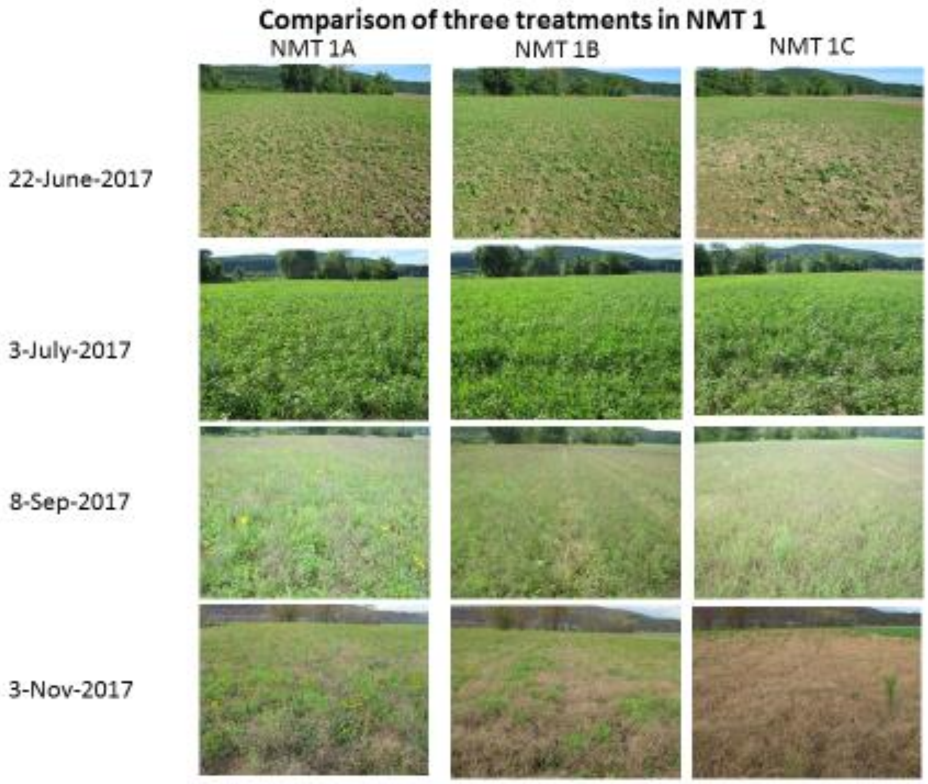
Appendix 2.2 Photographic comparison of the three experimental plots seeded with Seed Mix B

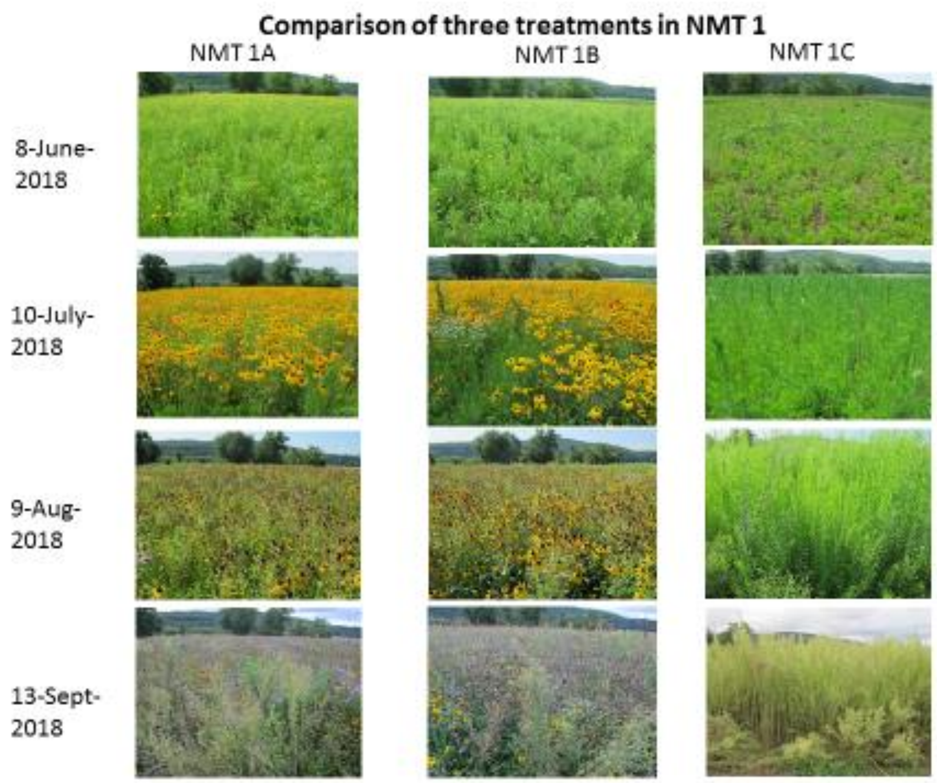


Appendix 2.3 Photographic comparison of the three control plots

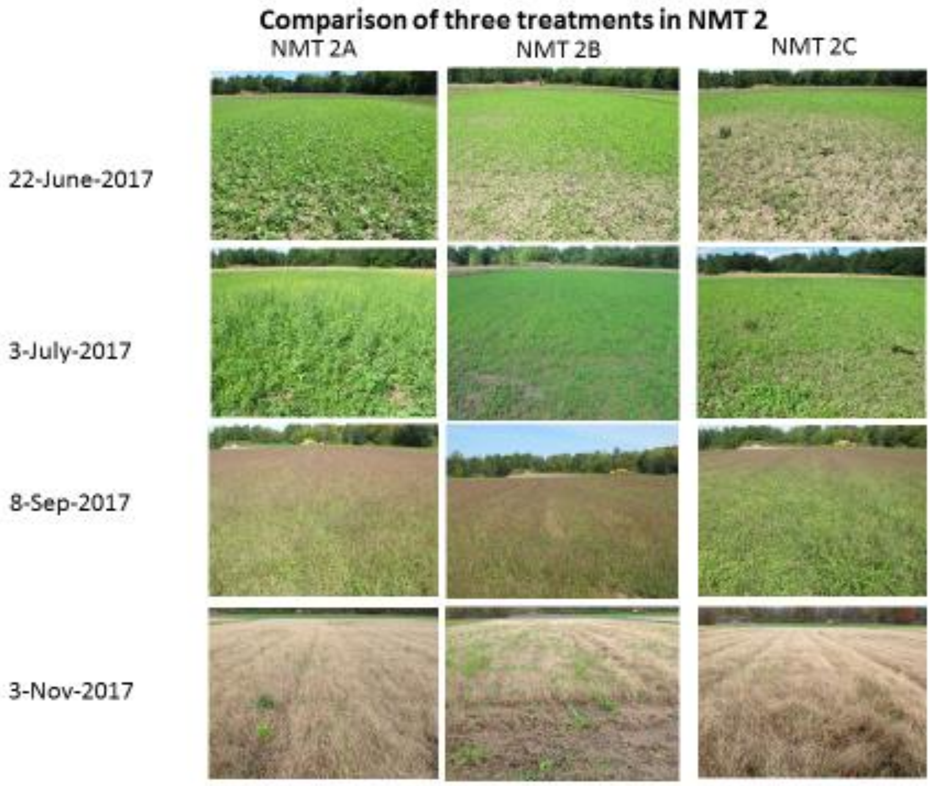


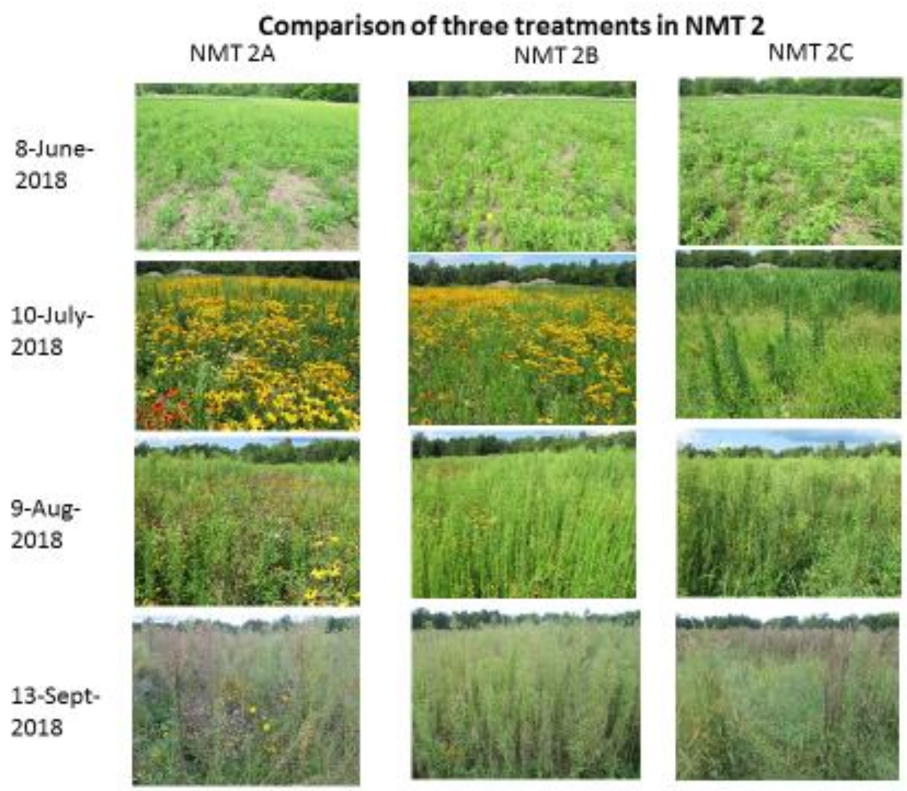
Appendix 3.1 Photographic comparison of the three treatments (seeded with Seed Mix A, seeded with Seed Mix B, and control) in trial area NMT1





Appendix 3.2 Photographic comparison of the three treatments (seeded with Seed Mix A, seeded with Seed Mix B, and control) in trial area NMT2





Appendix 3.3 Photographic comparison of the three treatments (seeded with Seed Mix A, seeded with Seed Mix B, and control) in trial area NMT3