Toronto and Region Conservation Authority

The Meadoway: Vegetation, Bird, and Butterfly Monitoring 2016, 2018-2023

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ACKNOWLEDGEMENTS

This report was prepared by Lyndsay Cartwright; however, the production of this report was a collaborative effort among multiple individuals within Toronto and Region Conservation Authority (TRCA). Field data were collected by TRCA's Terrestrial Inventories and Monitoring team including Brian Ford, Rivka Shachak, Paul Prior, Natasha Gonsalves, Gavin Miller, and Dell Tune among many others. Mapping was completed by Dell Tune, Alberta D'Souza, and Blair Scriven. Photos were provided by both the Terrestrial Inventories and Monitoring and Restoration teams. Conceptualization of the report contents was a collaborative effort including contributions from Brian Ford, Rivka Shachak, Paul Prior, Chris Cormack, Katie Turnbull, Sarah Kotsopoulos, Sue Hayes, Natasha Gonsalves, Paul Morris, and many others. This team of contributors also provided valuable qualitative field observations described in this report. Thank you to Sue Hayes, Rivka Shachak, Brian Ford, and Paul Prior for providing helpful comments on earlier drafts.

INTRODUCTION

The Meadoway project involves the revitalization of a 16 km linear hydro corridor, formerly known as the Gatineau Hydro Corridor (Figure 1 and Figure 2). The goals of the revitalization are to create and maintain meadow habitat and to create an active east-west link between downtown Toronto and Rouge National Urban Park becoming one of the largest greenspaces in Canada (Sharma 2018).

Restoration and maintenance activities have included seeding portions of the corridor with flora species native to meadows in the region, selective mowing, and invasive species management. Restoration began in 2012 with the section near McCowan Road and Lawrence Avenue East being prepared and seeded. Several other sections were seeded between 2013 and 2016; however, some sections remained un-restored as highly manicured turfgrass. Several of these turfgrass areas started undergoing restoration (spraying, tilling, seeding cover crops) in the summer of 2019 while other sections began in 2020 and 2023. Mowing and herbicide application has occurred intermittently in different sections although became a more prominent focus in 2018.

Monitoring activities occurred in 2016 and 2018-2023 to document changes in species composition related to the vegetation, breeding birds, and butterfly presence. This report is an update to the 2022 monitoring report (TRCA 2022) with a similar focus on establishment of seeded species and invasive species management and comparing pre- and post-restoration vegetation communities but now with another year of data. We have also included a summary of data collected at an experimental plot called the Xerces plot that trialed a unique site preparation method. We also summarized the results of bird and butterfly surveys throughout The Meadoway and conducted pre- and post-restoration comparisons where possible.

Figure 1. Late June 2023 at The Meadoway.

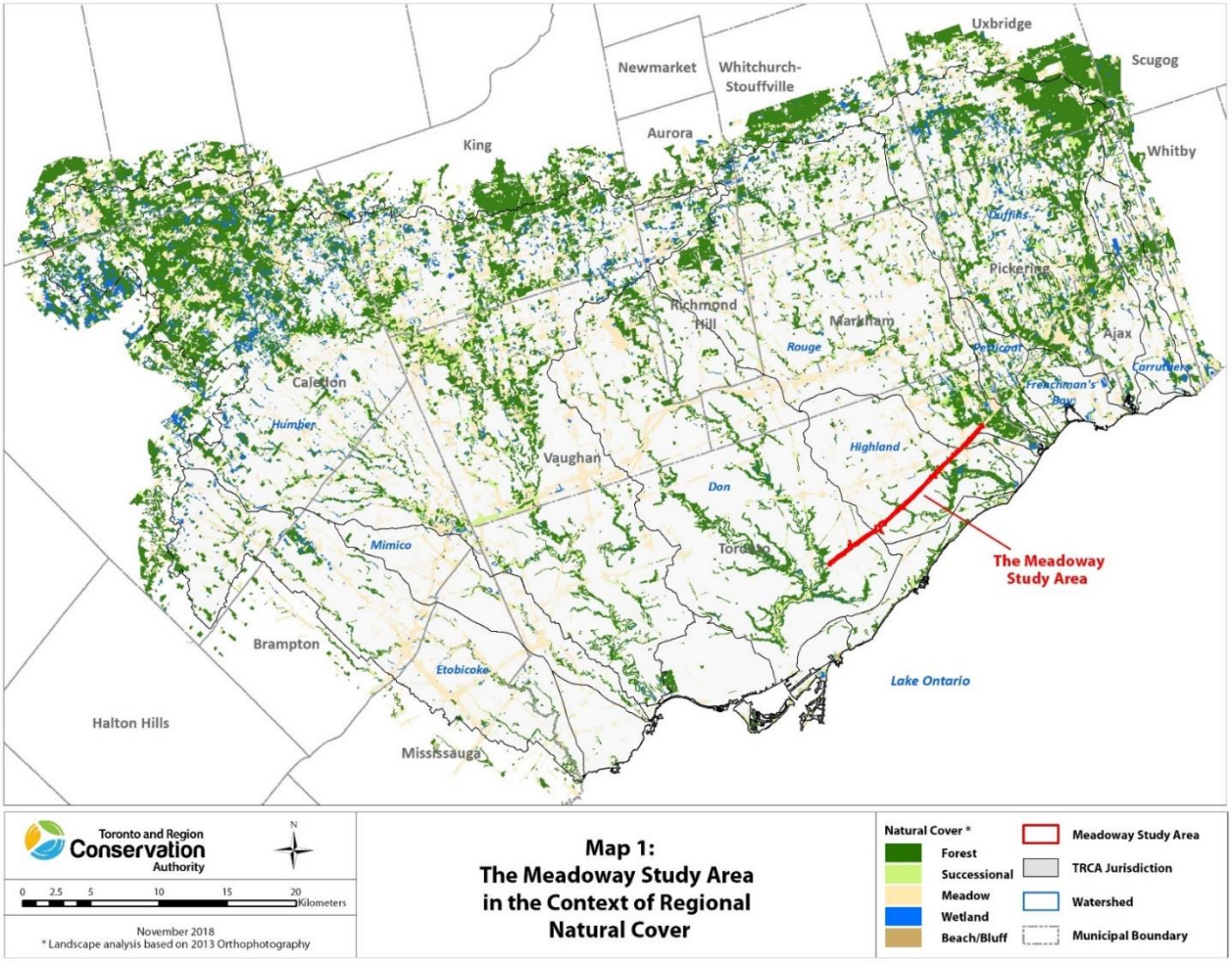

Figure 2. Geographic location of The Meadoway related to TRCA's jurisdiction.

METHODOLOGY

Vegetation plots

The methodology for monitoring meadow ecosystems used by Toronto and Region Conservation Authority (TRCA) is based on the Ecological Monitoring and Assessment Network (EMAN) endorsed terrestrial vegetation biodiversity monitoring protocols identified by Roberts-Pichette and Gillespie (1999). As the EMAN protocol was originally intended for forest communities, adaptations to the protocol were made making it specific to meadow ecosystems (Figure 3).

Each meadow plot consisted of one 20 x 20 m (400 m^2) main plot, five 2 x 2 m (4 m^2) shrub and sapling regeneration sub-plots and five 1 x 1 m (1 m^2) ground cover vegetation sub-plots (nested within the larger regeneration sub-plots). Shrub and sapling regeneration sub-plots were monitored once during the growing season (September). Sites were visited approximately the same time each year coinciding with the second ground vegetation visit. All shrubs and seedlings that were <10 cm diameter-at-breast-height and ≥16 cm in height were considered in regeneration sub-plots. Only live plants were recorded in regeneration sub-plots. The boundaries of the 2 x 2 m sub-plots were identified and delineated. All qualifying plant species originating within the sub-plot were identified. Individuals within each species were then measured with a metre stick and recorded into the appropriate height class located on the data sheet. Height measurements were taken from the ground to the upper most living portion of the plant. For plants that leaned, the vertical distance from the ground to the highest part of the plant was recorded as the height. The percent cover that each species provides was estimated.

Figure 3. Monitoring vegetation plots at The Meadoway in 2023.

All herbaceous plants, regardless of size, as well as shrub, tree, and woody vines <16 cm in height were considered in ground vegetation sub-plots. Ground vegetation sub-plot monitoring was conducted twice during the growing season to capture early and late growing meadow/prairie species. The first visit was in early June and the second in late summer (September). Sites were visited approximately the same time each year. Each plant species originating within or hanging over into the 1 x 1 m sub-plot was identified. A 50 x 50 cm grid square consisting of smaller 10 x 10 cm grids was positioned over corner “A” of the sub-plot and shifted to the other three corners. The number of 10 x 10 cm squares that each species occupies was summed to determine their total percentage of cover within the sub-plot. It was also noted if a species was solitary. The cover of dead vegetation (thatch) was also measured in the ground vegetation plots (only in the spring visit).

Species lists were created for the plot as a whole using data combined from the 20 x 20, all 2 x 2s and all 1 x 1s. For a detailed description of vegetation monitoring methodology please see the Meadow Vegetation LTMP Monitoring Protocol (TRCA 2022).

Vegetation data were interpreted using TRCA’s local rank (L-rank) system for flora (TRCA 2017). The L-rank system is a species scoring and ranking system developed at TRCA to provide guidance for natural heritage protection and management within the jurisdiction. The L-rank system uses simple ranks to convey individual species’ ecological needs and sensitivities rather than just “rarity” in order to portray such complexities on a

simple ordinal scale. Flora are scored using four criteria: local occurrence, population trend, habitat dependence and sensitivity to development impacts. For example, species ranked L1 would have: a limited local occurrence, declining population trends, habitat specialist preferences, and a sensitivity to development. Species ranked L5 would have: a widespread local occurrence, increasing population trends, habitat generalist preferences, and a tolerance to development. These are extreme examples and species can be ranked L1, L2, L3, L4 or L5 based on the scores associated with this combination of ecological needs and population status assessments. In addition, flora species can be categorized as follows: L1-L3 species are of regional conservation concern, L4 species are of conservation concern in urban areas, L5 species are not of conservation concern at this time, L* species are native to southern Ontario but with no known natural records in TRCA jurisdiction, LX species have been extirpated from the TRCA jurisdiction (but have been planted since extirpation), L+ species are introduced species not native to the TRCA jurisdiction, L+? species are probably introduced.

Bird stations

Meadow bird monitoring followed an adapted Ontario Forest Bird Monitoring Protocol (Figure 4). This protocol is also used for meadow bird surveys conducted through TRCA's Terrestrial Long-term Monitoring Program (TRCA 2011). Meadow birds were monitored twice during the field season with the first visit occurring between May 15th and May 30th, and the second visit between May 30th and June 15th, with at least 10 days between visits. Counts were conducted between 05:00 and 10:00 hours and at approximately the same time of day on subsequent visits from year to year. Counts were only conducted in good weather conditions (no rain, light winds). All birds seen or heard within a 100 m radius circle and during a 10-minute time period were recorded. This report only contains species potentially breeding at the site.

Figure 4. Biologist conducting bird monitoring.

Butterfly transects

Butterflies were surveyed by slowly walking a specified path through the meadow and identifying/counting butterfly species observed (Figure 5). Butterflies were identified to species where possible or to genus if species-level identification was not possible. Four visits were made each year to capture variation in adult emergence dates among resident and migratory species. Surveys were conducted between 09:00 and 16:00 and only in good weather conditions (>10^{o}C, no rain, light winds). Start and end times were recorded and were generally consistent among years.

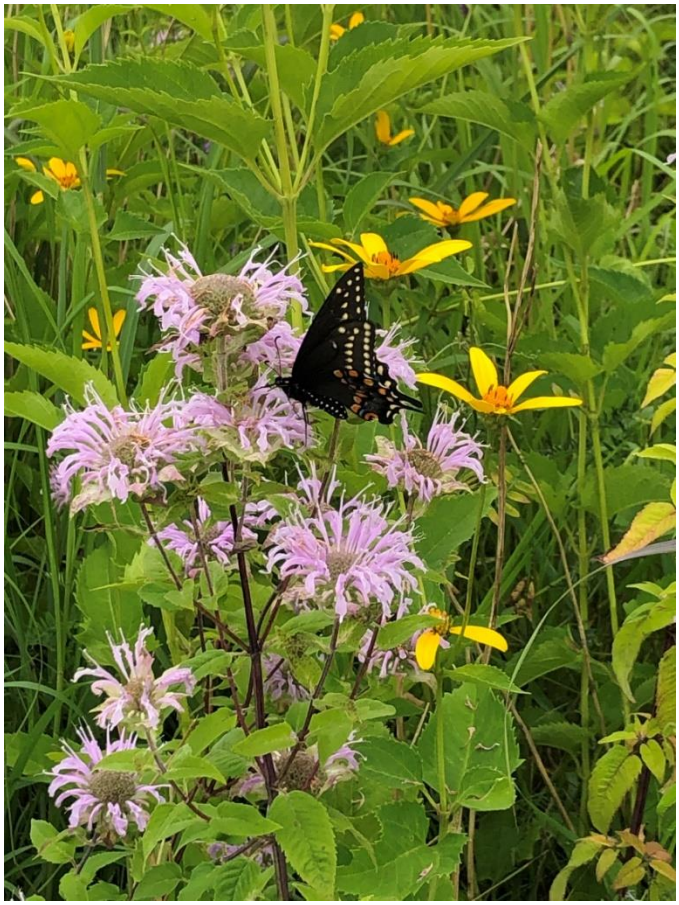

Figure 5. Black Swallowtail (*Papilio polyxenes*).

RESULTS

Thirty-five vegetation plots were set up between 2016 and 2023 (Table 1, Figure 6). Plots were set up in different years corresponding to the occurrence of management activities. Bird and butterfly monitoring were completed in 2016, and 2018-2023. In 2016 and 2018, five sections were surveyed for butterflies with transects situated on the paved trail that runs the length of the corridor. In 2019, transects were moved slightly in each section to run beneath the northmost hydro wires for the entire length of the corridor (instead of along the trail).

Table 1. Vegetation plots, bird surveys, and butterfly survey locations and years surveyed.

Section	Veg plot name	Vegetation plot monitoring years	Bird survey station #	Bird survey years	Butterfly transect	Butterfly survey years
1.1	MV-24_1.1X	2019, 2020, 2021-2023	11	2021-2023	1C	2021-2023
	MV-24_1.1Y	2020, 2021-2023				
1.2	MV-24_1.2P	2018, 2019, 2020, 2021- 2023	8	2020-2023	Bermondsey to Soccer Pitch	2022, 2023
					1F	2020-2023
1.3	MV-24_1.3Q	2018, 2020, 2021-2023	12	2021-2023	1H	2021-2023
	MV-24_1.3V	2019 (abandoned post-2019)				
1.4	MV-24_1.4W	2019	6	2018, 2019, 2021-2023	1J	2019, 2021-2023
	MV-24_1.4R	2019 (abandoned post-2019)				
	MV-24_1.4AI	2023				
2.2	MV-24_2.2AJ	2023	15	2022, 2023	2	2022, 2023
	MV-24_2.2S	2018, 2019, 2021-2023				
2.3	MV-24_2.3T	2018, 2019, 2021-2023				
2.4	MV-24_2.4U	2018, 2019, 2021-2023	7	2018, 2019-2023	2K	2019, 2021-2023
3.2	MV-24_3.2AA	2020				
3.3	MV-24_3.3AB	2020				
4.1	MV-24_4.1G	2016, 2018, 2019, (2020 summer only), 2021-2023	1	2016, 2018-2023	A	2016, 2018-2023
	MV-24_4.1H	2016, 2018, 2019, (2020 summer only), 2021-2023			B	2016, 2018, 2019, 2021-2023
	MV-24_4.1I	2016, 2018, 2019, 2021-2023				
4.2	MV-24_4.2A	2016, 2018-2023	2	2016, 2018-2023	A, B, C, D	2016, 2018-2023
	MV-24_4.2B	2016, 2018-2023				
	MV-24_4.2C	2016, 2018-2023				
4.3	MV-24_4.3D	2016, 2018-2023	3	2016, 2018-2023	A, B, D	2016, 2018-2023
	MV-24_4.3E	2016, 2018, 2019, (2020 summer only), 2021-2023				
	MV-24_4.3F	2016, 2018, 2019, (2020 summer only), 2021-2023				
4.4	MV-24_4.4J	2016, 2018, 2019, (2020 summer only), 2021-2023	4	2016, 2018-2023	B	2016, 2018-2023

Section	Veg plot name	Vegetation plot monitoring years	Bird survey station #	Bird survey years	Butterfly transect	Butterfly survey years
	MV-24_4.4K	2016, 2018, 2019, (2020 summer only), 2021-2023			E	2021-2023
	MV-24_4.4L	2016, 2018, 2019, (2020 summer only), 2021-2023				
5.1	MV-24_5.1AC	2020, 2023				
5.2	N/A	N/A	9	2020, 2023	D	2020, 2023
5.3	MV-24_5.3AD	2020, 2023	10	2020, 2023	E, F	
5.4	MV-24_5.4AE	2020, 2023			G	
6.1	MV-24_6.1AF	2020				
6.2	MV-24_6.2AG	2020	13	2021, 2022	B	2021-2022
6.4	MV-24_6.4AH	2020	14	2021, 2022	C	2021-2022
7.1	MV-24_7.1M	2016, 2018-2023	5	2016, 2018-2023	A, B, C, D, E	2016, 2018-2023 (E only surveyed in 2019)
	MV-24_7.1N	2016, 2018-2023				
	MV-24_7.1O	2016, 2018-2023				

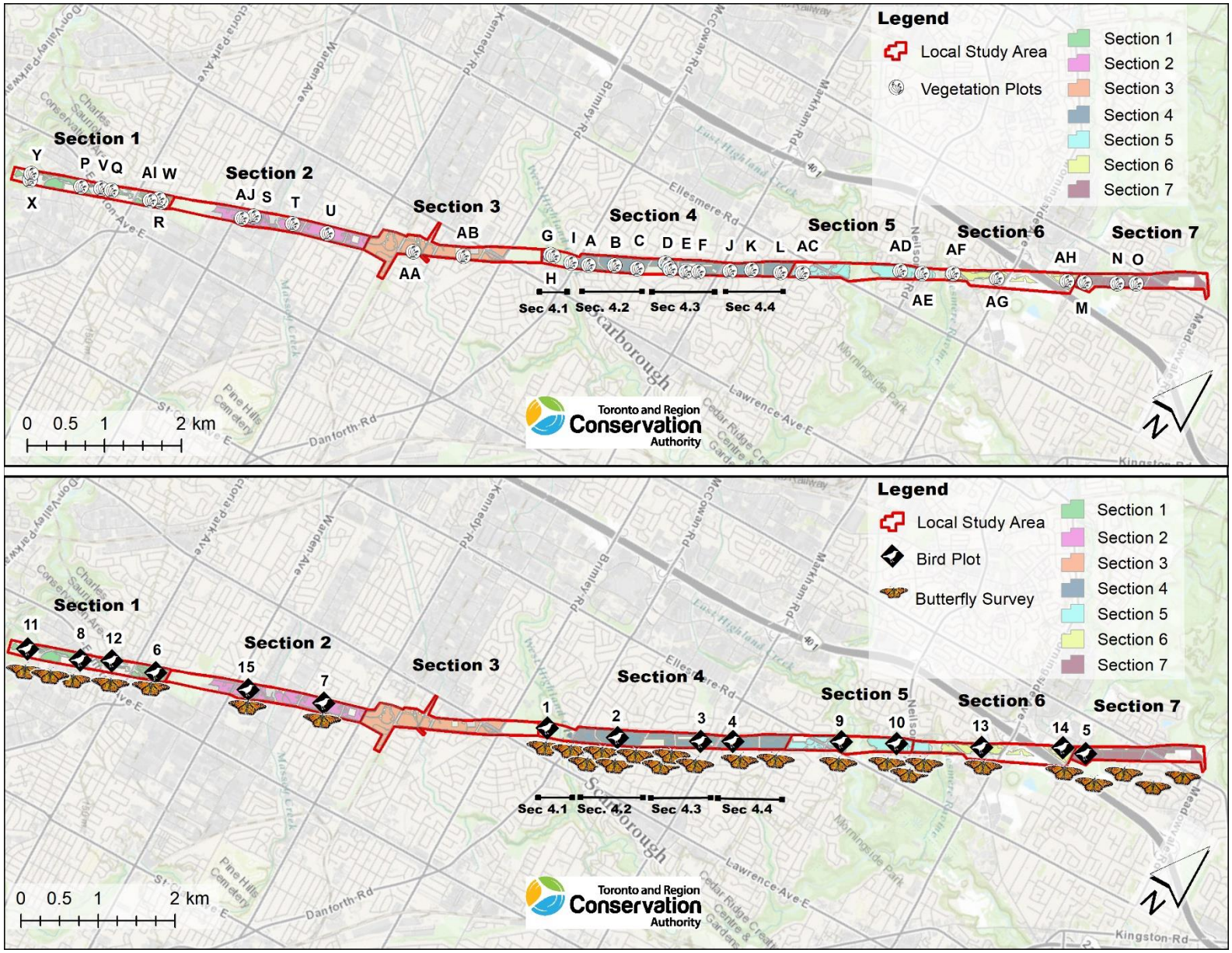

Figure 6. Vegetation plot, bird, and butterfly survey locations at The Meadoway in 2016, 2018-2023.

Vegetation plots

Vegetation monitoring plots were subject to different, and often multiple, management techniques over the past seven years of monitoring. Due to this variation, each part of this report focuses on different aspects of restoration. For example, we focus on long-term changes in sections 4 and 7, areas with the longest post-restoration monitoring data. We also contrast pre- and post-restoration plant communities where data exist. We examined the effectiveness of invasive species management across multiple sections, particularly the targeted treatment/removal of creeping thistle (Cirsium arvense) and dog-strangling vine (Cynanchum rossicum; DSV), by comparing the absolute maximum cover in each sub-plot over the years monitored.

Section 1: Pre- and post-restoration comparisons

We compared species composition of seeded species observed in the sub-plots and examined changes in cover and occurrence pre- and post-restoration using the maximum cover of the spring and summer visits.

Section 1.1

Plot X was the only vegetation plot monitored both pre- and post-restoration in section 1.1. Plot X was first monitored in 2019 and was seeded in May 2020.

The number of seeded species that germinated increased between 2019 (1 species) and 2023 (17 species; Figure 7). It is important to note that heath aster (*Symphyotrichum ericoides* var. *ericoides*; a species in the seed mix) was naturally occurring in the plot pre-seeding. Maximum percent cover of seeded species also increased between 2019 and 2023 for most species (Figure 8). There was a drastic decline in the maximum percent cover of DSV from 90% in 2019 to 5% in 2023 due to management activities.

Figure 7. Photos of plot X in section 1.1 pre-restoration 2019 (left) and post-restoration 2023 (right) showing big bluestem (*Andropogon gerardi*) and tall goldenrod (*Solidago altissima* var. *altissima*).

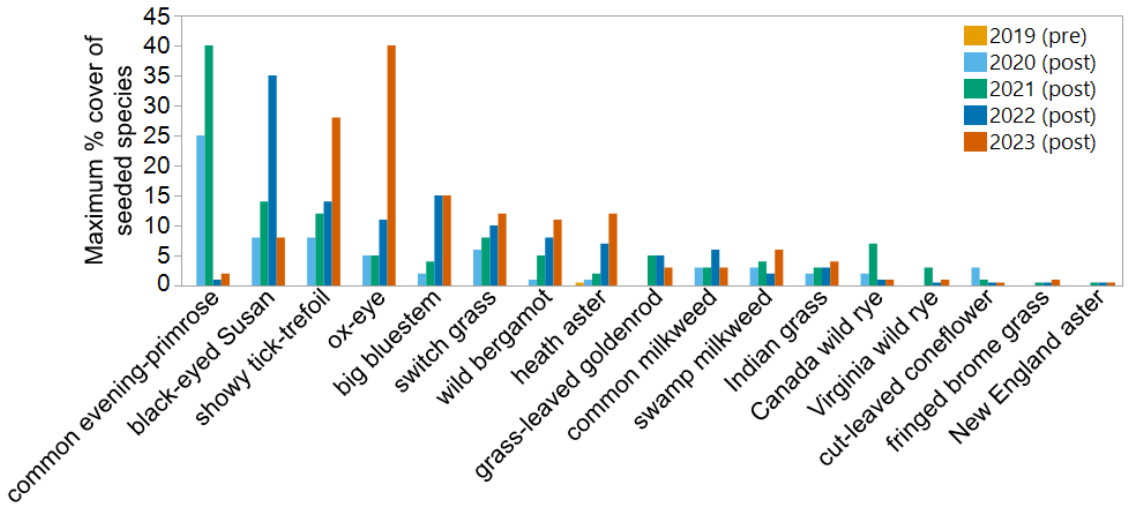

Figure 8. Changes in species occurrence and maximum percent cover of seeded species that germinated in plot X between 2019 and 2023. Note: heath aster occurred naturally in 2019.

Section 1.3

Plot Q was the only vegetation plot monitored both pre- and post-restoration in section 1.3 (Figure 9). Section 1.3 plot Q was first monitored in 2018 and was seeded in May 2020.

The number of seeded species that germinated increased between 2018 and 2023. Plot Q contained none of the seeded species in 2018, but by 2023, 10 seeded species occurred (Figure 10). No new seeded species were found in 2023 but the maximum percent cover was either relatively consistent with 2022 or increased. Increases in cover between 2022 and 2023 were considerable for ox-eye (*Heliopsis helianthoides*) and common evening-primrose (*Oenothera biennis*). Plot Q had a low maximum percent cover of DSV both pre- and post-restoration (<3%). Creeping thistle was absent pre-restoration but has reached 22% cover by 2023. While targeted spraying has occurred in this area, these data suggest that efforts should continue.

Figure 9. Photos of plot Q in section 1.3 pre-restoration 2018 (left) and post-restoration 2023 (right) showing tall goldenrod and ox-eye.

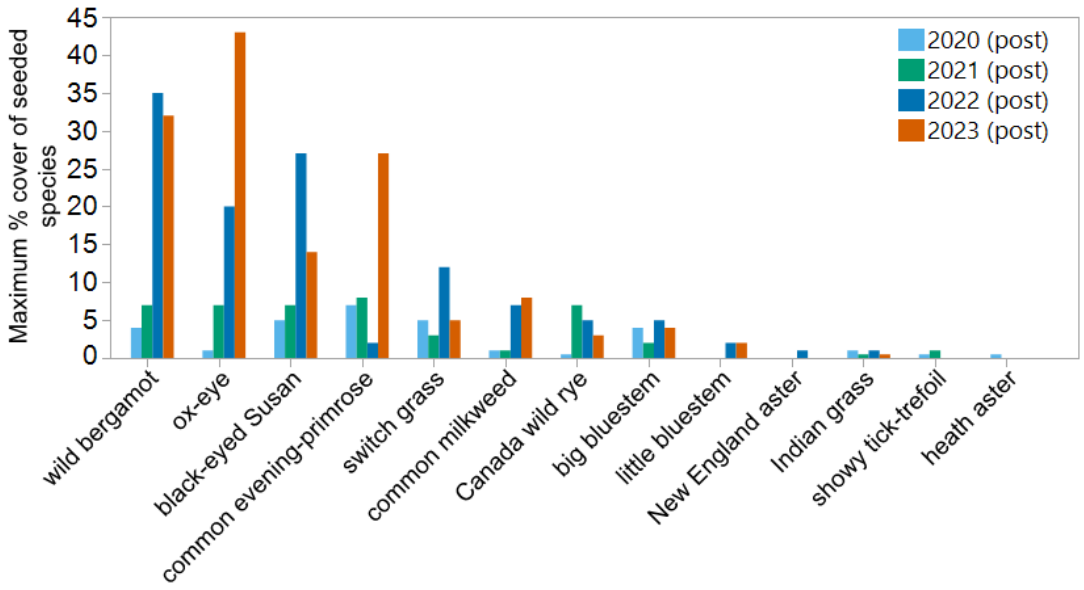

Figure 10. Maximum percent cover of seeded species that germinated in plot Q between 2020 and 2023. None of the seeded species were observed in 2018 (prior to seeding).

Section 1.4

Plot AI was monitored for the first time in 2023 after being seeded in October of 2021. Eight of 13 seeded species were observed in 2023 with high cover of Canada wild rye (65%; Figure 11). Foxglove beard-tongue (*Penstemon digitalis*), blue vervain (*Verbena hastata*), and Virginia wild rye (*Elymus virginicus* var. *virginicus*) were also observed. These species were not indicated in the seed mix but were likely seeded or dispersed from other nearby seeded areas.

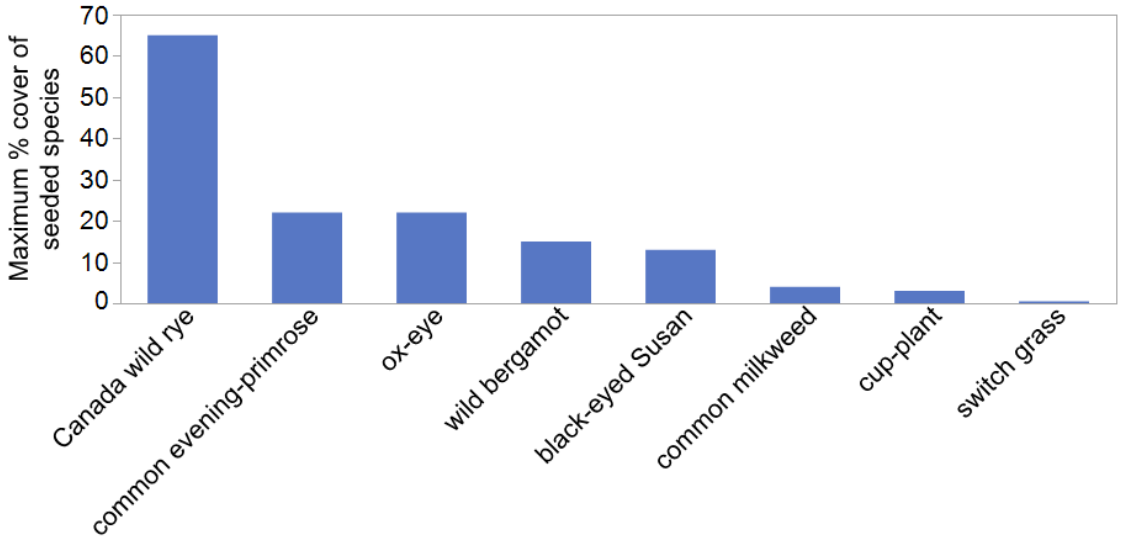

Figure 11. Maximum percent cover of seeded species that germinated in plot AI in 2023.

Section 2: Pre- and post-restoration comparisons

Similar to the analyses for section 1, we compared species composition of seeded species observed in the sub-plots and examined changes in cover and occurrence pre- and post-restoration using the maximum cover of the spring and summer visits.

Section 2.2

Plot AJ was monitored for the first time in 2023 after being seeded in November 2022 (Figure 12). The seed mix used was also supplemented with additional blue vervain and the plot data reflect this extra seeding effort. Common evening-primrose also had a high cover in the plots (25%).

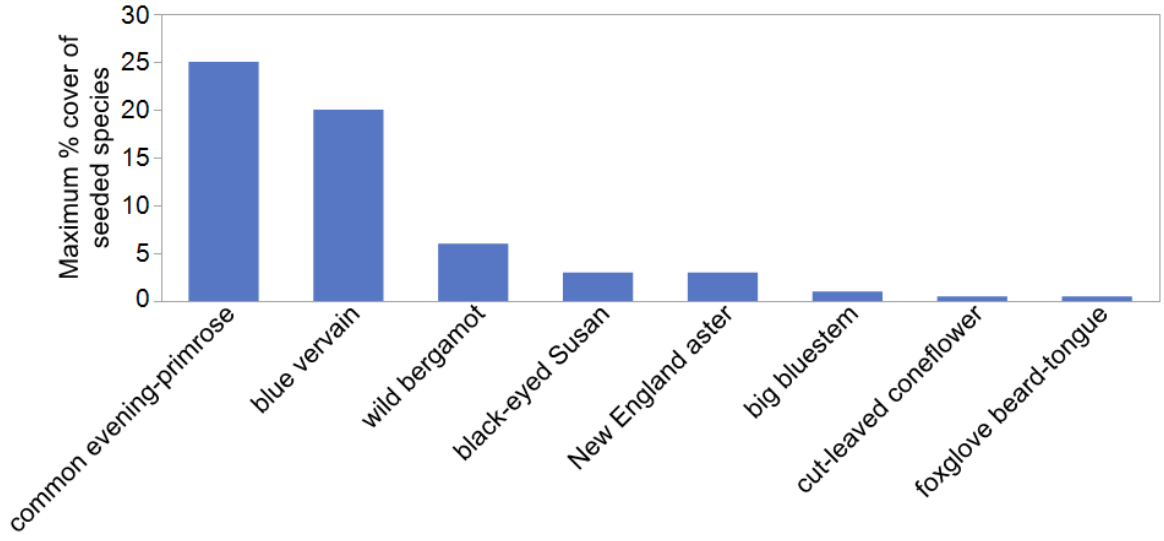

Figure 12. Maximum percent cover of seeded species that germinated in plot AJ in 2023

Plot S was the only vegetation plot monitored both pre- and post-restoration in section 2.2 (Figure 13). Section 2.2 was first monitored in 2018 and seeded in November 2020, April 2021, and November 2022.

The cover of many seeded species increased between 2022 and 2023 including common evening-primrose, Canada wild rye (*Elymus canadensis* var. *canadensis*), common milkweed (*Asclepias syriaca*), black-eyed Susan (*Rudbeckia hirta* var. *pulcherrima*), foxglove beard-tongue, switch grass (*Panicum virgatum*), and Virginia wild rye (Figure 14). Cover was highest for common evening-primrose (30%) and Canada wild rye (25%). DSV has been absent in plots since 2021. Creeping thistle cover was high in 2021 (60%) and 2022 (40%) but was only 12% in 2023 suggesting that targeted management has been effective.

Figure 13. Photos of plot S in section 2.2 pre-restoration 2019 (left) and post-restoration 2023 (right) showing switch grass.

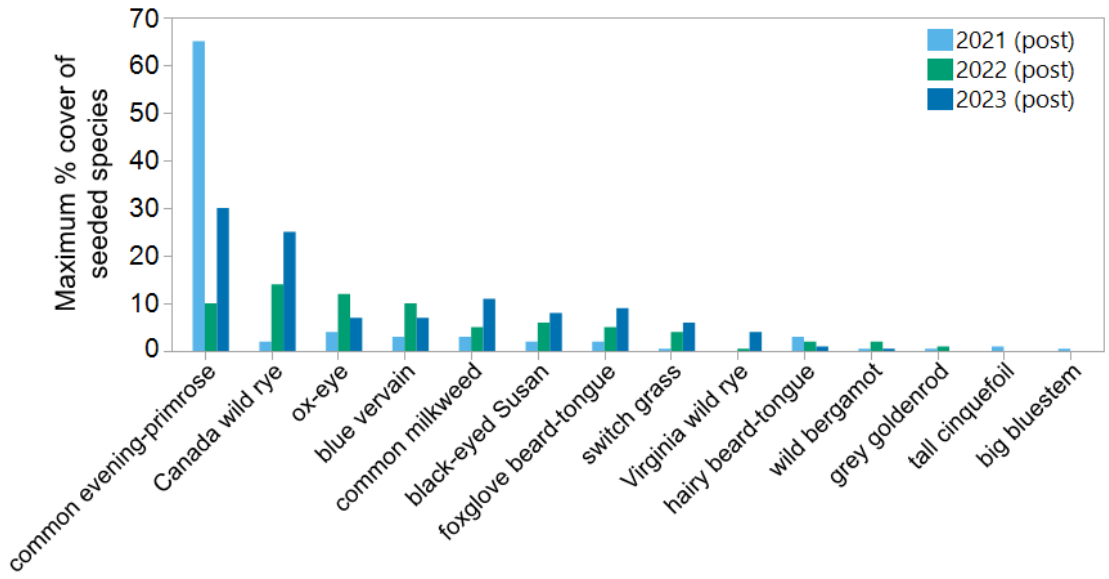

Figure 14. Maximum percent cover of seeded species that germinated in plot S in 2021 and 2023. None of the seeded species were observed in 2018 (prior to seeding).

Section 2.3

Plot T was the only vegetation plot monitored both pre- and post-restoration in section 2.3 (Figure 15). Plot T was first monitored in 2018 and seeded in November 2020 and April 2021.

The number of seeded species that germinated increased between 2018 and 2021, followed by a decrease in 2022, then an increase in 2023. Plot T contained none of the seeded species in 2018, but in 2021, 14 seeded species were observed (Figure 16). By 2022, only 9 of the seeded species occurred but by 2023, 12 species were found. Several species were found for the first time in 2023 including New England aster (*Symphyotrichum*

novae-angliae) and heath aster. Seven species had higher percent covers in 2023 compared to 2022 including common evening-primrose, ox-eye, blue vervain, black-eyed Susan, switch grass, common milkweed, and foxglove beard-tongue. Maximum DSV cover decreased from 6% in 2019 to 0% in 2022 and continues to be 0% in 2023. Creeping thistle percent cover increased from 0% in 2019 to 12% in 2023. This area may also need continued targeting for thistle management.

Figure 15. Photos of plot T in section 2.3 pre-restoration 2019 (left) and post-restoration 2023 (right) showing tall goldenrod.

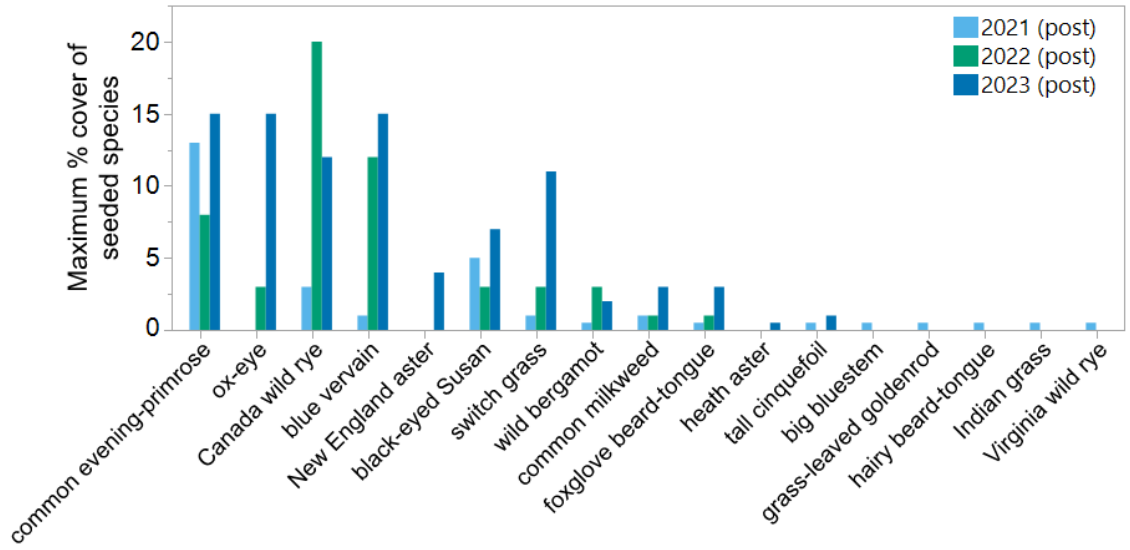

Figure 16. Maximum percent cover of seeded species that germinated in plot T in 2021 and 2023. None of the seeded species were observed in 2018 (prior to seeding).

Section 2.4

Plot U was the only vegetation plot monitored both pre- and post-restoration in section 2.4 (Figure 17). Section 2.4 plot U was first monitored in 2018 and was seeded in November 2020.

The number of seeded species that germinated increased between 2018 and 2022, although decreased in 2023. Plot U contained none of the seeded species in 2018, 13 seeded species in 2021, 14 seeded species in 2022, and 8 species in 2023. No new seeded species were found in 2023; however, prairie dock (*Silphium terebinthinaceum*) was found for the first time in 2023. This species was likely inadvertently included in the seed mix. Switch grass and grass-leaved goldenrod had the greatest increase in cover between 2022 and 2023 (Figure 18). DSV was only found in 2018 and 2019 with a cover of <1% and creeping thistle was only found in 2022 and 2023 with a maximum cover of 7% but appears to be increasing in cover each year.

Figure 17. Photos of plot U in section 2.4 pre-restoration 2019 (left) and post-restoration 2023 (right) showing switch grass and tall goldenrod.

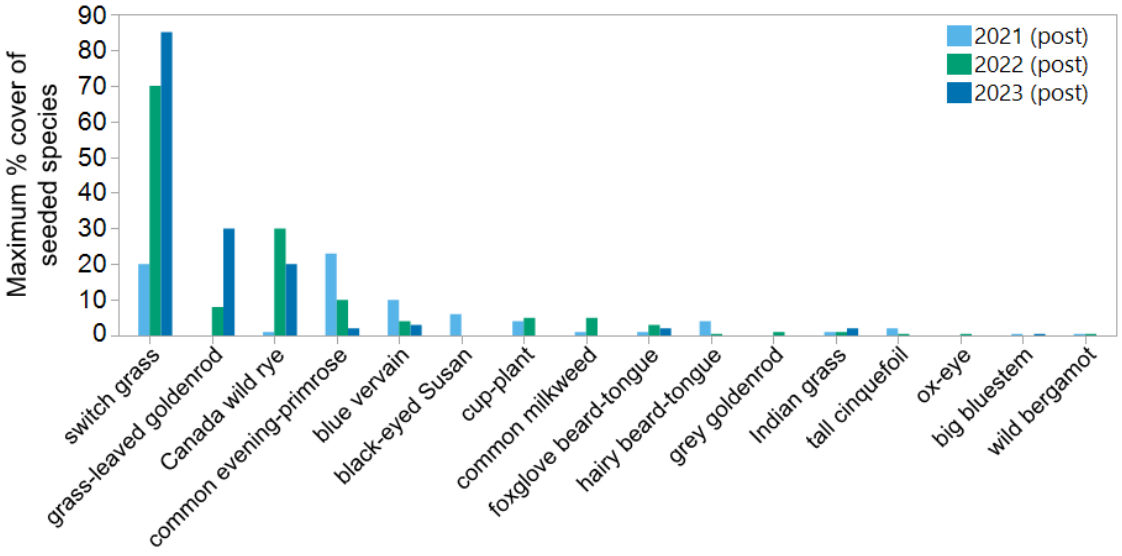

Figure 18. Maximum percent cover of seeded species that germinated in plot U between 2021 and 2023. None of the seeded species were observed in 2018 (prior to seeding).

Section 3

Sections 3.2 and 3.3 were monitored for the first time in 2020 (vegetation plots AA and AB) and represent pre-management, turfgrass communities. Plots primarily contained meadow fescue (*Lolium pratense*) and Kentucky blue grass (*Poa pratensis* ssp. *pratensis*). No management activities occurred in this section in 2020 or 2021 and the plots were not monitored 2021-2023. Section 3.2 was unique for pre-restoration areas with several, naturally occurring native species including golden-fruited sedge (*Carex aurea*), blue-eyed grass (*Sisyrinchium montanum*), plantain-leaved pussytoes (*Antennaria parlenii* ssp. *fallax*), and Howell's pussytoes (*Antennaria howellii* ssp. *howellii*).

Section 4

Twelve vegetation plots have been monitored in section 4 since 2016 (plots A-L). The plots in this section provide the longest record of data collection within The Meadoway, similar to section 7, allowing us to evaluate success over a longer time period compared to more recently restored sections. In this section, we explored changes in percent cover of seeded species within sub-plots to examine establishment.

Section 4.1

Vegetation plots G and H were set up in 2016 in section 4.1. In 2020, only summer surveys were conducted so we compared percent cover from these summer visits for 2016 and 2018-2023. Invasive species management targeted DSV and thistle.

Cover of seeded species that germinated varied by year and by species (Figure 19). The cover of well-established species (e.g., black-eyed Susan, tall sunflower (*Helianthus giganteus*), wild bergamot (*Monarda fistulosa* var. *fistulosa*), and ox-eye) has been similar since 2021 although tall sunflower and ox-eye decreased slightly and wild bergamot increased.

Cover of DSV was low (0-6%) in all years in plots G and H. In plot G, average cover increased from 0.1% to 3.4% between 2016 and 2023. In plot H, average cover changed from 0.5% in 2016 to 2.4% in 2022 but back down to 1.3% by 2023. Cover of thistle was also generally low although did reach 13% in sub-plot 2 of G in 2019. The cover of thistle in plot G was the lowest in 2021 and 2022 and continues to be low in 2023 suggesting control efforts for thistle have been effective. Invasive species management started in 2018 in this section.

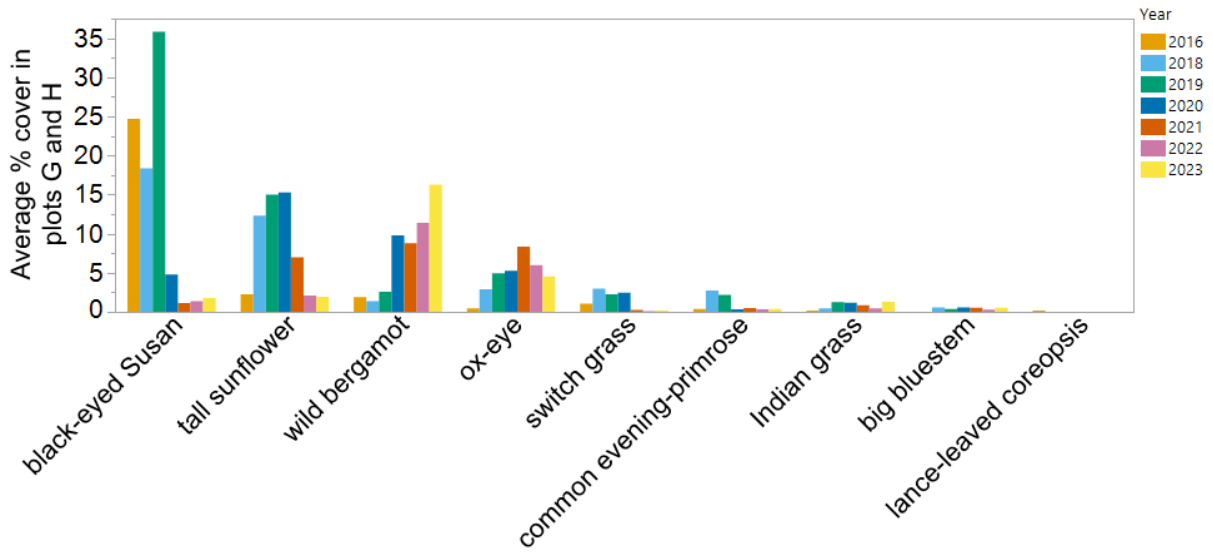

Figure 19. Average percent cover of seeded species that germinated in plots G and H between 2016 and 2023.

Section 4.2

Vegetation plots A, B and C were set up in 2016 in section 4.2. In 2016, only summer surveys were conducted so we compared percent cover from these summer visits for 2016, and 2018-2023. Invasive species management has targeted DSV and thistle since 2018.

Many species appear to be establishing well in section 4.2 including ox-eye, wild bergamot, common milkweed, Indian grass (*Sorghastrum nutans*), stiff goldenrod (*Solidago rigida* ssp. *rigida*), Virginia mountain-mint (*Pycnanthemum virginianum*), grey-headed coneflower (*Ratibida pinnata*), and butterfly milkweed (*Asclepias tuberosa* ssp. *interior*; Figure 20). Cover appears to be slightly lower in 2023 for several species although average cover for all species is generally lower in these plots (<8%).

The average percent cover of thistle steadily declined between 2016 (14%) and 2022 (1.9%) and is similar in 2023 (2.3%). In contrast, the average cover of DSV appears to be increasing slightly each year from 0.8% in 2016 to 7.3% in 2023.

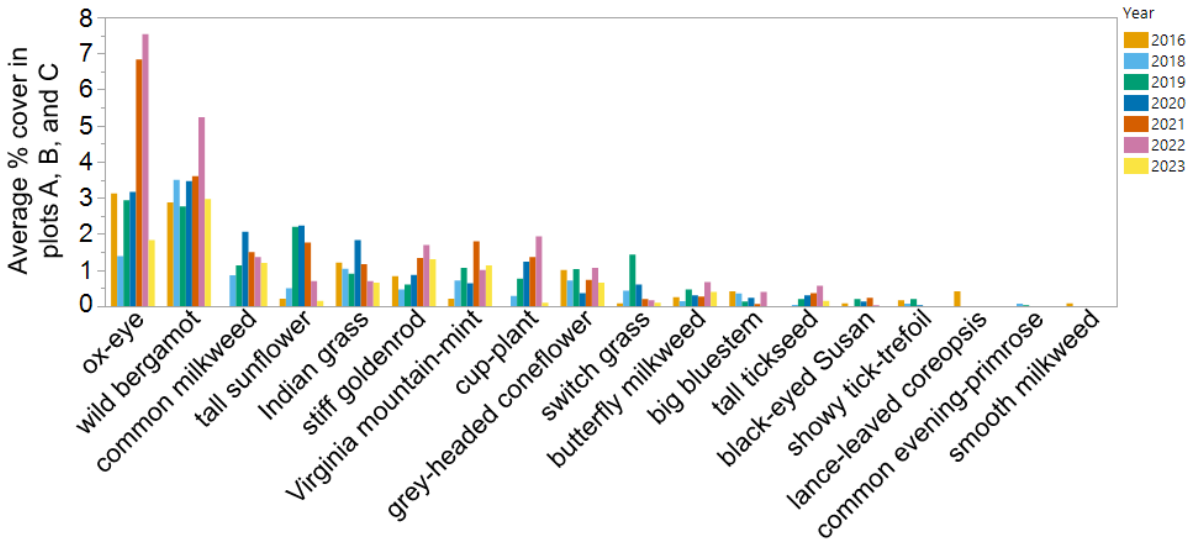

Figure 20. Average percent cover of seeded species that germinated in plots A, B, and C between 2016 and 2023.

Section 4.3

Vegetation plots D, E, and F were set up in 2016 in section 4.3. In 2016, only summer surveys were conducted so we compared percent cover from these summer visits for 2016, and 2018-2023. Invasive species management has targeted DSV and thistle since 2018.

Big bluestem and wild bergamot appear to be establishing well with higher percent covers although many species appear to be showing decreasing trends in cover (Figure 21). Indian grass, cup-plant (*Silphium perfoliatum* var. *perfoliatum*), butterfly milkweed, and stiff goldenrod increased in cover between 2022 and 2023.

Average thistle cover was 6% in 2016 and 1.4% in 2023. While a drastic reduction in cover occurred since management began, sub-plot 3 of plot D had higher covers of 15% in 2022 and 12 % in 2023. The average cover of DSV was 2.1% in 2023 across all sub-plots; however, DSV cover continues to increase in sub-plot 2 in plot D (20% in 2023).

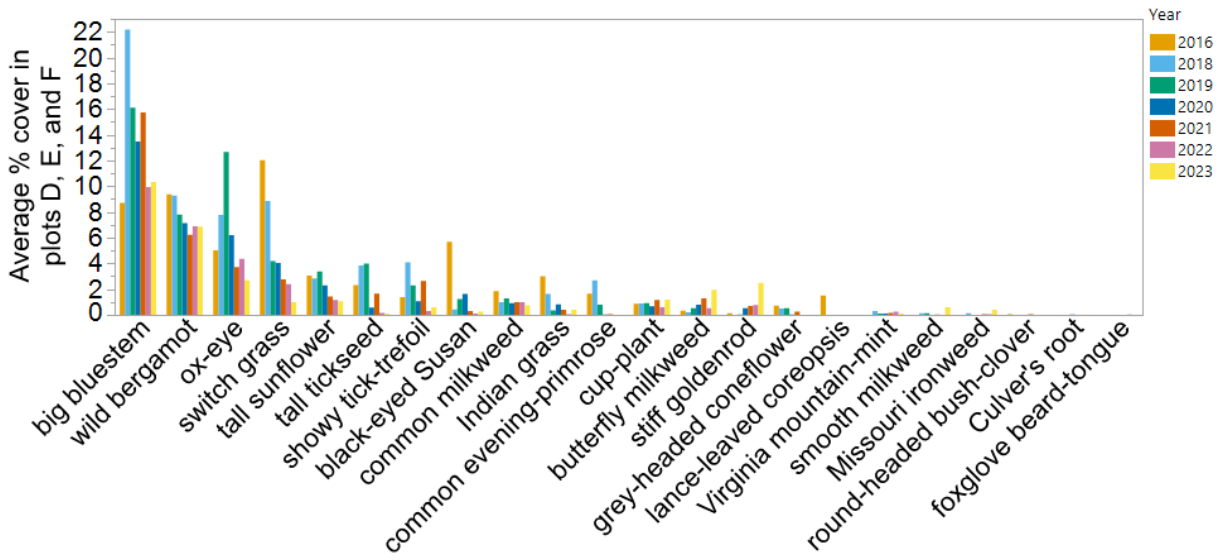

Figure 21. Average percent cover of seeded species that germinated in plots D, E, and F between 2016 and 2023.

In the spring of 2021, a portion of section 4.3 was burned due to an unknown cause. In natural tallgrass prairie ecosystems, fires occur intermittently and are an important process as part of a positive feedback system (Packard and Mutel 2005). Prairie grasses provide excellent fuel for fire, and the fire in turn, stimulates the growth of the prairie grasses. Prairie ecosystems respond differently to fire, grazing, and mowing with both fire and grazing occurring in more natural ecosystems while mowing may be considered more suitable in urban areas such as The Meadoway. Burning often causes short-term changes in soils including increased soil temperature and decreased soil moisture (Ojima et al. 1994). Annual burning can stimulate root growth and both burning and mowing tend to favour C4 grasses while decreasing cover of woody species and forbs (Gibson et al. 1993, Johnson and Matchett 2001).

In June 2021, we set up one new plot (consisting of five sub-plots) in the burned area and one in an adjacent unburned area to examine variation in species composition (% native species), the number of woody stems, and % cover. We monitored vegetation in these plots in 2021, 2022, and 2023.

There were six woody stems in the unburned plots compared to only two stems in the burned plots in 2021 (Figure 22). In 2022, there were 12 woody stems in the unburned plots and 4 stems in the burned plots. By 2023, there were 9 woody stems in the unburned plots and only 1 woody stem in the burned plots.

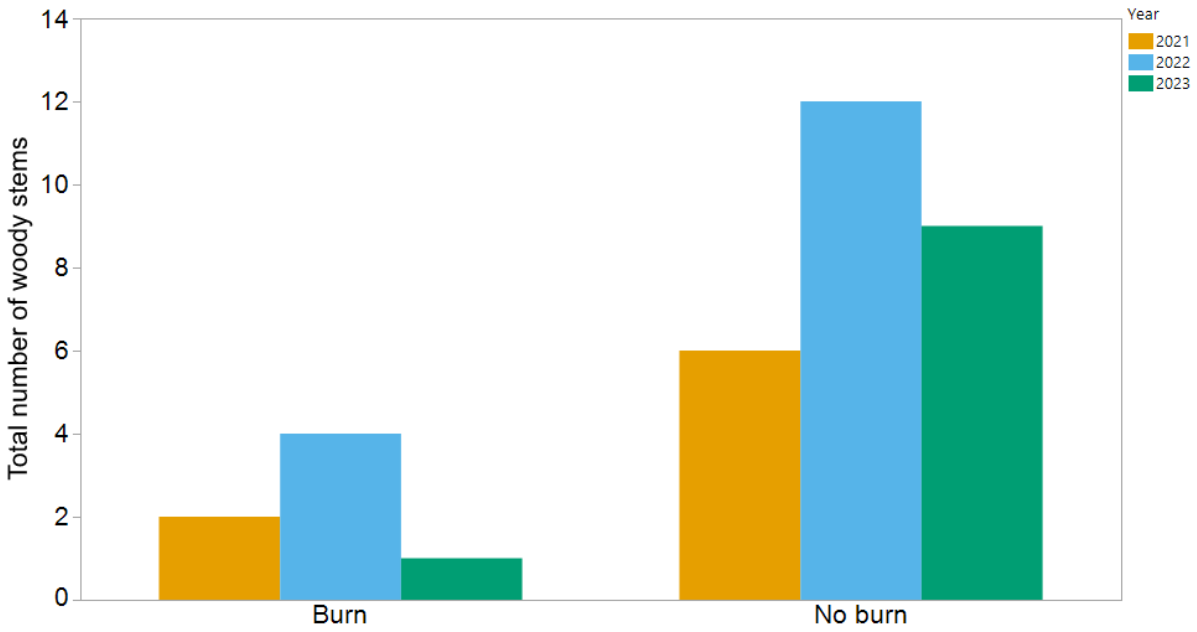

Figure 22. Total number of woody stems in burned and unburned plots between 2021 and 2023.

The average percent cover of grasses was highest during the summer visit and during 2021 and 2023 (Figure 23). The burned and unburned sub-plots did not show any clear variation in grass cover but the burned areas may have a consistently higher cover of forbs.

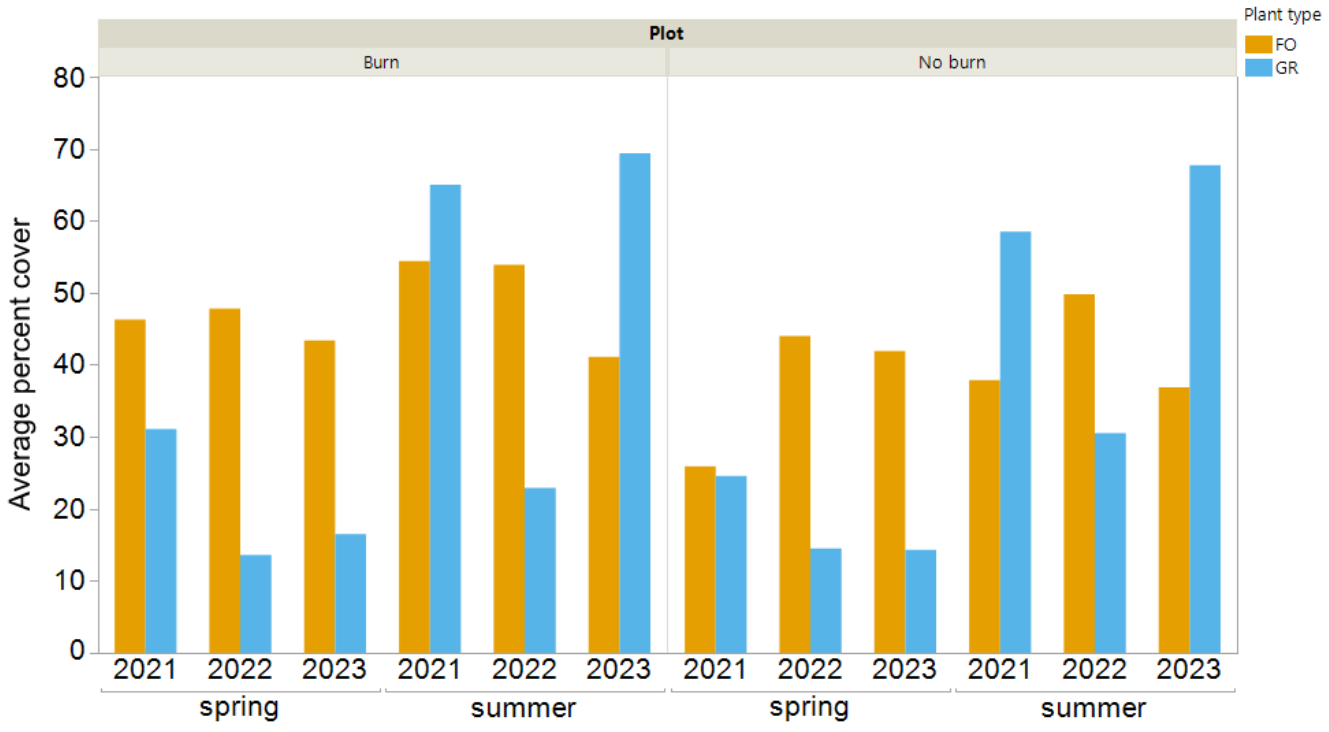

Figure 23. Average percent cover of forb (FO) and grass (GR) plant types in burned and unburned sub-plots by season and year.

The burned sub-plots contained more species in general compared to the unburned sub-plots; however, more than one half of these species were exotic (Table 2). In the burned plot, the number of exotic species was high in 2021 (early post-disturbance) but has decreased over time. The unburned plot contained fewer species overall, but often contained more native species than exotic species. It is possible that the burning disturbance led to the immigration of more exotic (and other) species compared to the unburned plot but without pre-burn data it is difficult to determine if these differences are a result of burning or pre-existing conditions.

Table 2. The total number of flora species, native species, and exotic species in burned and unburned plots between 2021 and 2023.

Plot type	Year	Number of species		
		Total	Native	Exotic
Burn	2021	42	16	26
	2022	37	18	19
	2023	33	15	18
No burn	2021	28	14	14
	2022	20	11	9
	2023	21	14	7

Section 4.4

Vegetation plots J, K, and L were set up in 2016 in section 4.4. In 2016, only summer surveys were conducted so we compared percent cover from these summer visits for 2016, and 2018-2020, and 2022-2023. Active management was occurring in plot J in 2021 so we used only K and L for the analysis.

In plots and K and L, several of the seeded species occurred in each year but cover varied (Figure 24). Most species had similar, or higher, percent covers in 2023 compared to 2022. The average cover of thistle was 1.6% in 2016 and 4.4% in 2023 across plots K and L. Two sub-plots had higher covers of thistle including sub-plot 5 in plot K at 22% and sub-plot 1 in plot L at 11%. Average cover of DSV was relatively low in this section with an average cover of 0.2% in 2016 and 1% in 2023.

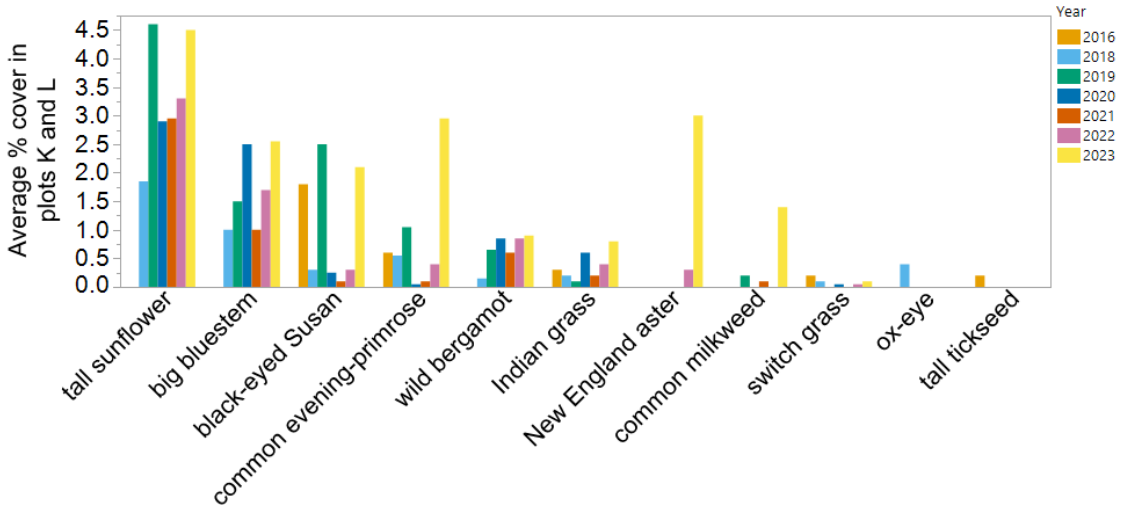

Figure 24. Average percent cover of seeded species that germinated in plots K and L between 2016 and 2023

Section 5: Pre- and post-restoration comparisons

Section 5.3

Plot AD was monitored both pre- (2020) and post-restoration (2023) in section 5.3. This area was turfgrass in 2020 and were seeded in 2022 (June, November, December) and in April 2023. Additional heath aster, common evening-primrose, and little bluestem (*Schizachyrium scoparium* var. *scoparium*) were seeded as well. In 2020 (pre-restoration), the plot primarily consisted of tall fescue (*Lolium arundinaceum*), red fescue (*Festuca rubra* ssp. *rubra*), yellow hawkweed (*Pilosella caespitosa*), Kentucky bluegrass, and dandelion (*Taraxacum officianale*). In 2023 (post-restoration), the plot contained 15 seeded species including higher covers of common evening-primrose, black-eyed Susan, and ox-eye (Figure 25).

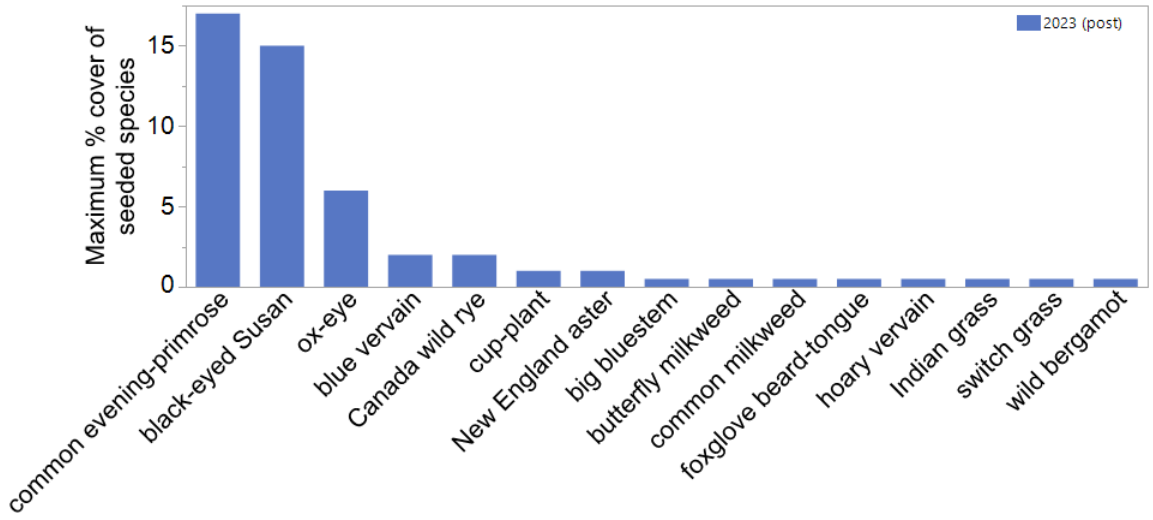

Figure 25. Maximum percent cover of seeded species that germinated in plot AD between 2020 and 2023. None of the seeded species were observed in 2020 (prior to seeding)

Section 5.4

Plot AE was monitored both pre- (2020) and post-restoration (2023) in section 5.4. This area was turfgrass in 2020 and was seeded in November/December 2022. In 2020 (pre-restoration), the plot primarily consisted of tall fescue, Kentucky bluegrass, and dandelion. In 2023 (post-restoration), the plot contained 10 seeded species including higher cover of black-eyed Susan (Figure 26).

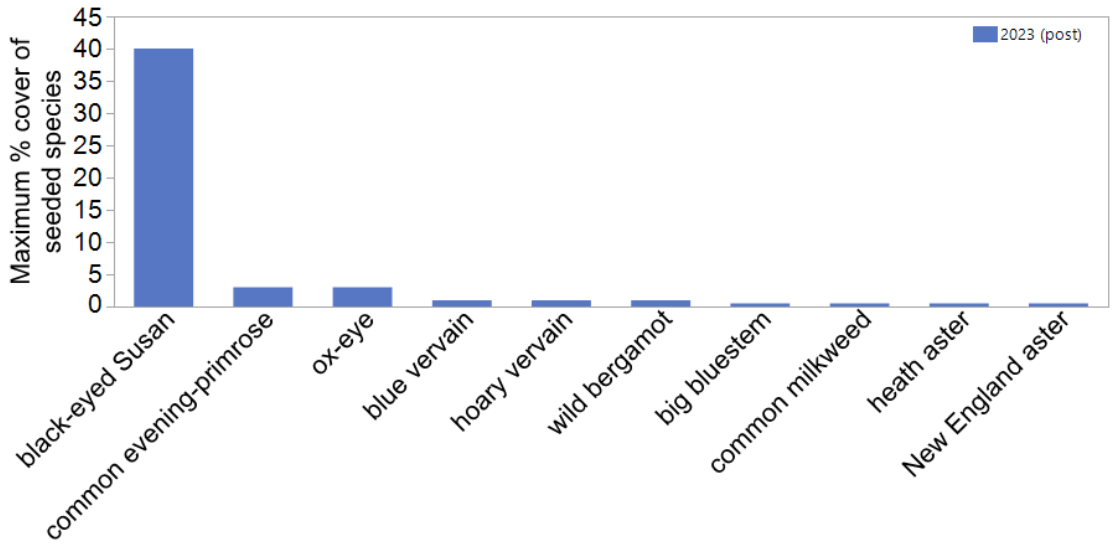

Figure 26. Maximum percent cover of seeded species that germinated in plot AE between 2020 and 2023. None of the seeded species were observed in 2020 (prior to seeding).

Section 6

No monitoring has occurred in section 6 since plots were established in 2020 (AF, AG, and AH). In 2020, the plots represented pre-management, turfgrass communities and were not monitored in 2021-2023 since restoration work had not yet started. Similar to the results for other pre-management sections, the plots primarily contained meadow fescue, Kentucky bluegrass, red fescue, and orchard grass (*Dactylis glomerata*).

Section 7

We set up three vegetation plots in section 7.1 in 2016 (M, N, and O). Plots M, N, and O were seeded pre-2016 and again in May/June 2021, then plot M was seeded again in 2022 (Figure 27).

Due to the dry, sandy conditions present in section 7 (and particularly near plot N), Indian grass proved to be the most successful seeded species. Several native species that were not present in the seed mixes are establishing well including hairy panic grass (*Dichanthelium implicatum*), golden-fruited sedge (*Carex aurea*), and blue-eyed grass (*Sisyrinchium montanum*).

Percent cover of seeded species that germinated varied by species and year with most species establishing well and several species increasing in cover including Indian grass, switch grass, ox-eye, and black-eyed Susan (Figure 28). Thistle cover was relatively low in this section in recent years only occurring in one sub-plot in 2021 and 2022, and two sub-plots in 2023 with a cover of 2% or less. Average DSV cover was low (<2.5%) in all years although some sub-plots reached covers of up to 15% in 2023. Different sub-plots displayed different patterns among years but between 2022 and 2023, the majority of sub-plots decreased in cover. Spotted knapweed (*Centaurea stoebe* ssp. *micranthos*) was also targeted for invasive species management in this section. Management actions appear to be successful since spotted knapweed cover peaked during the summers of 2018-2021 (up to 8% cover in plots) but then was lower in 2022 (1%) and only found in the spring by 2023 and with very low cover (1%).

Figure 27. Plot N in section 7.1 showing pre-restoration in 2016 (left) and post-restoration in 2023 (right) showing Indian grass.

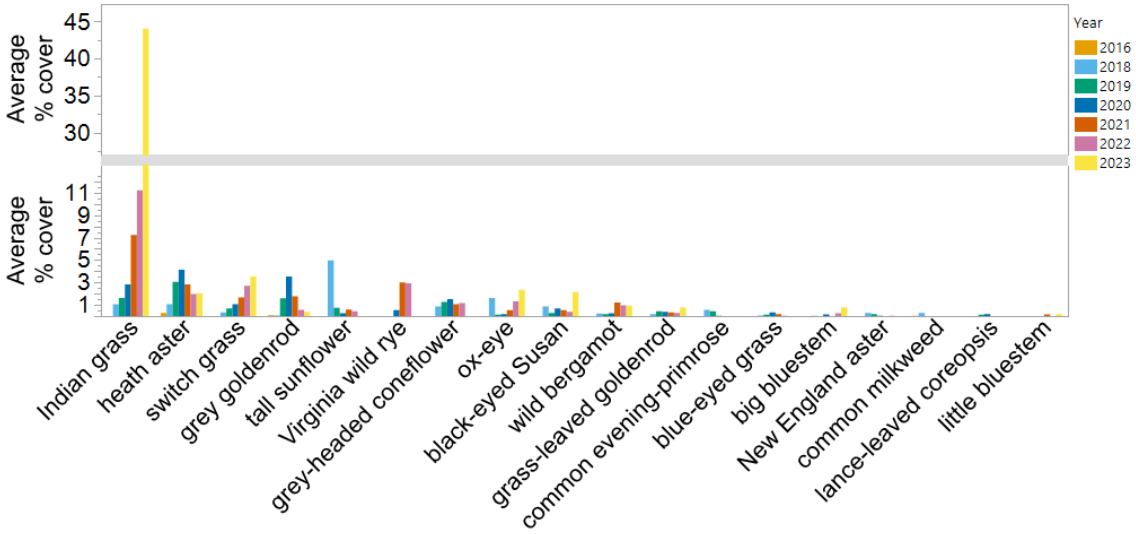

Figure 28. Average percent cover of seeded species that germinated in plots M, N, and O between 2018 and 2023.

Xerces experimental plots

In 2022, an experimental site preparation trial plot was set up in section 5.3. The broad goal of the study was to determine how a unique site preparation technique (termed the Xerces technique) affects seeding success in The Meadoway. The Xerces site preparation method included performing a deep plow, flipping the soil, followed by a light discing, and seeding in mid-June 2022. Common evening-primrose seed was also added in fall/winter 2022. Additionally, no spraying with glyphosate occurs in the Xerces method. This leads to less disturbance to the seed bed, the soil is less compact, and there is no use of glyphosate. This contrasts with the currently used site preparation method that involves more thorough rototilling in multiple rounds and spraying of glyphosate. By conducting this study, we would like to understand how the percent cover of native species and stem count of species from the seed mix varies between the Xerces method and the current method.

For this assessment, the most effective method was defined as the one that maximized both the percent cover of native species and total stem count of species from the seed mix.

In August 2023, 10 plots (1m x 1m) were monitored that were treated with the Xerces method and 4 plots (1m x 1m) were monitored that were treated with the current method. While we aimed for consistency of all factors other than the site preparation method, there were several differences between the Xerces method plots and the current method plots including using different seed mixes, different timing of seeding, and different treatments for invasives. These differences should be considered when interpreting results.

The percent cover of native and exotic species varied among plots treated with the Xerces method and those treated with the current method (Figures 29 and 30). Plots treated with the Xerces method had on average 54% cover of native species while plots treated with the current method had on average 49% cover of native species. Plots treated with the Xerces method had on average 48% cover of exotic species while plots treated with the current method had 27% cover of exotic species. It is important to note that there was more variation in percent cover among the Xerces method plots (standard deviation = 42%) compared to the current method plots (standard deviation = 26%). This means that while on average the Xerces plots had a slightly higher percent cover of native species and a higher cover of exotic species, some plots had considerably higher cover than average, while others had considerably lower cover than average. Stem counts of seeded species appeared to be higher in the current method plots (average stem count = 47) compared to the Xerces method plots (average stem count = 12; Figure 31). Stem counts were more consistent among plots within each method (Xerces or current) compared to the variation in percent cover of native species.

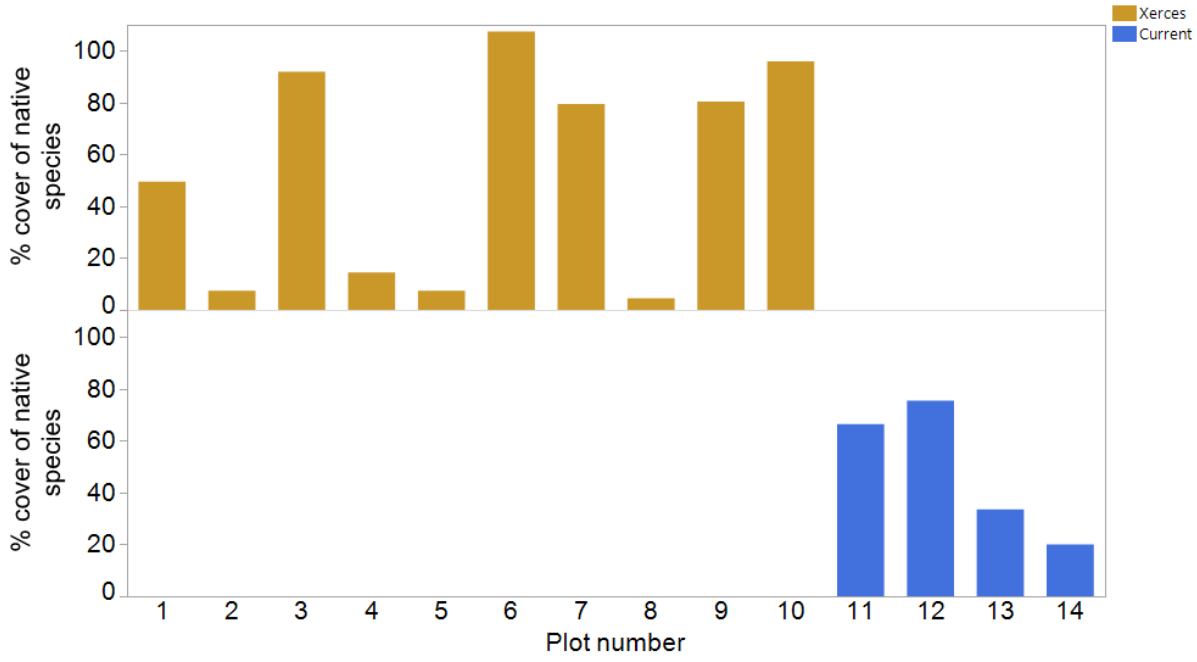

Figure 29. Total percent cover of native plant species in plots treated with the Xerces method or the current method.

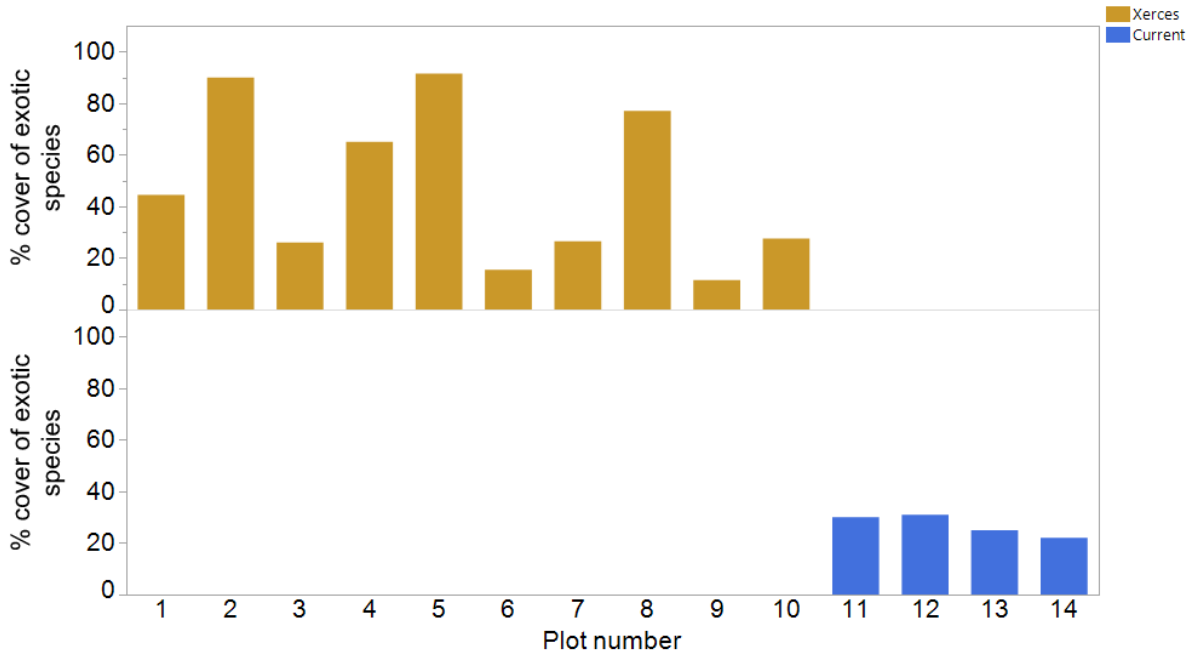

Figure 30. Total percent cover of exotic plant species in plots treated with the Xerces method or the current method.

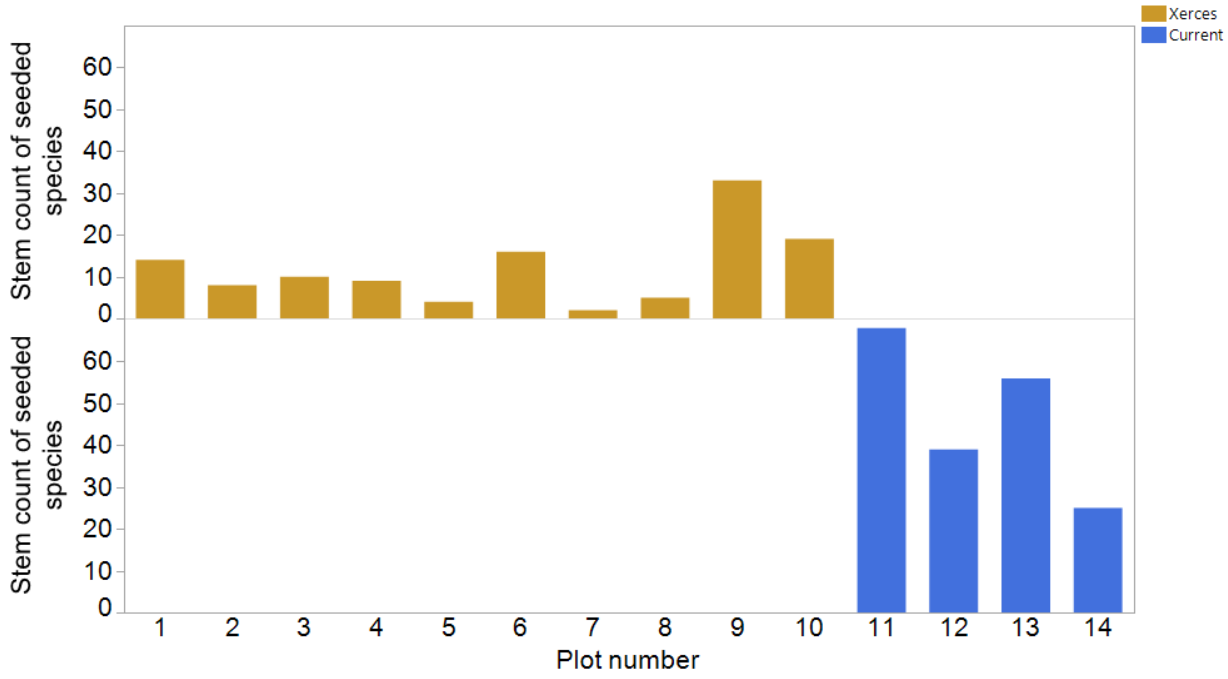

Figure 31. Total stem count of seeded species in plots treated with the Xerces method or the current method.

Breeding Bird surveys

Bird surveys have been conducted in The Meadoway since 2016 (Table 1). Sections 4 and 7 (all post-restoration), have the longest record of data (seven years). In sections 1.2, 1.4, 2.4, and 5.3 there are pre- and post-restoration data for comparisons. No new bird stations were added in 2023.

Forty-four breeding bird species were detected during surveys between 2016 and 2023 (Appendix 1). These included three species of conservation concern in the Toronto Region (ranked L3): Eastern Meadowlark (*Sturnella magna*), Wild Turkey (*Meleagris gallopavo*), and Least Flycatcher (*Empidonax minimus*). Eastern Meadowlark is a meadow-dependent species and a species-at-risk, while the other three species are forest-edge species that use various shrubs and other successional or forest habitats for nesting. There were four additional meadow-dependent species detected during surveys including Savannah Sparrow (*Passerculus sandwichensis*), Willow Flycatcher (*Empidonax traillii*), Field Sparrow (*Spizella pusilla*), and Eastern Kingbird (*Tyrannus tyrannus*). Red-winged Blackbird (*Agelaius phoeniceus*), Song Sparrow (*Melospiza melodia*), and American Robin (*Turdus migratorius*) were the most frequently occurring and most abundant species detected during surveys. Several Warbling Vireos (*Vireo gilvus*) were observed in 2023, a species that feeds mainly on caterpillars, moths, and butterflies (Figure 32).

Figure 32. Warbling Vireo (*Vireo gilvus*).

Sections 4 and 7

We compared bird communities in sections 4 and 7 using ordination (Nonmetric Multidimensional Scaling – NMS, R Core Team 2021). This method provides a comparison of bird communities over time. Earlier restoration years had several species not in the later time period including Savannah Sparrow (SAVS), Eastern Meadowlark (EAME), Northern Mockingbird (*Mimus polyglottos*; NOMO), Northern Flicker (*Colaptes auratus*; NOFL), and Cedar Waxwing (*Bombycilla cedrorum*; CEDW; Figure 33). Later years post-restoration had several species not found in earlier years or found in a higher abundance including American Redstart (AMRE), Orchard Oriole (*Icterus spurius*; OROR), Cooper's Hawk (*Accipiter cooperii*; COHA), Rose-breasted Grosbeak (*Pheucticus ludovicianus*; RBGR), Field Sparrow (FISP), and Least Flycatcher (LEFL), Warbling Vireo (WAVI), along with two non-native species that are more related to urban areas, House Sparrow (*Passer domesticus*; HOSP) and House Finch (*Haemorhous mexicanus*; HOFI).

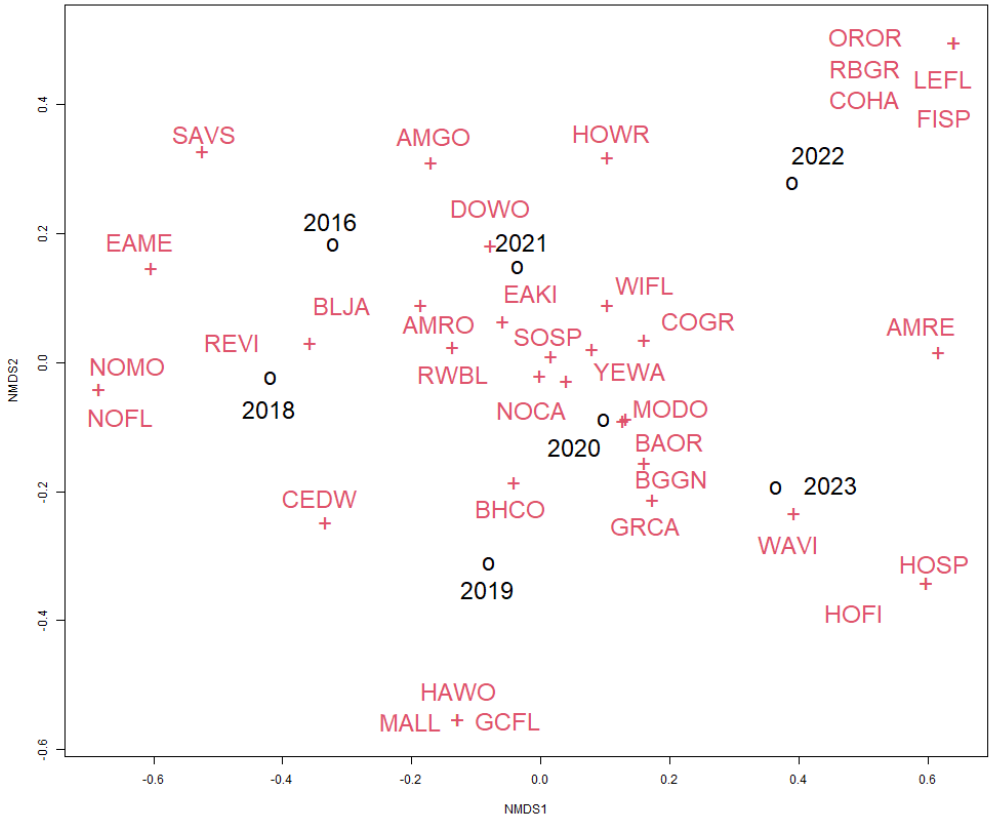

Figure 33. An ordination of bird community composition in sections 4 and 7 between 2016 and 2023 (earlier and later post-restoration). The location of species codes represents their relationship with specific years (e.g., if a species name is located near a year point, that species was found in higher abundance during that year). Species found in the centre of the plot often were found in multiple years (e.g. AMRO – American Robin, or RWBL – Red-winged Blackbird)

Pre- and post-restoration bird communities

We compared pre- and post-restoration bird communities in sections 1.2 (station 8), 1.4 (station 6), 2.4 (station 7), and 5.3 (station 10) since both pre- and post-restoration data were available. The years considered pre- or post-restoration varied among sections (Table 3). Since a different number of surveys occurred pre- versus post-restoration, we used an average species abundance to compare communities.

Table 3. Pre- and post-restoration years for bird surveys by section in The Meadoway.

Section	Bird survey station #	Pre-restoration years	Post-restoration year
1.2	8	2020	2021, 2022
1.4	6	2018, 2019, 2021	2022
2.4	7	2018, 2019	2021, 2022
5.3	10	2020	2023

Red-winged Blackbird and Song Sparrow appeared to benefit the most from meadow restoration in sections 1.2, 1.4, 2.4, and 5.3. The abundance of both Red-winged Blackbird (t_{11}=1.97, p=0.08) and Song Sparrow (t_{11}=3.24, p<0.01) increased post-restoration (Figure 34).

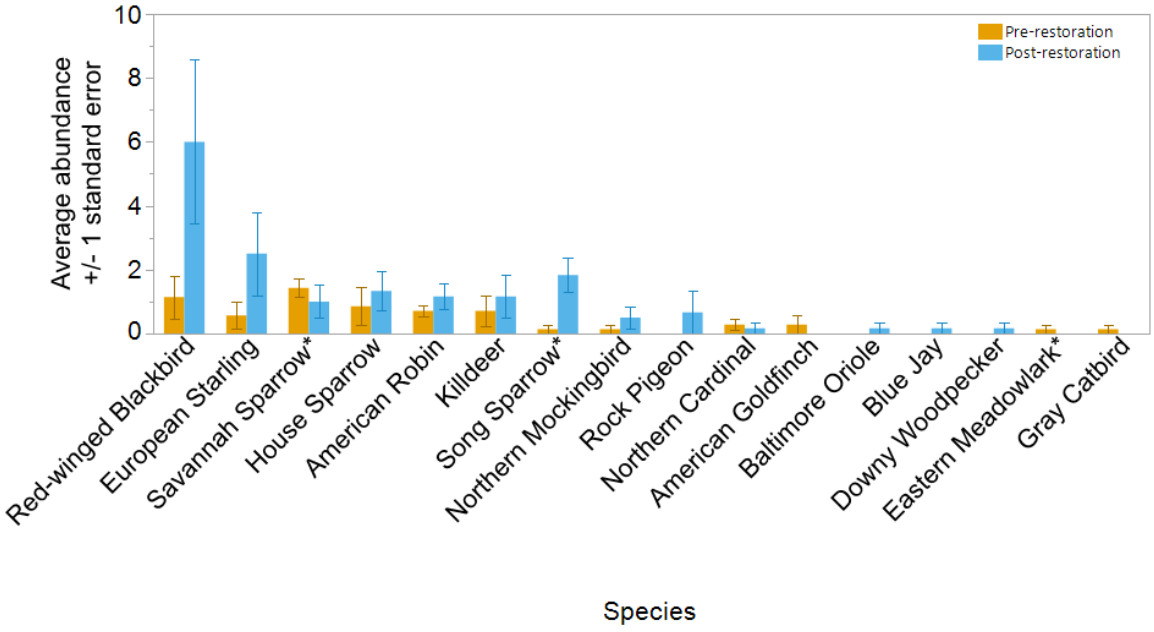

Figure 34. Temporal changes in bird species composition and abundance in sections 1.2, 1.4, 2.4, and 5.3 (stations 8, 6, 7, and 10) pre- and post-restoration. An asterisk (*) indicates a meadow-dependent species. Average and 1 standard error is shown.

Butterfly surveys

Forty-five butterfly species were observed during surveys between 2016 and 2023 (Appendix 2). Of these 45 species, the Acadian Hairstreak (*Satyrium acadica*), Giant Swallowtail (*Papilio cresphontes*), Delaware Skipper (*Anatrytone logan*), Silver-spotted Skipper (*Epargyreus clarus*), Pearl Crescent (*Phyciodes tharos*), and Wild Indigo Duskywing (*Erynnis baptisiae*) are ranked at the provincial level as S4 species. Species with an S4 rank are not rare species, but are uncommon, and there is some cause for long-term concern due to population declines or other factors (Nature Serve 2018). Monarch (*Danaus plexippus*) were also found using The Meadoway in very high numbers although numbers varied from year-to-year. For example, 280 monarchs were counted using section 4.3 (between Bellamy Road North and Markham Road) in 2019; however, only 14 were recorded in 2023.

Sections 4 and 7

We compared butterfly communities in sections 4 and 7 using regressions of year and count by species. We grouped Pearl Crescent, Northern Crescent (*Phyciodes cocyta*), and Crescent spp. (*Phyciodes* spp.) into one group (Crescent spp.), American Lady (*Vanessa virginiensis*), Painted Lady (*Vanessa cardui*), and Lady spp. (*Vanessa* spp.) into one group (Lady spp.), and Spring Azure (*Celastrina lucia*), Summer Azure (*Celastrina neglecta*), and Azure spp. (*Celastrina* spp.) in one group (Azure spp.).

Most species or species groups had non-significant trends over time; however, both Black Swallowtail (*Papilio polyxenes*) and Silvery Blue (*Glaucopsyche lygdamus*) decreased in abundance between 2016 and 2023 ($p<0.08$). European Common Blue (*Polymmatus icarus*) increased in abundance ($p<0.01$; Figure 35).

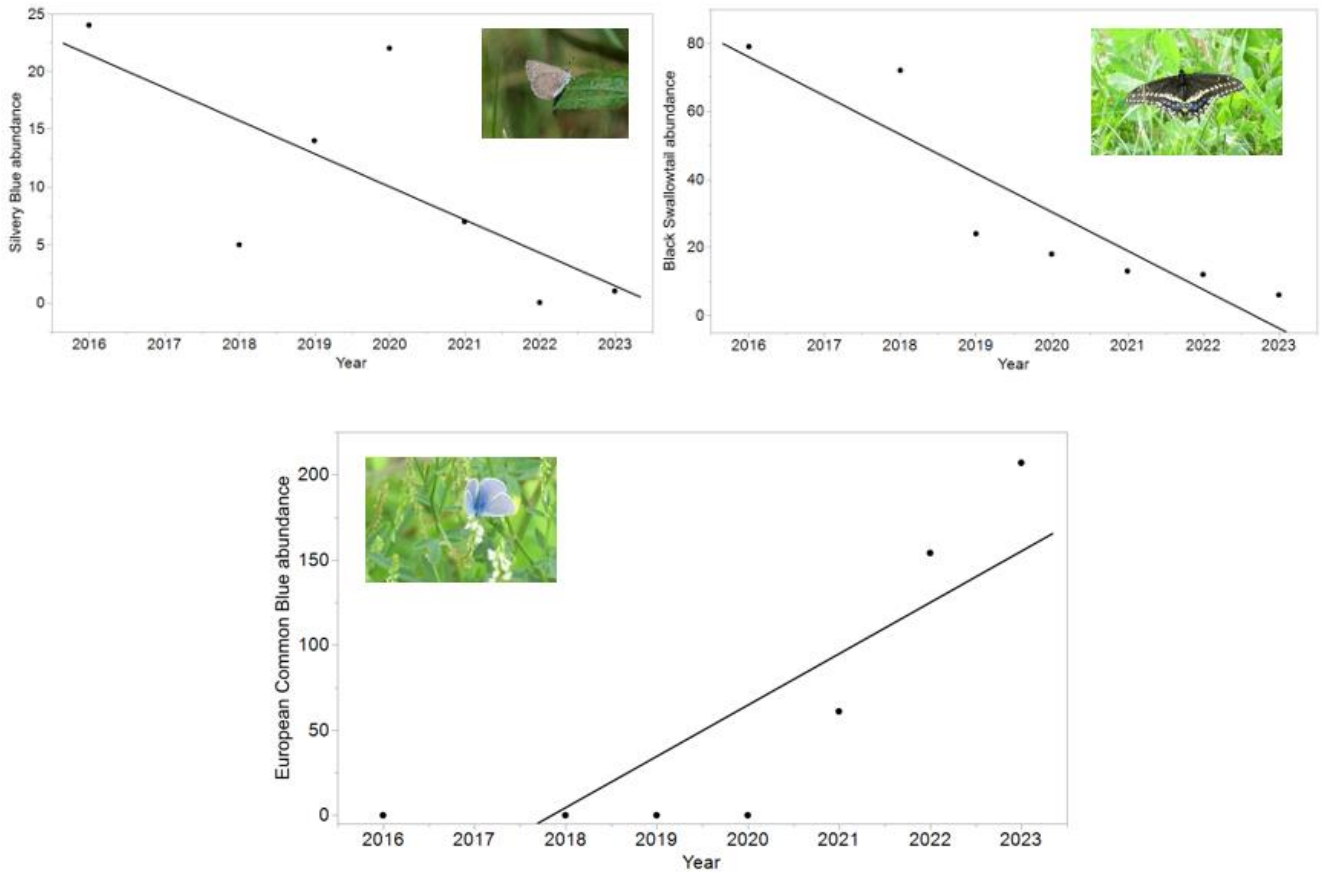

Figure 35. Significant temporal trends ($p<0.10$) for butterfly species in sections 4 and 7 and between 2016 and 2023.

In addition to sections 4 and 7, European Common Blue has been increasing in abundance across The Meadoway since 2020 (Figure 36). It is a non-native species discovered in North America first in 2007 near Montreal and has since spread both to the east and west of Montreal being observed in Ontario for the first time in 2017.

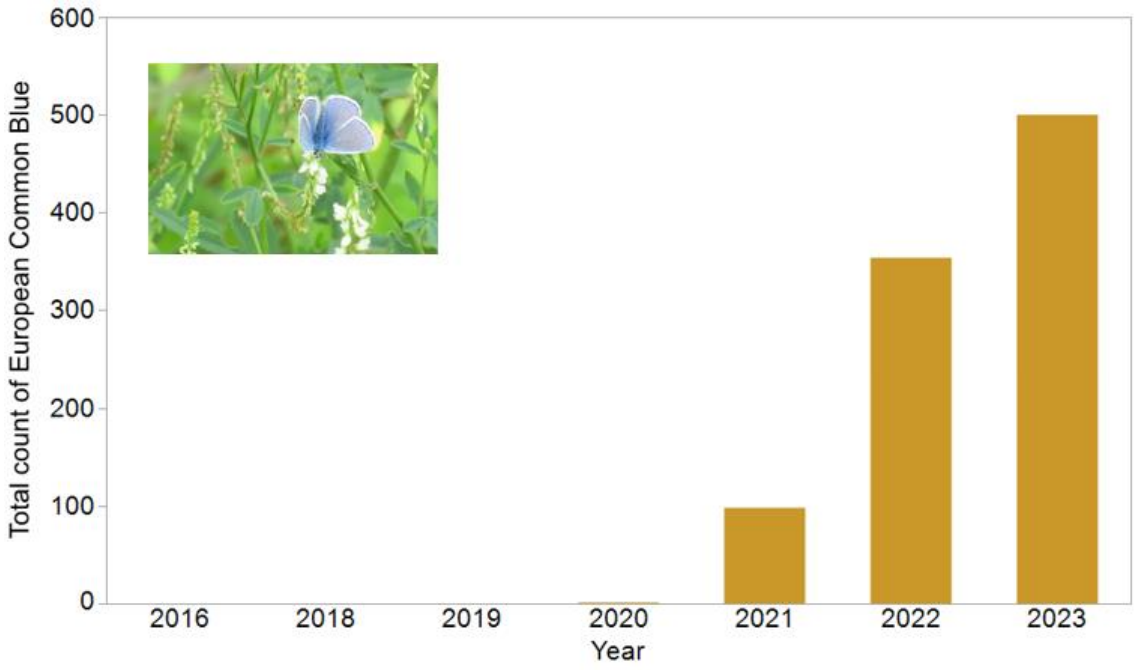

Figure 36. Total count of European Common Blue across The Meadoway since 2016.

Sections 1 and 2

Sections 1.4 (transect 1J) and 2.4 (transect 2K) were monitored both pre-restoration (2019) and post-restoration (2021-2023). Butterfly communities appeared to have changed between 2019 and 2021-2023 by increasing in either species richness or abundance of specific species (Figures 37 and 38). In section 1, only 8 species were present pre-restoration (2019), and post-restoration in 2022, 8 species were also present, but by 2023, 14 species were observed. Species only present post-restoration included Blue species, Common Wood-Nymph (*Cercyonis pegala*), European Common Blue, Pearl Crescent, Peck's Skipper (*Polites peckius*), and Silvery Blue. Acadian Hairstreak (*Satyrium acadica*) was found for the first time in 2023 in the west end of section 1.2. Pre-restoration in section 2, only 6 species were present, while post-restoration species richness was higher (2021 – 10 species, 2022 – 10 species, 2023 – 11 species). New species found post-restoration include European Common Blue which has been increasing in other areas of The Meadoway, but also four resident species including Eastern Tailed Blue (*Cupido comyntas*), European Skipper (*Thymelicus lineola*), Peck's Skipper, and Silvery Blue.

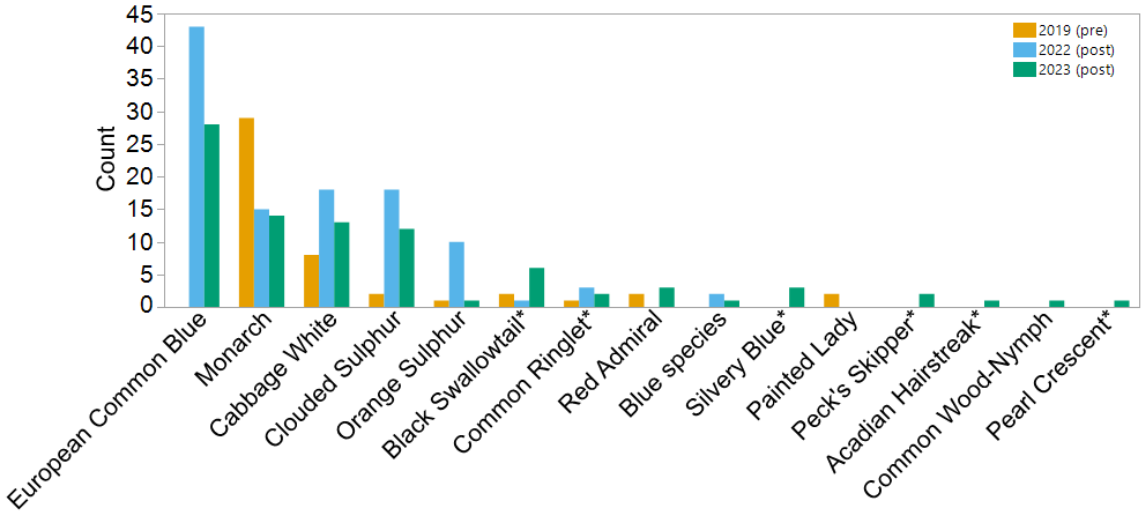

Figure 37. Temporal changes in butterfly species composition and abundance on transect 1J in section 1.4 pre- and post-restoration. An asterisk (*) indicates a resident species.

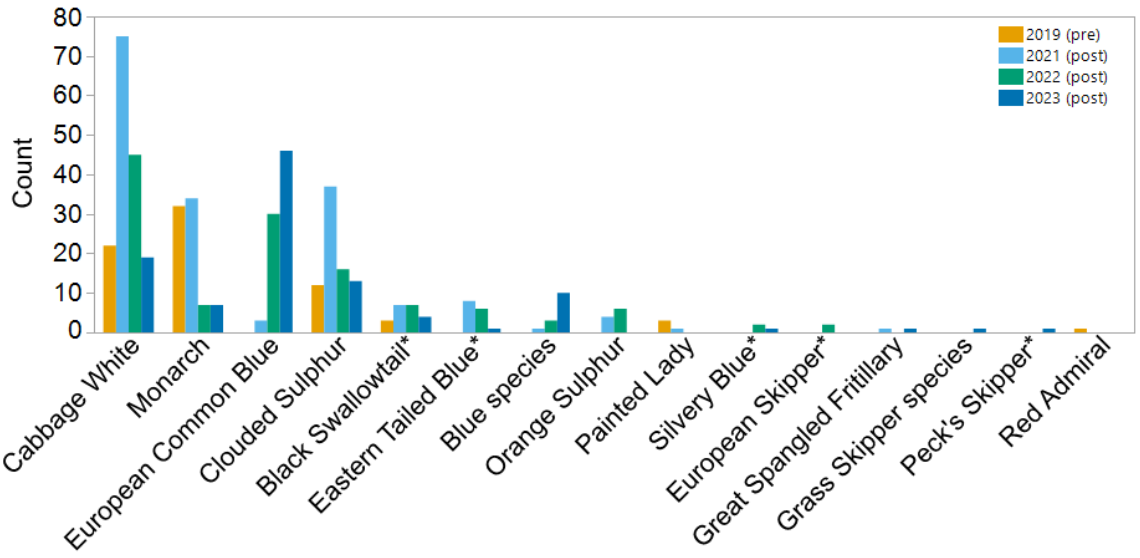

Figure 38. Temporal changes in butterfly species composition and abundance on transect 2K in section 2.4 pre- and post-restoration. An asterisk (*) indicates a resident species.

Section 5

Sections 5.3 (transects E and F) and 5.4 (transect G) were monitored both pre-restoration in 2020 and post-restoration in 2023. Butterfly species richness was similar both pre- and post-restoration with higher abundance of both European Common Blue and Cabbage White (*Pieris rapae*) post-restoration (Figure 39). New species only found post-restoration include European Common Blue, Little Wood Satyr (*Megisto cymela*), and Painted Lady (*Vanessa cardui*).

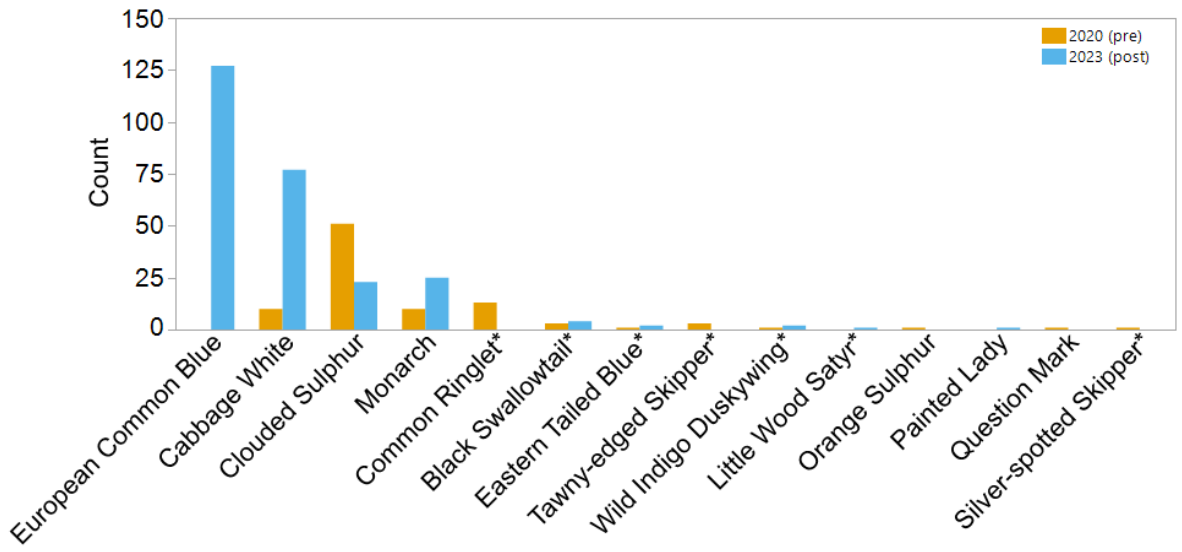

Figure 39. Temporal changes in butterfly species composition and abundance on transects E, F, and G in sections 5.3 and 5.4 pre- and post-restoration. An asterisk (*) indicates a resident species.

SUMMARY

Meadow monitoring during 2016, and 2018-2023 generally indicated that restoration work in The Meadoway has successfully introduced a variety of meadow flora through seeding, provides habitat used by breeding birds, and foraging opportunities for butterflies. A wide range of species were found during monitoring including numerous rare and sensitive species and species of conservation concern. In addition to these sensitive species, invasive flora species are persisting in The Meadoway although recent management initiatives have been successful at reducing their extent.

Pre- and post-restoration comparisons in sections 1 and 2 continue to show drastic changes in vegetation communities, and new pre- and post-restoration data from section 5 have also shown major changes. Pre-restoration communities were dominated by meadow fescue, dandelion, and red clover (*Trifolium pratense*). Post-restoration communities contained many seeded species with covers of up to 85% for some species. Butterfly communities appeared to respond to these changes with higher species richness post-restoration including species likely using the seeded species as host plants. Some changes could also be due to broader changes in butterfly populations including the large increase in European Common Blue which occurred across The Meadoway. Bird communities did not appear to respond as strongly to changes although both Red-winged

Blackbird and Song Sparrow increased in abundance post-restoration and this may be due to changes in vegetation structure.

After seven years of monitoring, several patterns emerged related to the longer term success of restoration efforts. Sections with the longest record of restoration and monitoring indicated that many of the seeded species were establishing populations although again, there was variation among sections and species. In general, multiple seeded species have increased in cover and remained high into 2023 including wild bergamot, ox-eye, common milkweed, stiff goldenrod, cup-plant, big bluestem, tall sunflower, and Indian grass.

Figure 40. Tall coreopsis (*Coreopsis tripteris*), wild bergamot (*Monarda fistulosa*) (left); New England aster (*Symphyotrichum novae-angliae*), panicled aster (*Symphyotrichum lanceolatum* var. *lanceolatum*), Canada wild rye (*Elymus canadensis* var. *canadensis*) (right).

Invasive species management has been effective throughout The Meadoway with most sub-plots showing decreases in cover of thistle and DSV. In the recently restored section 1, the change in cover of DSV was dramatic, decreasing from 90% in 2019 to 5% in 2023. Overall, current methods appear to be mostly effective for controlling thistle and DSV although cover appears to be increasing slowly in many sub-plots. Even with these small increases, without management, it is likely that DSV would quickly spread and outcompete other species.

The Xerces experimental plots trialed a new site preparation method that would help to limit both glyphosate application and disturbance to the seed bed. Monitoring plots treated with the Xerces method and the current method may help to provide insight into how site preparation affects the success of seeded species. Percent cover of native species was similar between the Xerces plots (54%) and the current method plots (49%); however, the cover of exotic species appeared to be higher in the Xerces plots (48%) compared to the current method plots (27%). Stem count was higher in the current method plots (average stem count = 47) compared to the Xerces method plots (average stem count = 12). While there appear to be differences in seeding success and exotic cover between treatments, variation in other factors between treatments (e.g., seed mix, seed timing) may have affected results and as such, these results should be interpreted cautiously.

Bird communities in The Meadoway consist of a mix of meadow, forest-edge, and early successional species along with several species that have adapted to urban environments. Several meadow-dependent species have been observed in multiple years including Eastern Kingbird, Willow Flycatcher, and Field Sparrow. Other meadow-dependent species such as Savannah Sparrow have been less abundant although their occurrence

largely depends on the section and availability of suitable nesting habitat. Song Sparrow, a generalist which often uses meadow habitat, has increased in abundance post-restoration in several sections. Point counts provide important information on habitat use and species occurrence, but the quality of the habitat for breeding birds is better reflected through nest success. A large proportion of meadow-dependent birds are ground-nesters and are often subject to higher levels of nest predation in urban meadows although nest success remains unknown in The Meadoway. The Meadoway also provides important foraging opportunities for birds as the restored areas attract and provide habitat for invertebrates and other species that might be consumed by birds nesting either in the corridor or in adjacent natural areas. For example, Cooper's Hawk has been found in more recent years and this could be related to an increasing population of small mammals. Although speculation about an increasing small mammal population requires further research, it correlates well with anecdotal observations by botanists of increased herbivory in The Meadoway. In addition to important breeding and foraging habitat, The Meadoway likely serves as an important stopover area for migratory birds.

Butterfly monitoring continues to detect species characteristic of meadows in more urbanized areas of southern Ontario. Monarch, Clouded Sulphur (*Colias philodice*), and Cabbage White remain the most abundant species in The Meadoway. European Common Blue (a non-native species first observed in 2020) has now been found in all sections of The Meadoway and increasing in abundance. The Meadoway also provides habitat for several relatively uncommon native resident species such as Acadian Hairstreak (first found in 2023), Delaware Skipper (*Anatrytone logan*), Pearl Crescent, Silver-spotted Skipper, and Wild Indigo Duskywing. In addition to resident species, The Meadoway continues to be used by numerous migratory butterfly species due to the abundant nectaring opportunities.

Pre- and post-restoration monitoring suggests that restoration increases the number of butterfly species and this could be related to both seeded species that are host plants and/or improved nectaring opportunities. Many resident butterfly species either only occurred post-restoration or increased in abundance post-restoration including Acadian Hairstreak, Eastern Tailed Blue, European Skipper, Silvery Blue, and Silver-spotted Skipper. This is important to consider since resident butterflies occupy an area year-round and are non-migratory. These pre- and post-restoration data suggest that restoration efforts are creating habitat for many butterfly species including resident species. Additional pre- and post-restoration data collected in future years for vegetation, birds, and butterflies should continue to provide evidence of the overall effectiveness of restoration efforts in The Meadoway.

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APPENDIX

Appendix 1. Bird occurrence in The Meadoway 2016, 2018-2023.

Species	L-Rank	Guild	Section 4.1							Section 4.2							Section 4.3							Section 4.4							Section 7.1							Section 1.4							Section 2.4							Section 1.2							
			Station 1							Station 2							Station 3							Station 4							Station 5							Station 6							Station 7							Station 8							
			2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023
American goldfinch	L5	generalist mid-level nester										1												1	3		3																																																					
American kestrel	L4	generalist upper-level nester																																																																	
American redstart	L3	forest-edge mid-level nester							1	1																																																									
American robin	L5	generalist mid-level nester			1	1	1		1	1	1		1	3	1	4	2	3	3			1	2	1	1	3	2			1	2	1	1		1		3		3	1	4	1			1	1			1	6			1	1		2	2	3					1			1
Baltimore oriole	L5	generalist upper-level nester	1		1		1	1	1	2			1	1	1		1				1			1	2								1															1																				
black-capped chickadee	L5	generalist mid-level nester																																																																	
blue jay	L5	generalist upper-level nester					1												1																																																	
blue-gray gnatcatcher	L4	forest upper-level nester					1																																																													
brown-headed cowbird	L5	special case	1					1		1																										3	1																														
cedar waxwing	L5	generalist mid-level nester				2								4										3				1			2													1																											
chipping sparrow	L5	generalist mid-level nester																																																								1								
common grackle	L5	generalist mid-level nester					1				1			1	3	4	7	2	1		1	2	2	2	1	1						1		3																	1																	2
Coopers hawk	L4	forest upper-level nester																								1																																									
downy woodpecker	L5	forest-edge mid-level nester															2	1		1			1											1																												1											
eastern kingbird	L4	meadow upper-level nester					2								1		1															1			2	2				1																																		
eastern meadowlark	L3	meadow low-level nester			1									1						2																																					1																	
European starling	L+	generalist mid-level nester			5	2	1	3		1			1			71	10	2	2				2	8	1	1			2	14		18		1			4	7		3	9	1			3				2	2				1			7									4
field sparrow	L4	meadow low-level nester																																									1																										
gray catbird	L4	generalist mid-level nester			1	2	1								1	1			1								1																	1	2																												
great crested flycatcher	L4	forest upper-level nester				1																																																														
hairy woodpecker	L4	forest upper-level nester				1																																																														
house finch	L+	generalist mid-level nester									1		1												1	3	1																		1															1								
house sparrow	L+	generalist mid-level nester	1		4			6		1	2		2	1									1	1		2	1	1			1			1	1														4	2	2						4								2		1	1
house wren	L5	generalist mid-level nester																								1	1																			1																											
killdeer	L5	generalist low-level nester																																																	2											4									3	1		
least flycatcher	L3	forest-edge upper-level nester																																									1																										
mallard	L5	wetland low-level nester				2																																																														
mourning dove	L5	generalist mid-level nester									1		1	2		1		1	1		1	1	1	1	3	9	2					1	1	3	1		1	1	2			2								1																	1
northern cardinal	L5	generalist mid-level nester	1		1	2	2	1	1							1	1	2	1	1			1									1				1	1				1	2		2				1																						
northern flicker	L4	generalist upper-level nester																																					1																														
northern mockingbird	L5	generalist mid-level nester																					1																																														1	2	1	
orchard oriole	L5	generalist upper-level nester																																									1																										
red-breasted nuthatch	L4	forest upper-level nester																																																																	
red-eyed vireo	L4	forest mid-level nester	1		1	1		1																																																												
red-tailed hawk	L5	generalist upper-level nester																																																																	
red-winged blackbird	L5	generalist mid-level nester	3		7	7	2	3	2	2	9		10	4	5	4	11	4	11		6	6	3	6	4	5	3		12	7	5	4	7	6	6			1	1	2	4	3						5	6	4				1		3	18	6					1	3	6	6
rock pigeon	L+	generalist mid-level nester																																																		4						4												
rose-breasted grosbeak	L4	forest-edge mid-level nester							1																																																											
savannah sparrow	L4	meadow low-level nester																									1																			1	2			2	2			2	2				1					2	3	1	
song sparrow	L5	generalist low-level nester	1		4	3	3	3	2	4	4		1	3	3	2	3	4	3		2	2	3	2	3	2	2		1	2	3	2	2	3	4		2	4	4	3	4	4							1	1						1	4	4					1	1	3	2
warbling vireo	L5	generalist upper-level nester					1			1				1			1																	1								1								1																
wild turkey	L3	forest-edge low-level nester																																																																	
willow flycatcher	L4	meadow mid-level nester													1	1	2									1												2		2	1	1	1																										
yellow warbler	L5	generalist mid-level nester	1		1	1	2	1	1					1	1	1	1	2	2															1		1		1	2	1	2	4	2																								

Appendix 1. (cont'd)

Species	L-Rank	Guild	Section 5.2 Station 9								Section 5.3 Station 10								Section 1.1 Station 11								Section 1.3 Station 12								Section 6.2 Station 13								Section 6.4 Station 14								Section 2.2 Station 15							
			2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023	2016	2017	2018	2019	2020	2021	2022	2023
American goldfinch	L5	generalist mid-level nester													2																									2																	
American kestrel	L4	generalist upper-level nester					1																																																	
American redstart	L3	forest-edge mid-level nester																																																					
American robin	L5	generalist mid-level nester					1			2								2						1	1	1						2	2	2						1	1					2							2	2
Baltimore oriole	L5	generalist upper-level nester																														1																					
black-capped chickadee	L5	generalist mid-level nester																															1																				
blue jay	L5	generalist upper-level nester																1							1																													
blue-gray gnatcatcher	L4	forest upper-level nester																																																				
brown-headed cowbird	L5	special case																																																				
cedar waxwing	L5	generalist mid-level nester																														1																					
chipping sparrow	L5	generalist mid-level nester																																																			
common grackle	L5	generalist mid-level nester																						1																														
Coopers hawk	L4	forest upper-level nester																																																			
downy woodpecker	L5	forest-edge mid-level nester																														1																					
eastern kingbird	L4	meadow upper-level nester																							1	1																												1
eastern meadowlark	L3	meadow low-level nester																																																		
European starling	L+	generalist mid-level nester																6														2	14																			1			7
field sparrow	L4	meadow low-level nester																																																		
gray catbird	L4	generalist mid-level nester					1			1					1									1	2	1																	1	1												
great crested flycatcher	L4	forest upper-level nester																																																		
hairy woodpecker	L4	forest upper-level nester																																																		
house finch	L+	generalist mid-level nester																																																	1	1
house sparrow	L+	generalist mid-level nester																1						1		2								1																				
house wren	L5	generalist mid-level nester																																																		
killdeer	L5	generalist low-level nester								2								2																																			
least flycatcher	L3	forest-edge upper-level nester																																																		
mallard	L5	wetland low-level nester																																																		
mourning dove	L5	generalist mid-level nester																														1																					
northern cardinal	L5	generalist mid-level nester					1							1			1							1	1	1						1	1	1						2	2							3	1				1	
northern flicker	L4	generalist upper-level nester																																																		
northern mockingbird	L5	generalist mid-level nester																							1																												
orchard oriole	L5	generalist upper-level nester																																																		
red-breasted nuthatch	L4	forest upper-level nester																																																	1	
red-eyed vireo	L4	forest mid-level nester																																																	
red-tailed hawk	L5	generalist upper-level nester																														1																				
red-winged blackbird	L5	generalist mid-level nester					1							1										1		1						3	2	4						1								2	1		3	
rock pigeon	L+	generalist mid-level nester																																																	
rose-breasted grosbeak	L4	forest-edge mid-level nester																																																
savannah sparrow	L4	meadow low-level nester					1							1																																				2	
song sparrow	L5	generalist low-level nester					1										1							2	3	4						2	3	3						1	2							2	3		5	2
warbling vireo	L5	generalist upper-level nester																														1	1																1			
wild turkey	L3	forest-edge low-level nester																																															1		
willow flycatcher	L4	meadow mid-level nester																														1																1	1		
yellow warbler	L5	generalist mid-level nester																							1							2	1	2								1							3	1		

Appendix 2. Butterfly occurrence in The Meadoway 2016, 2018-2023.

Common name	Scientific name	S-rank	Section 1							Section 2							Section 4.1							Section 4.2							Host plant
			2016	2018	2019	2020	2021	2022	2023	2016	2018	2019	2020	2021	2022	2023	2016	2018	2019	2020	2021	2022	2023	2016	2018	2019	2020	2021	2022	2023	
Acadian Hairstreak*	*Satyrium acadica*	S4							2				x																		Various willow species including black willow (*Salix nigra*) and silk willow (*Salix sericea*)
American Lady	*Vanessa virginiensis*	S5											x		1												1			Sunflower family, pearly everlasting, plantain-leaved pussy toes, wormwood, ironweed, burdock
Azure species*	*Celastrina* spp.	n/a											x					1							1					
Black Swallowtail*	*Papilio polyxenes*	S5			2	2	4	12	8			3	x	7	11	5	3	5	3	1	1			22	19	7	7	2	4	1	Carrot family… parsley, dill, celery,Queen Anne's lace
Blue species	Lycaenidae family	n/a					15	3	1				x	1	3	10										2		2	4	1	
Cabbage White	*Pieris rapae*	SNA			8	13	148	151	54			22	x	75	82	35	55	90	24	12	36	11	11	21	51	36	12	72	36	49	Mustards… cabbage, cauliflower and broccoli
Clouded Sulphur	*Colias philodice*	S5			2	16	105	107	36			12	x	37	30	20	5	5	1	7	14	3	6	32	52	17	33	46	19	13	Legumes… cultivated crops
Common Buckeye	*Junonia coenia*	SNR (G5)											x																		Uncommon breeding migrant
Common Ringlet*	*Coenonympha tullia*	S5			1		2	4	2				x				2	1			1	1		1	3	7	17	10	18	1	Kentucky bluegrass
Common Wood-Nymph	*Cercyonis pegala*	S5							1				x								1			1	1		1	4	1		Grasses (Poaceae)
Crescent species*	*Phyciodes* spp.	n/a											x										2								
Delaware Skipper*	*Anatrytone logan*	S4											x																		Big bluestem and old switch panicgrass
Dun Skipper*	*Euphyes vestris*	S5											x							1											Sedges: chufa flatsedge, sun sedge
Duskywing species*								1																							
Eastern Comma*	*Polygonia comma*	S5											x						1												Elm and nettle families: American elm, hops, nettle, false nettle, wood nettle
Eastern Tailed Blue*	*Cupido comyntas*	S5				2	13		1				x	8	8	1	4		1			6		6	4	8	5	20	1	1	Clovers and legumes
Eastern Tiger Swallowtail*	*Pterourus glaucus*	S5											x											1	1			1		1	Trees… hop tree, cherries and ashes
European Common Blue	*Polymmatus icarus*	SNA					32	87	83				x	3	54	62					2	1	10					4	25	14	Alfalfa, clover, crown vetch (Burghardt et al. 2001), bird's-foot trefoil (many other legumes black medick)
European Skipper*	*Thymelicus lineola*	SNA					6	6	11				x		2	1									1	1					Grasses (Poaceae) prefers common timothy
Giant Swallowtail	*Papilio cresphontes*	S4											x																		Common prickly ash and common hop tree
Grass Skipper species	Hesperiinae family	n/a					2						x			1			1										2		
Hobomok Skipper*	*Lon hobomok*	S5						1																							Various grasses including panic grasses (*Panicum*) and blue grasses
Great-spangled Fritillary	*Speyeria cybele*	S5					1						x	1		1								1							Violets
Lady species	*Vanessa* spp.	n/a											x													1					
Least Skipper*	*Ancyloxypha numitor*	S5					2	8	1				x																		Grasses (Poaceae)
Little Wood-Satyr*	*Megisto cymela*	S5					1						x									1									Grasses (Poaceae)… Kentucky bluegrass orchard grass
Monarch	*Danaus plexippus*	S2N,S4B			29	13	50	38	25			32	x	34	20	15		6	37	11	16	9	1	7	217	195	46	86	59	22	Milkweeds
Mourning Cloak*	*Nymphalis antiopa*	S5											x															2		1	Trees… willows, elms, cottonwoods and hackberries
Northern Broken-Dash*	*Wallengrenia egeremet*	S5											x																		Panic grasses: deertongue
Northern Crescent*	*Phyciodes cocyta*	S5							1				x				1	2													Asters
Orange Sulphur	*Colias eurytheme*	S5			1	4	20	23	1				x	4	8		2	1				2		3	1	3	3	7	3		Legumes… clovers and alfalfas
Painted Lady	*Vanessa cardui*	S5			2							3	x	1												7					Broad: most often thistles, hollyhock, mallow, various legumes, knapweed, burdock
Pearl Crescent*	*Phyciodes tharos*	S4							1				x								1						1				Smooth-leaved true asters
Peck's Skipper*	*Polites peckius*	S5					1		6				x			1			1	1				2	1	3	1	1	1	1	Kentucky bluegrass and little bluestem
Question Mark	*Polygonia interrogationis*	S5											x																		American elm, red elm, hackberry, Japanese hop, nettles, false nettle
Red Admiral	*Vanessa atalanta*	S5			2		2		14			1	x						13					1	1	15	1	2		4	Nettles
Silver-spotted Skipper*	*Epargyreus clarus*	S4					3	3	1				x				2			1		1	2	1							Legumes… showy tick-trefoil, Am. hog peanut and black locust
Silvery Blue*	*Glaucopsyche lygdamus*	S5					1	1	4				x		2	1								1		2					Legumes… tufted vetch, white sweet clover and alphlfa
Spring Azure*	*Celastrina lucia*	S5											x																		Cherrys, blueberrys and early blooming viburnums
Tawny-edged Skipper*	*Polites themistocles*	S5											x																		Panicgrasses and bluegrasses
Summer Azure*	*Celastrina neglecta*	S5							1				x															1			Dogwoods, New Jersey tea, meadowsweets and viburnums
Swallowtail species													x																	1	
Viceroy*	*Limenitis archippus*	N5											x					1										3			Willow and poplar
White Admiral*	*Limenitis arthemis*	S5											x														1				Trees and shrubs… wild cherry, aspen, poplar, cottonwood, oaks, hawthorn, birch, willows, basswood
Wild Indigo Duskywing*	*Erynnis baptisiae*	S4							2				x				1	1				2		1		1		1			Purple crown-vetch

Appendix 2. (cont'd)

Common name	Scientific name	S-rank	Section 4.3							Section 4.4							Section 5				Section 6			Section 7							Host plant
			2016	2018	2019	2020	2021	2022	2023	2016	2018	2019	2020	2021	2022	2023	2020	2021	2022	2023	2021	2022	2023	2016	2018	2019	2020	2021	2022	2023	
Acadian Hairstreak*	*Satyrium acadica*	S4																x													Various willow species including black willow (*Salix nigra*) and silk willow (*Salix sericea*)
American Lady	*Vanessa virginiensis*	S5						1				1						x											1		Sunflower family, pearly everlasting, plantain-leaved pussy toes, wormwood, ironweed, burdock
Azure species*																		x											0		
Black Swallowtail*	*Papilio polyxenes*	S5	26	17	3	4	1	1		25	20	8	3	1	4	4	5	x		4	1	2		3	11	3	3	8	3	1	Carrot family… parsley, dill, celery and Queen Anne's lace
Blue species	Lycaenidae family	n/a			21		3	3	2			2		1	6	3		x		1						5	1	3	2	3	
Cabbage White	*Pieris rapae*	SNA	26	56	40	15	34	17	48	53	86	38	2	44	46	93	20	x		89	15	28		61	327	28	36	77	95	113	Mustards… cabbage, cauliflower and broccoli
Clouded Sulphur	*Colias philodice*	S5	35	37	17	40	38	29	15	37	62	25	18	30	11	27	80	x		33	31	23		24	105	58	57	32	45	41	Legumes… cultivated crops
Common Buckeye	*Junonia coenia*	SNR (G5)													1			x						1					0		Uncommon breeding migrant
Common Ringlet*	*Coenonympha tullia*	S5		1		1	3	3	2				3	11	18	3	15	x			8	49		20	66		4	7	14	13	Kentucky bluegrass
Common Wood-Nymph	*Cercyonis pegala*	S5			1	1	2	2	3								1	x							1			3		1	Grasses (Poaceae)
Crescent species*			1															x						2	8						
Delaware Skipper*	*Anatrytone logan*	S4	2				2											x													Big bluestem and old switch panicgrass
Dun Skipper*	*Euphyes vestris*	S5			3			1										x								2					Sedges: chufa flatsedge, sun sedge
Duskywing species*																															
Eastern Comma*	*Polygonia comma*	S5																x													Elm and nettle families: American elm, hops, nettle, false nettle, wood nettle
Eastern Tailed Blue*	*Cupido comyntas*	S5	7		40	52	58	20	8	2	1	6	5	23	2	3	2	x		2	3	2		13	10			8		2	Clovers and legumes
Eastern Tiger Swallowtail*	*Pterourus glaucus*	S5								1			1					x												1	Trees… hop tree, cherries and ashes
European Common Blue	*Polymmatus icarus*	SNA					6	29	17					7	61	119	1	x		148	2	59						42	38	47	Alfalfa, clover, crown vetch (Burghardt et al. 2001), bird's-foot trefoil (many other legumes e.g. black medick)
European Skipper*	*Thymelicus lineola*	SNA			5	1			1				1	5		3		x													Grasses (Poaceae) prefers common timothy
Giant Swallowtail	*Papilio cresphontes*	S4																x							1						Common prickly ash and common hop tree
Grass Skipper species	Hesperiinae family	n/a										1		4	1		1	x				1								2	
Hobomok Skipper*	*Lon hobomok*	S5																												1	Various grasses including panic grasses (*Panicum*) and blue grasses
Great-spangled Fritillary	*Speyeria cybele*	S5																x													Violets
Lady species					1													x													
Least Skipper*	*Ancyloxypha numitor*	S5																x													Grasses (Poaceae)
Little Wood-Satyr*	*Megisto cymela*	S5																x		1		1									Grasses (Poaceae)… Kentucky bluegrass and orchard grass
Monarch	*Danaus plexippus*	S2N,S4B	3	46	280	49	68	39	14	5	28	79	11	44	43	13	12	x		40	20	10		4	38	227	7	46	11	11	Milkweeds
Mourning Cloak*	*Nymphalis antiopa*	S5			1					1						1		x							1			3			Trees… willows, elms, cottonwoods and hackberries
Northern Broken-Dash*	*Wallengrenia egeremet*	S5			1													x											1		Panic grasses: deertongue
Northern Crescent*	*Phyciodes cocyta*	S5																x							2						Asters
Orange Sulphur	*Colias eurytheme*	S5	2	4	2	3	3	4		7	22	2		5	21		3	x			2	15		9	21	2	3	2	22	6	Legumes… clovers and alfalfas
Painted Lady	*Vanessa cardui*	S5			1							4						x		1								3			Broad: most often thistles, hollyhock, mallow, various legumes, knapweed, burdock
Pearl Crescent*	*Phyciodes tharos*	S4					1							2				x				1						13	1		Smooth-leaved true asters
Peck's Skipper*	*Polites peckius*	S5			7	1	2		2			2		1	1	2	1	x						1	2						Kentucky bluegrass and little bluestem
Question Mark	*Polygonia interrogationis*	S5										1					1	x													American elm, red elm, hackberry, Japanese hop, nettles, false nettle
Red Admiral	*Vanessa atalanta*	S5	2		16		1	1		1		11				1		x								5			1		Nettles
Silver-spotted Skipper*	*Epargyreus clarus*	S4															2	x							1		1	1			Legumes… showy tick-trefoil, Am. hog peanut and black locust
Silvery Blue*	*Glaucopsyche lygdamus*	S5	6		10	12	5			1		1	8	2				x						16	5	1	2			1	Legumes… tufted vetch, white sweet clover and alphlfa
Spring Azure*	*Celastrina lucia*	S5			1													x													Cherrys, blueberrys and early blooming viburnums
Tawny-edged Skipper*	*Polites themistocles*	S5						1								1	4	x				4		3	7						Panicgrasses and bluegrasses
Summer Azure*	*Celastrina neglecta*	S5																x											1		Dogwoods, New Jersey tea, meadowsweets and viburnums
Swallowtail species																		x													
Viceroy*	*Limenitis archippus*	N5																x			1							2	5		Willow and poplar
White Admiral*	*Limenitis arthemis*	S5																x													Trees and shrubs… wild cherry, aspen, poplar, cottonwood, oaks, hawthorn, birch, willows, basswood
Wild Indigo Duskywing*	*Erynnis baptisiae*	S4				1	1									2		x		2	5	16						3		1	Purple crown-vetch

Appendix 2. (cont'd)

S2N (non-breeding)-Imperiled-imperiled nationally because of rarity due to very restricted range, very few population (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation nationally
S3B (breeding)-Vulnerable-vulnerable in the provice due to a restructed range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation
S4-Apparently secure-uncommon but not rare; some cause for long-term concern due to declines or other factors
S5-Secure-common, widespread, and abundant in Ontario
N5-Secure-common, widespread, and abundant in the nation
SNR-Unranked-provincial conservation status not yet assessed (G5-globally secure)
SNA-Not applicable-a conservation status rank is not applicable because the species is not a suitable target for conservation activities
*resident species

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