Toronto and Region Conservation Authority

The Meadoway: Vegetation, Bird, and Butterfly Monitoring 2016, 2018-2022

Prepared by Watershed Planning and Ecosystem Science

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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. Database support was provided by Ming Guo. Mapping was completed by Dell Tune and Alberta D'Souza. 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 between 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 2022. Mowing and herbicide application has occurred intermittently in different sections although became a more prominent focus in 2018.

Monitoring activities occurred in 2016 and 2018-2022 to document changes in species composition related to the vegetation, breeding birds, and butterfly presence. This report is an update to the 2021 monitoring report (TRCA 2021) 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 an additional year of data to a special section on several experimental seeding plots focusing on germination success based on the seasonality of planting, method of planting, and glyphosate application. We also summarized the results of bird and butterfly surveys throughout The Meadoway and some pre- and post-restoration comparisons where possible.

Figure 1. Sunset in July 2022 at The Meadoway.

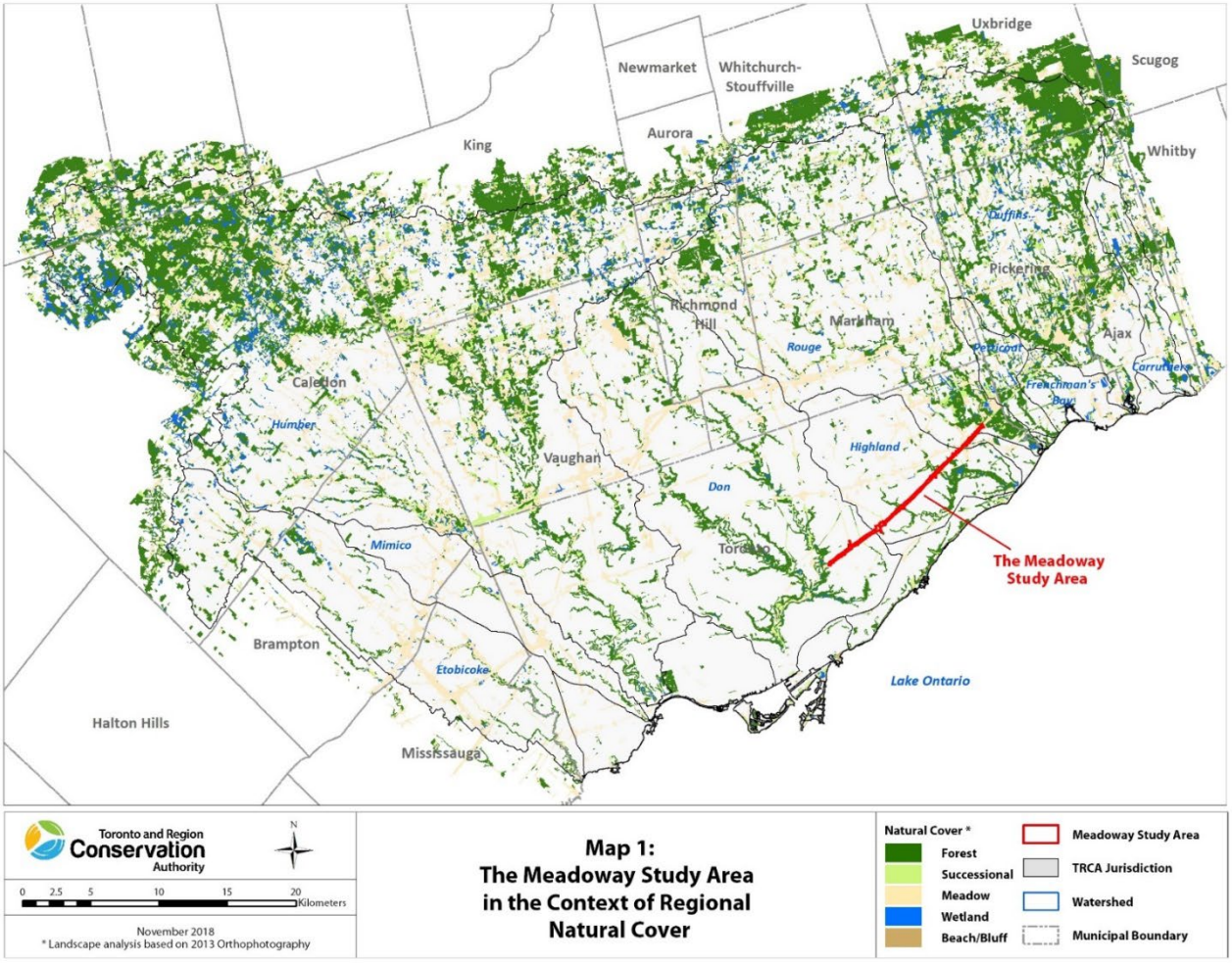

Figure 2. Geographic location of The Meadoway related to TRCA's jurisdiction.

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).

Figure 3. Monitoring vegetation plots at The Meadoway in 2022.

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.

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 in 2016, and 2018-2022 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 species and migratory species. Surveys were conducted between 09:00 and 16:00 and only in good weather conditions (>20°C, no rain, light winds). Start and end times were recorded and were generally consistent among years.

Figure 5. Least Skipper (*Ancyloxypha numitor*).

RESULTS

Thirty-three vegetation plots were set-up between 2016 and 2022 (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 2018-2022. 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 there were several changes to butterfly transects. First, transects were added to sections 1 and 2 (Figure 6). Second, 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). Third, Hydro One established a works yard in a portion of section 7 making comparisons across the three years difficult.

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 survey years
1.1	MV-24_1.1X	2019, 2020, 2021, 2022	11	2021, 2022	2021, 2022
	MV-24_1.1Y	2020, 2021, 2022			
1.2	MV-24_1.2P	2018, 2019, 2020, 2021, 2022	8	2020-2022	2020- 2022
1.3	MV-24_1.3Q	2018, 2020, 2021, 2022	12	2021, 2022	2021, 2022
	MV-24_1.3V	2019 (abandoned post-2019)			
1.4	MV-24_1.4W	2019	6	2018, 2019-2022	2019- 2022
	MV-24_1.4R	2019 (abandoned post-2019)			
2.2	MV-24_2.2S	2018, 2019, 2021, 2022	15	2022	2022
2.3	MV-24_2.3T	2018, 2019, 2021, 2022			
2.4	MV-24_2.4U	2018, 2019, 2021, 2022	7	2018, 2019-2022	2019- 2022
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, 2022	1	2016, 2018-2022	2016, 2018-2022
	MV-24_4.1H	2016, 2018, 2019, (2020 summer only), 2021, 2022			
	MV-24_4.1I	2016, 2018, 2019, 2021, 2022			
4.2	MV-24_4.2A	2016, 2018-2022	2	2016, 2018-2022	2016, 2018-2022
	MV-24_4.2B	2016, 2018-2022			
	MV-24_4.2C	2016, 2018-2022			
4.3	MV-24_4.3D	2016, 2018-2022	3	2016, 2018-2022	2016, 2018-2022
	MV-24_4.3E	2016, 2018, 2019, (2020 summer only), 2021, 2022			
	MV-24_4.3F	2016, 2018, 2019, (2020 summer only), 2021, 2022			
4.4	MV-24_4.4J	2016, 2018, 2019, (2020 summer only), 2021, 2022	4	2016, 2018-2022	2016, 2018-2022
	MV-24_4.4K	2016, 2018, 2019, (2020 summer only), 2021, 2022			
	MV-24_4.4L	2016, 2018, 2019, (2020 summer only), 2021, 2022			
5.1	MV-24_5.1AC	2020			
5.2	N/A	N/A	9	2020	2020
5.3	MV-24_5.3AD	2020	10	2020	
5.4	MV-24_5.4AE	2020			
6.1	MV-24_6.1AF	2020			

Section	Veg plot name	Vegetation plot monitoring years	Bird survey station #	Bird survey years	Butterfly survey years
6.2	MV-24_6.2AG	2020	13	2021, 2022	2021, 2022
6.4	MV-24_6.4AH	2020	14	2021, 2022	2021, 2022
7.1	MV-24_7.1M	2016, 2018-2022	5	2016, 2018-2022	2016, 2018-2022
	MV-24_7.1N	2016, 2018-2022			
	MV-24_7.1O	2016, 2018-2022			

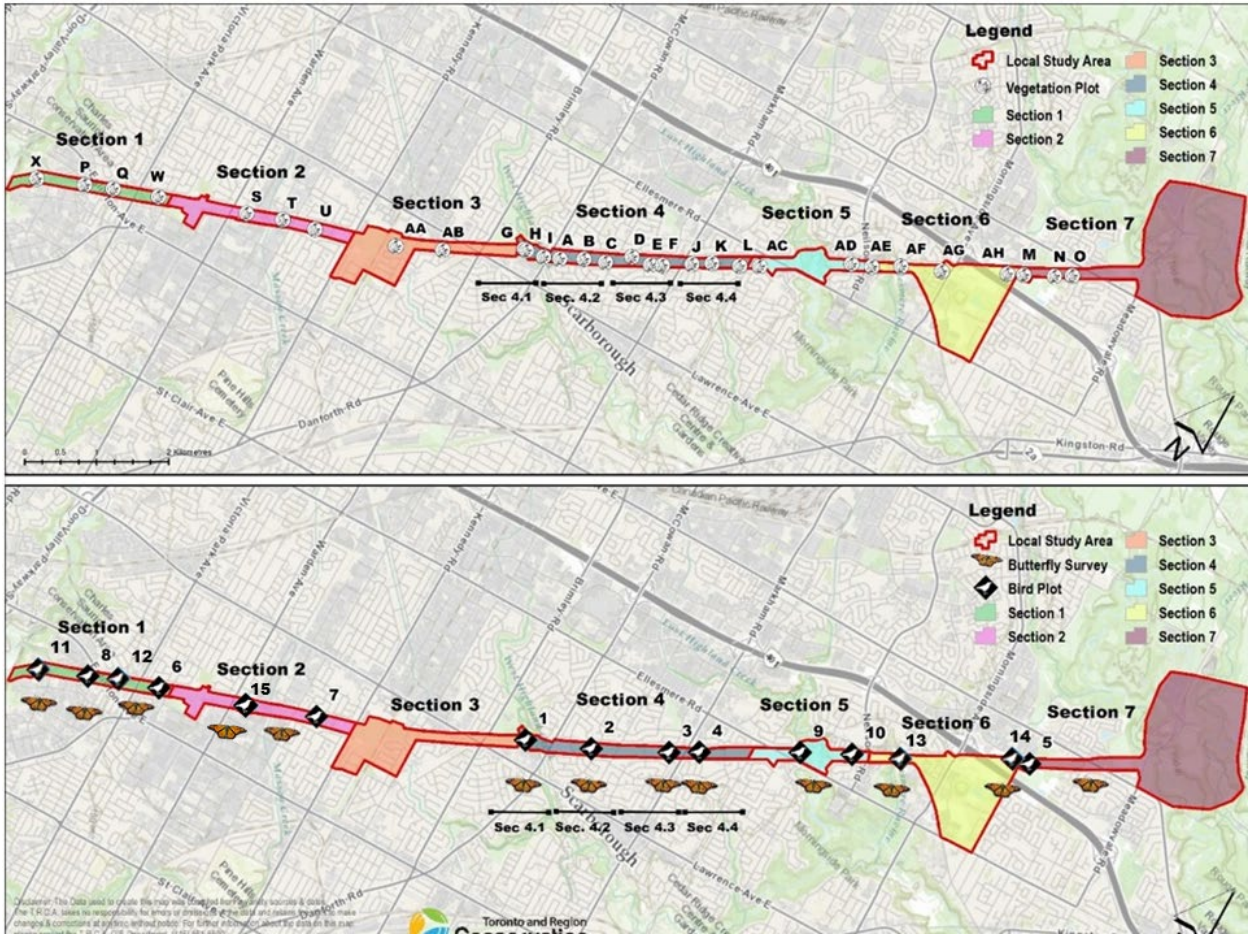

Figure 6. Vegetation plot, bird, and butterfly survey locations at The Meadoway in 2016, 2018-2022 (only showing active plots/stations).

Vegetation plots

Vegetation monitoring plots were subject to different, and often multiple, management techniques over the past six years of monitoring. Due to this variation, each part of this report focuses on different aspects of restoration. For example, since we now have pre- and post-restoration data for sections 1 and 2, we compared vegetation communities pre- and post-restoration. 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. Other species were targeted for invasive species management including common reed (*Phragmites australis*), spotted knapweed (*Centaurea stoebe* ssp. *micranthos*), and tansy (*Tanacetum vulgare*), and were only included in the analysis if applicable to a specific section and vegetation monitoring plot.

Section 1: Pre- and post-restoration comparisons

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

Section 1.1

Plot X was the only vegetation plot monitored both pre- and post-restoration in section 1.1. 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 and 2021, but not between 2021 and 2022. Plot X only contained one of the seeded species in 2019, but in 2020, 13 seeded species were observed and by 2021 and 2022, 17 seeded 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 2022 for most species (Figure 8). There was a drastic decline in the maximum percent cover of DSV from 90% in 2019 to 3% in 2022 most likely due to management activities.

Figure 7. Photos of plot X in section 1.1 pre-restoration 2019 (left) and post-restoration 2022 (right).

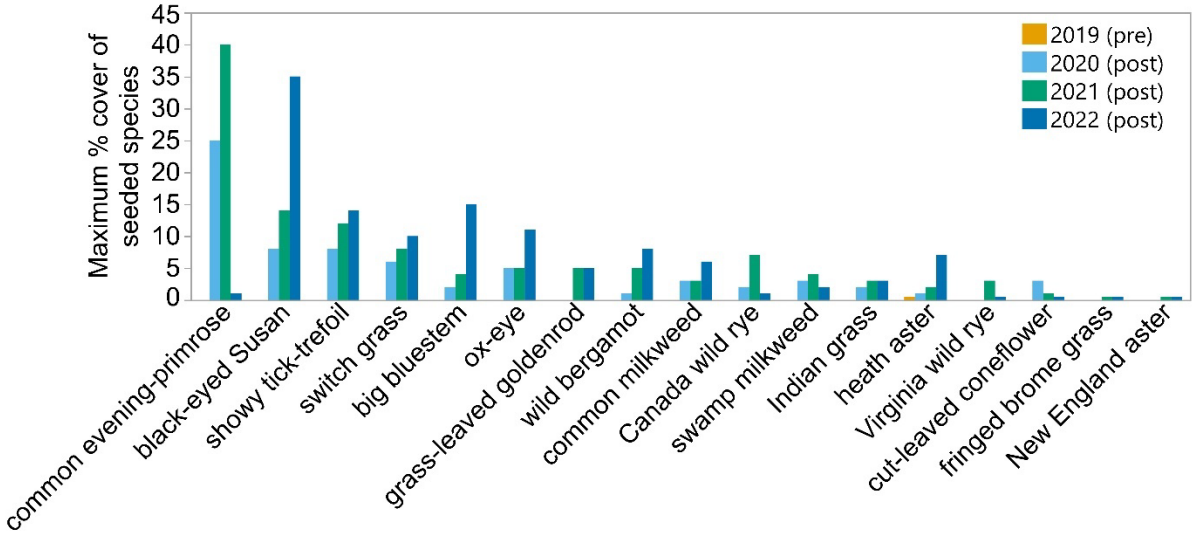

Figure 8. Changes in species occurrence and maximum percent cover of seeded species that germinated in plot X between 2019 and 2022. Note: heath aster occurred naturally in 2019.

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 2022. Plot Q contained none of the seeded species in 2018, but by 2022, 11 seeded species were observed with both little bluestem (*Schizachyrium scoparium* var. *scoparium*) and New England aster (*Symphyotrichum novae-angliae*) found for the first time in 2022 (Figure 10). Maximum percent cover of seeded species increased between 2020 and 2022 for eight species including big bluestem (*Andropogon gerardi*), black-eyed Susan (*Rudbeckia hirta*), Canada wild rye (*Elymus*

canadensis), common evening primrose (*Oenothera biennis*), common milkweed (*Asclepias syriaca*), ox-eye (*Heliopsis helianthoides*), showy tick-trefoil (*Desmodium canadense*), switchgrass (*Panicum virgatum*), and wild bergamot (*Monarda fistulosa*) (Figure 10). Increases were considerable for black-eyed Susan, ox-eye, and wild bergamot. Plot Q had a low maximum percent cover of both DSV and creeping thistle pre- and post-restoration until 2021 (0-3%), although in 2022 creeping thistle maximum cover increased to 14%.

Figure 9. Photos of plot Q in section 1.3 pre-restoration 2018 (left) and post-restoration 2022 (right).

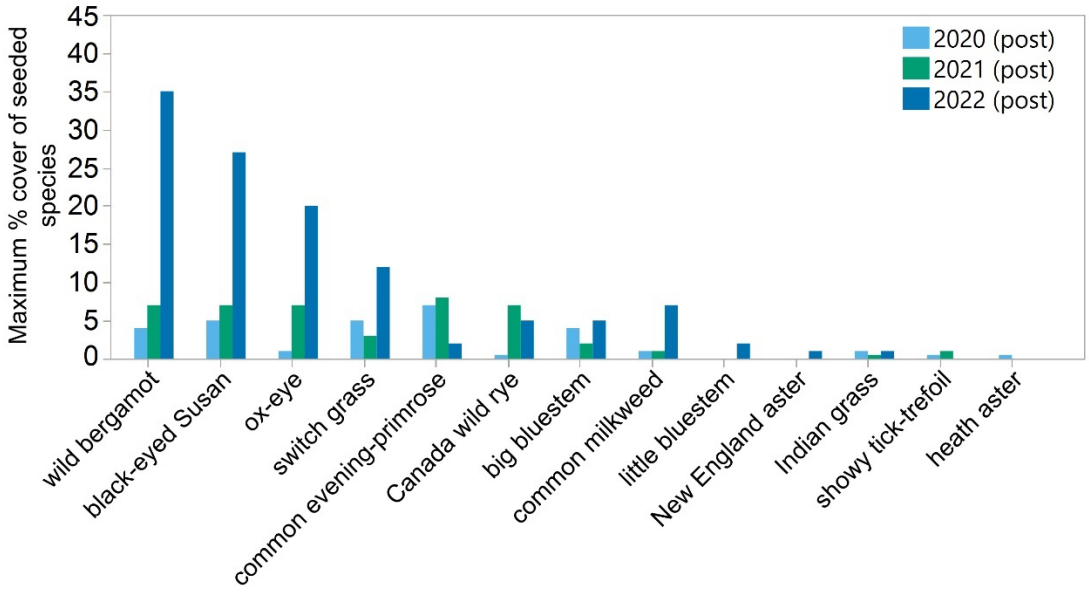

Figure 10. Maximum percent cover of seeded species that germinated in plot Q between 2020 and 2022. None of the seeded species were observed in 2018 (prior to seeding).

Section 2: Pre- and post-restoration comparisons

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

Section 2.2

Plot S was the only vegetation plot monitored both pre- and post-restoration in section 2.2 (Figure 11). Section 2.2 was first monitored in 2018 and seeded in November 2020 and April 2021.

The number of seeded species that germinated increased between 2018 and 2022. Plot S contained none of the seeded species in 2018, and 13 seeded species in both 2021 and 2022. Tall cinquefoil (*Drymocallis arguta*) was found in 2021 but not in 2022 while Virginia wild rye (*Elymus virginicus* var. *virginicus*) was found in 2022 but not in 2021 (Figure 12). The cover of all species increased between 2021 and 2022 except for common evening primrose and hairy beard-togue (*Penstemon hirsutus*). Maximum cover of DSV was low (<1%) in both years, while creeping thistle was high in 2021 (60%) and 2022 (40%). Thistle management may need to be targeted in this area in future years (if not already removed).

Figure 11. Photos of plot S in section 2.2 pre-restoration 2019 (left) and post-restoration 2022 (right).

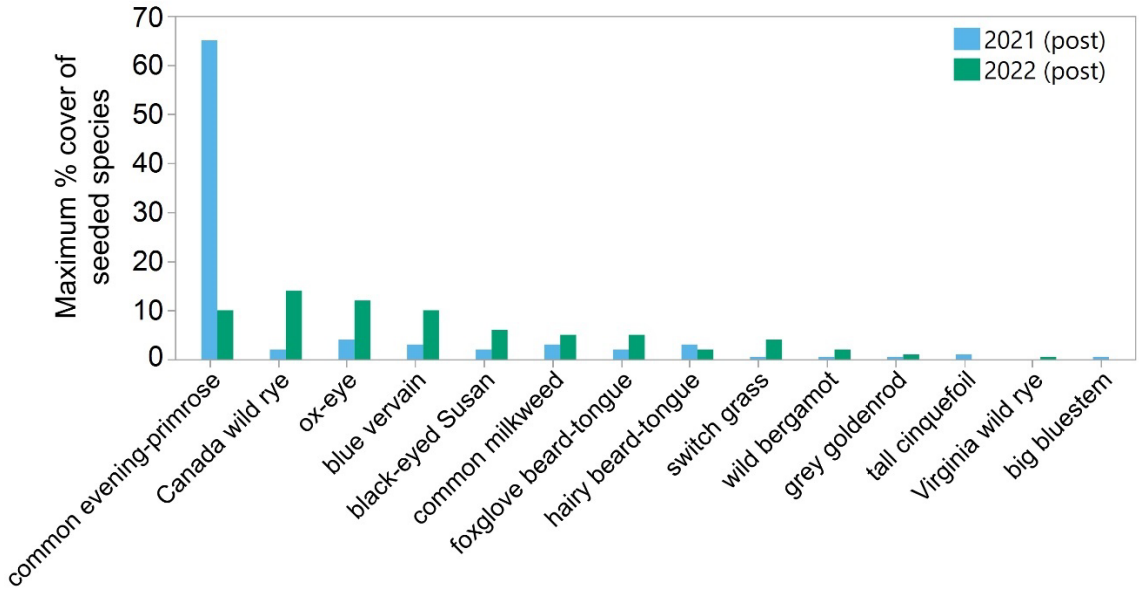

Figure 12. Maximum percent cover of seeded species that germinated in plot S in 2021 and 2022. None of the seeded species were observed in 2018 (prior to seeding).

Section 2.3

Plot T was the only vegetation plot monitored both pre- and post-restoration in section 2.3 (Figure 13). Section 2.3 plot T was first monitored in 2018 and seeded in November 2020 and April 2021. Note that plot markers were difficult to find in 2022 so sub-plot locations may have shifted slightly. This could affect the detection of species with low percent covers (e.g. <1%) from 2021.

The number of seeded species that germinated increased between 2018 and 2021 while a decrease occurred in 2022. Plot T contained none of the seeded species in 2018, but in 2021, 14 seeded species were observed (Figure 14). By 2022, only 9 of the seeded species occurred in the sub-plots with hairy beard-tongue, Indian grass (*Sorghastrum nutans*), tall cinquefoil, Virginia wild rye, and wild bergamot found in 2021 but not in 2022 within the sub-plots. All of these species were found in the species list except for Indian grass. Common evening primrose decreased in cover between 2021 and 2022. It is an early successional species usually found on dry or sandy roadsides, fields, clearings, and disturbed ground. Both Canada wild rye and blue vervain (*Verbena hastata*) had the greatest increases in cover between 2021 and 2022. Maximum DSV cover decreased from 6% in 2019 to 0% in 2022 and creeping thistle percent cover increased from 0% in 2019 to 10% in 2022.

Figure 13. Photos of plot T in section 2.3 pre-restoration 2019 (left) and post-restoration 2022 showing tall goldenrod and Canada wild rye (right).

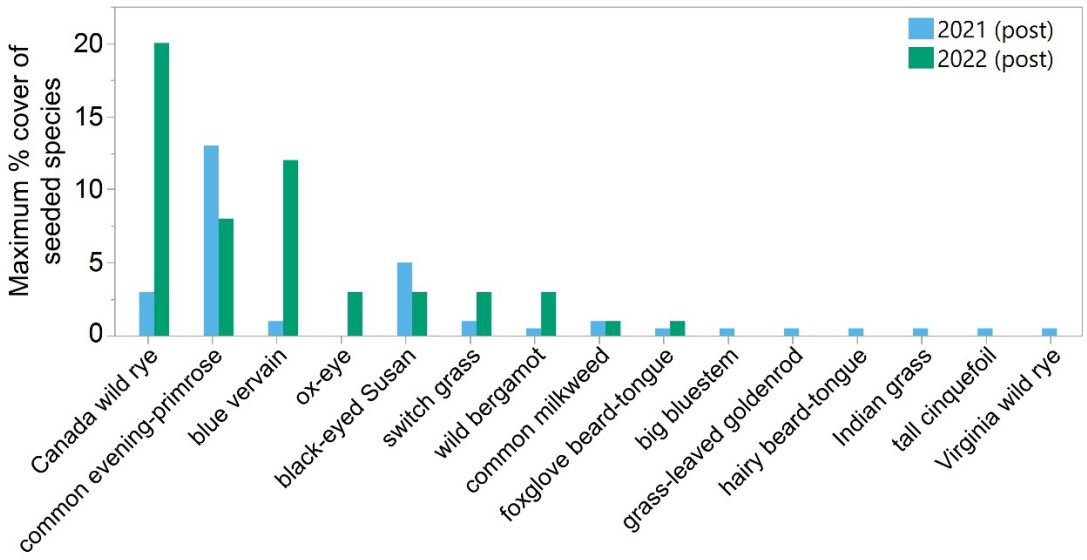

Figure 14. Maximum percent cover of seeded species that germinated in plot T in 2021 and 2022. None of the seeded species were observed in 2018 (prior to seeding).

Section 2.4

Plot U was the only vegetation plot monitored both pre- and post-restoration in section 2.4 (Figure 15). 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. Plot U contained none of the seeded species in 2018, 13 seeded species in 2021, and 14 seeded species in 2022. Several new seeded species occurred in 2022 including grass-leaved goldenrod (*Euthamia graminifolia*), grey goldenrod (*Solidago nemoralis* ssp. *nemoralis*), and ox-eye. Black-eyed Susan and blue vervain were found in 2021 but not in 2022 within the sub-plots. Canada wild rye and switchgrass had the greatest increase in cover between 2021 and 2022 (Figure 16). DSV was only found in 2018 and 2019 with a cover of <1% and creeping thistle was only found in 2022 with a maximum cover of 5%.

Figure 15. Photos of plot U in section 2.4 pre-restoration 2019 (left) and post-restoration 2022 showing goldenrods, blue vervain, panicled aster, and Canada wild rye (right).

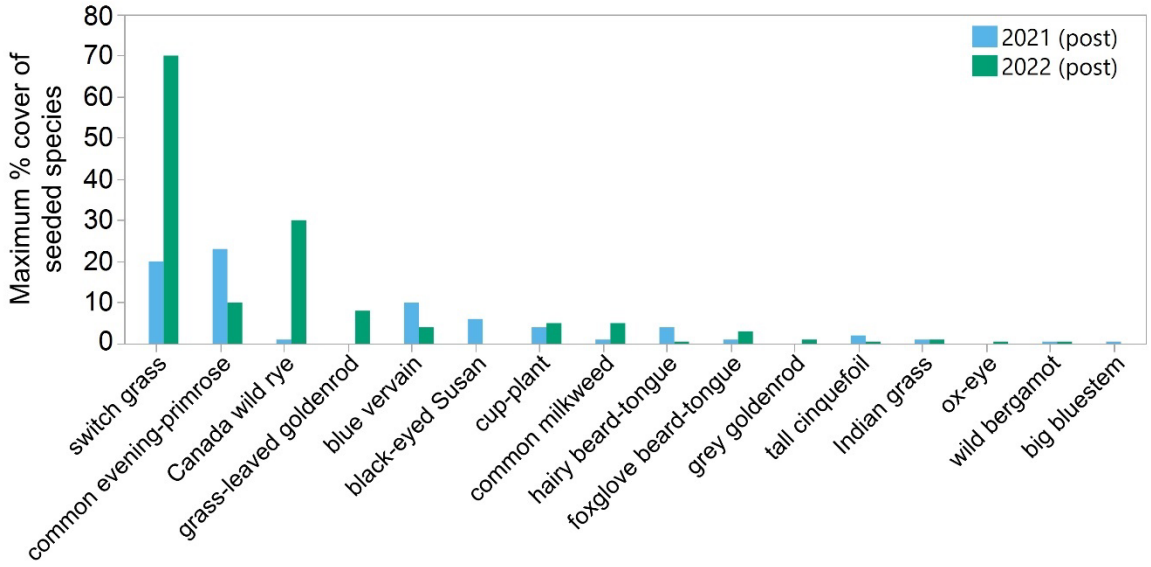

Figure 16. Maximum percent cover of seeded species that germinated in plot U in 2021 and 2022. None of the seeded species were observed in 2018 (prior to seeding).

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 in 2022. 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 only using data from summer visits for 2016 and 2018-2022. Invasive species management targeted DSV and thistle.

Cover of seeded species that germinated varied by year and by species (Figure 17). Both ox-eye and tall sunflower decreased in cover between 2021 and 2022. Most species had a similar cover, or a slight decrease in cover, between 2021 and 2022 although wild bergamot increased slightly in cover between 2021 and 2022.

Cover of DSV was low (0-4%) in all years in plots G and H. In plot G, average cover increased from 0.1% to 3% between 2016 and 2022. In plot H, average cover changed from 0.5% in 2016 to 2.4% in 2022. 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 perhaps suggesting control efforts for thistle have been effective. Invasive species management started in 2018 in this section.

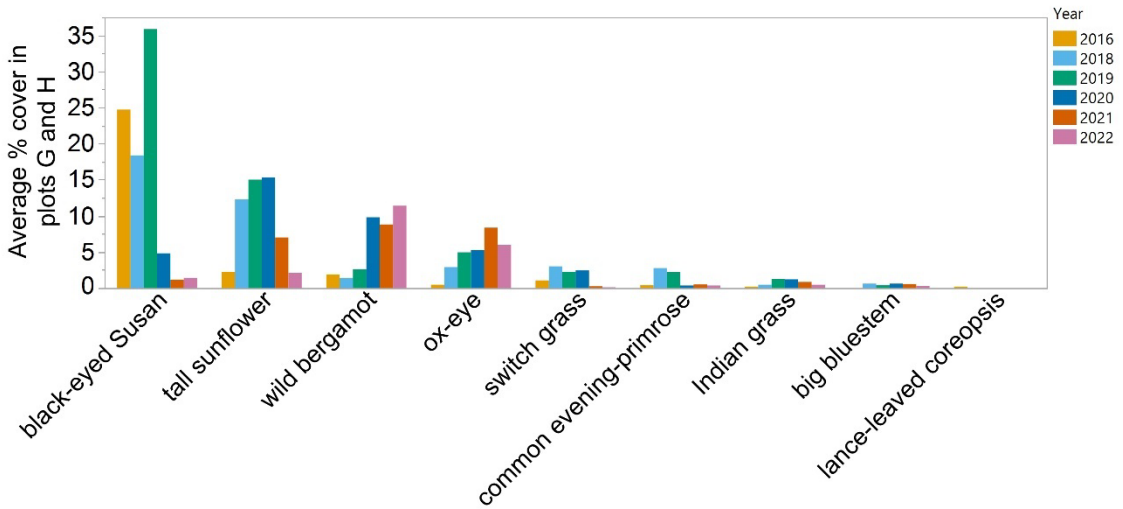

Figure 17. Average percent cover of seeded species that germinated in plots G and H between 2016 and 2022.

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 only using data from summer visits for 2016, and 2018-2022. Invasive species management has targeted DSV and thistle since 2018.

Many species appear to be establishing well in section 4.2 including big bluestem, butterfly milkweed (*Asclepias tuberosa* ssp. *interior*), common milkweed, cup-plant (*Silphium perfoliatum* var. *perfoliatum*), grey-headed coneflower (*Ratibida pinnata*), ox-eye, stiff goldenrod (*Solidago rigida* ssp. *rigida*), tall tickseed, Virginia mountain-mint (*Pycnanthemum virginianum*), and wild bergamot (Figure 18). Several species only occurred in earlier years including common evening primrose, lance-leaved coreopsis (*Coreopsis lanceolata*), showy tick trefoil, and smooth milkweed (*Asclepias sullivantii*).

The average cover of thistle has been steadily declining since 2016, with a percent cover of approximately 2% in 2022. In contrast, the average cover of DSV appears to be increasing slightly each year from 0.8% in 2016 to 7% in 2022.

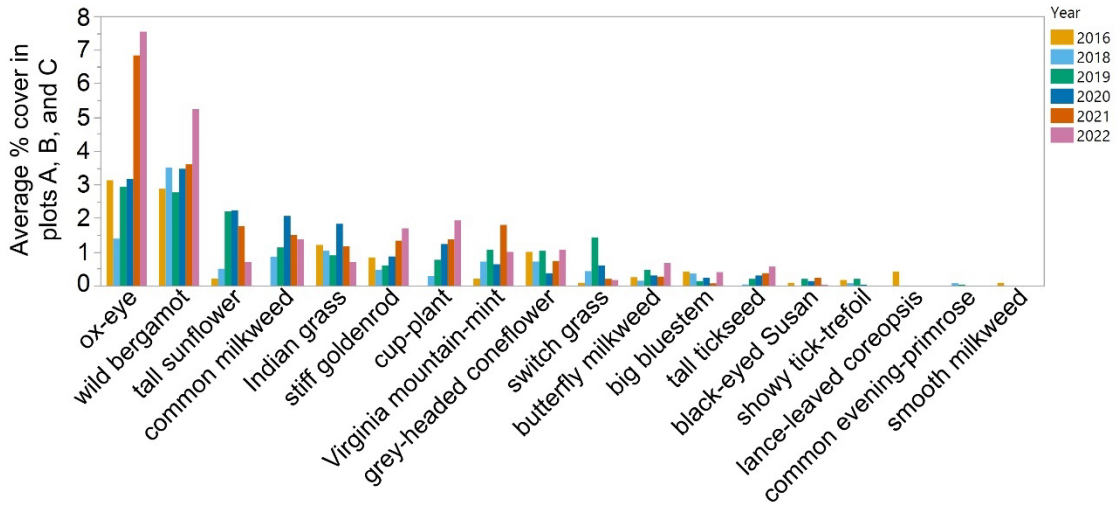

Figure 18. Average percent cover of seeded species that germinated in plots A, B, and C between 2016 and 2022.

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 only using data from summer visits for 2016, and 2018-2022. Invasive species management has targeted DSV and thistle since 2018.

Big bluestem, ox-eye, switch grass, and wild bergamot appear to be establishing well with higher percent covers although many species appear to be showing decreasing trends in cover (Figure 19). Multiple other seeded species are persisting at lower percent covers such as cup-plant, butterfly milkweed, and common milkweed.

Average thistle cover was 6% in 2016 and 1.5% in 2022. A major decrease in cover occurred between 2016 and 2018 when management began. The average cover of DSV was 1.3% in 2021 across all sub-plots. DSV is increasing in cover in sub-plots 2 and 5 in plot D.

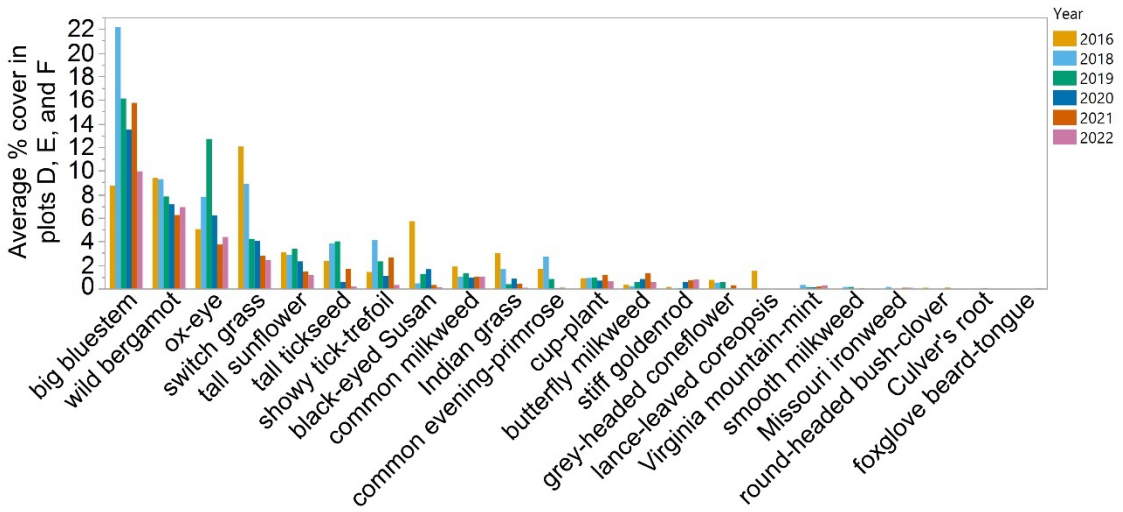

Figure 19. Average percent cover of seeded species that germinated in plots D, E, and F between 2016 and 2022.

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 and 2022.

There were six woody stems in the unburned plots compared to only two stems in the burned plots in 2021 (Figure 20). In 2022, there were 12 woody stems in the unburned plots and 4 stems in the burned plots.

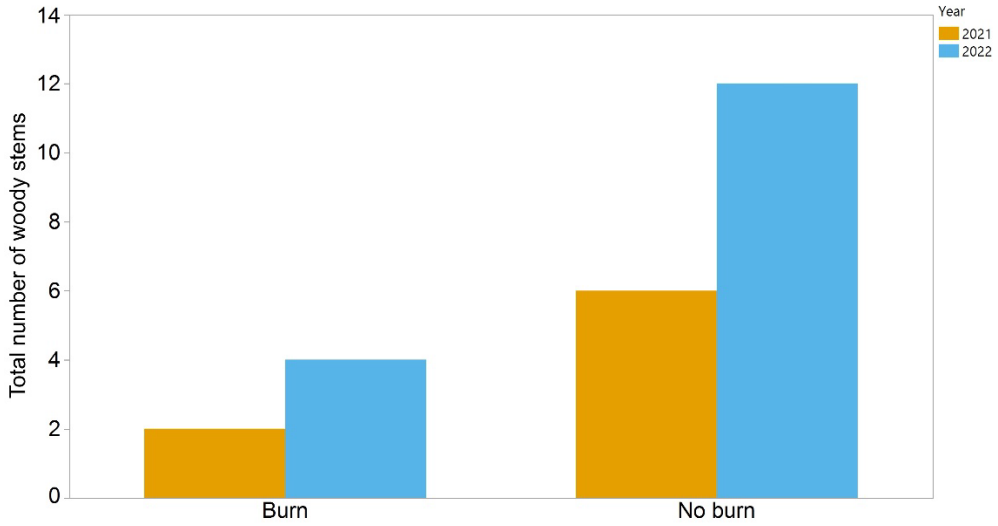

Figure 20. Total number of woody stems in burned and unburned plots in 2021 and 2022.

The average percent cover of grasses in the burned sub-plots was higher than the unburned sub-plots in 2021 (Figure 21). By 2022, the average percent cover of grasses was generally lower than in 2021 and was more similar between burned and unburned plots. In the summer visit of 2022, grass cover appeared to be lower in burned sub-plots compared to unburned sub-plots.

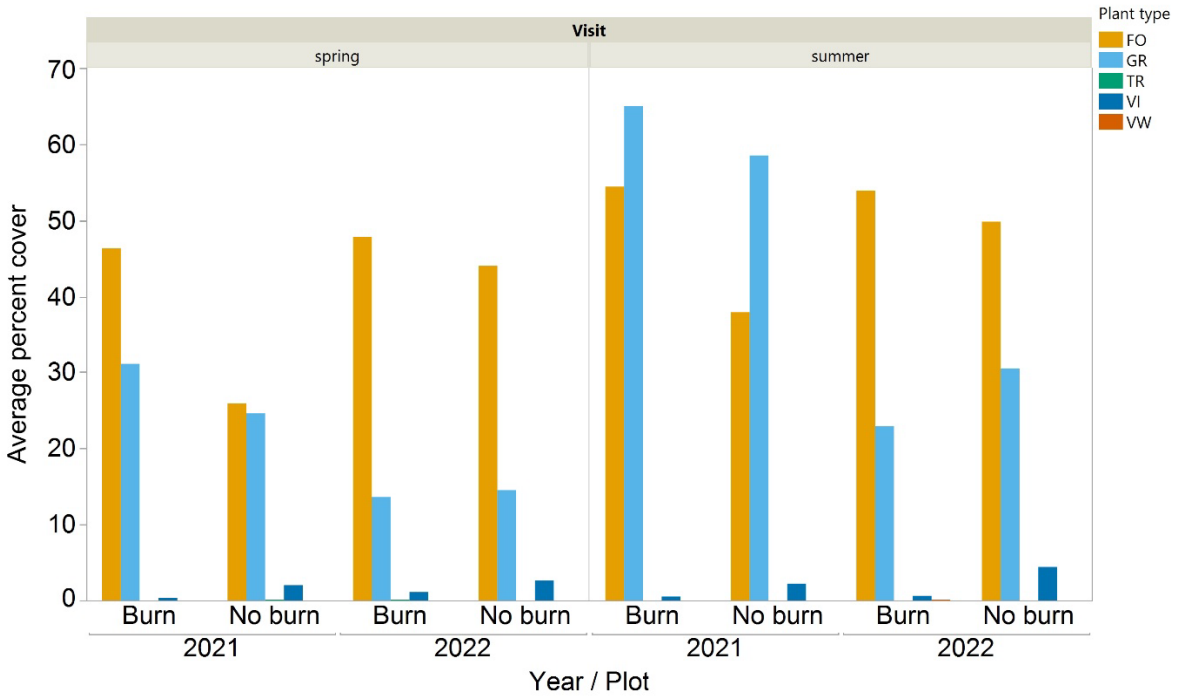

Figure 21. Average percent cover of each plant type in burned and unburned sub-plots by season, visit, and year. FO – forb, GR – grass, TR – tree, VI – herbaceous vine, VW – woody vine.

The burned sub-plots contained more species in general compared to the unburned sub-plots (Table 2). In the burned plot, the number of exotic species was high in 2021 (early post-disturbance) although had decreased by 2022. The burned plots also had an increase in native species between 2021 and 2022 while the unburned plots did not. 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 in 2021 and 2022.

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

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 only using data from summer visits for 2016, and 2018-2022. Active management was occurring in plot J in 2021 and as such, we only present percent cover results for K and L.

In plots and K and L, several of the seeded species occurred in each year but cover varied (Figure 22). Most species had similar, or higher, percent covers in 2022 compared to 2021. The average cover of thistle was 1.6% in 2016 and 1.1% in 2022 across plots K and L. Average cover of DSV was also relatively low in this section with an average cover of 0.2% in 2016 and 0.5% in 2022.

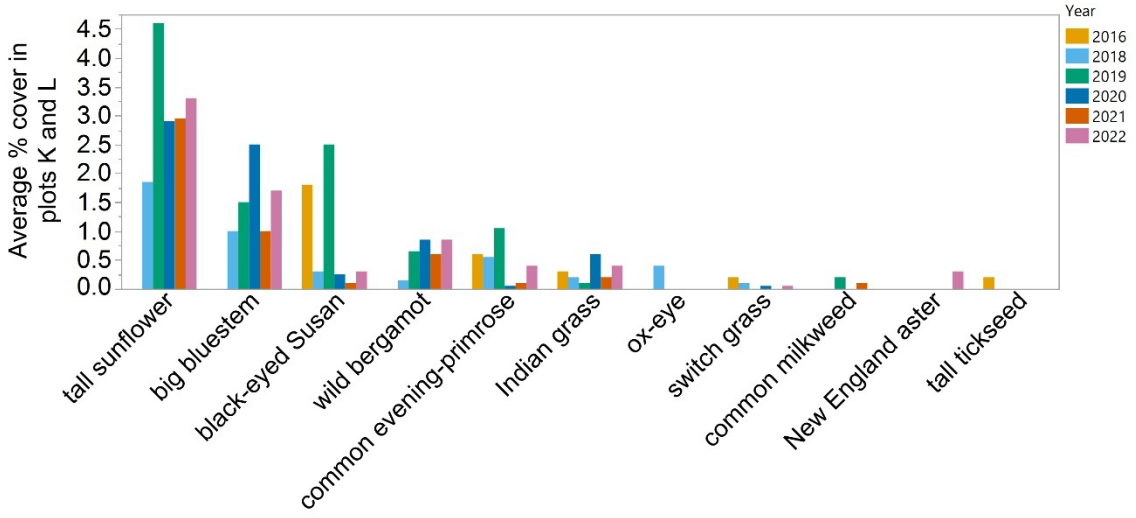

Figure 22. Average percent cover of seeded species that germinated in plots K and L between 2016 and 2022.

Sections 5 and 6

No monitoring has occurred in these sections since six plots were established in 2020 (AC, AD AE, AF, AG, and AH). In 2020, the plots represented pre-management, turfgrass communities and were not monitored in 2021 or 2022 since restoration work had not yet started (Section 6) or was underway (Section 5 in 2022). 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. Plot O was also seeded in July 2020 and October 2021 (Figure 23).

Due to the dry, sandy conditions present in section 7 (and particularly near plot N), Indian grass and grey goldenrod (*Solidago nemoralis* ssp. *nemoralis*) 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, and blue-eyed grass.

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, and Virginia wild rye (Figure 24). Thistle cover was relatively low in this section only occurring in two sub-plots in 2016 and one sub-plot in both

2021 and 2022 with a cover of 1% or less. Average DSV cover was low (<2.5%) in all years although some sub-plots reached covers of up to 18% in 2022. Different sub-plots display different patterns among years but the overall pattern was an increase in cover of DSV over time.

Figure 23. Plot N in section 7.1 showing pre-restoration in 2016 (left) and post-restoration in 2022 showing Indian grass and tall sunflower (right).

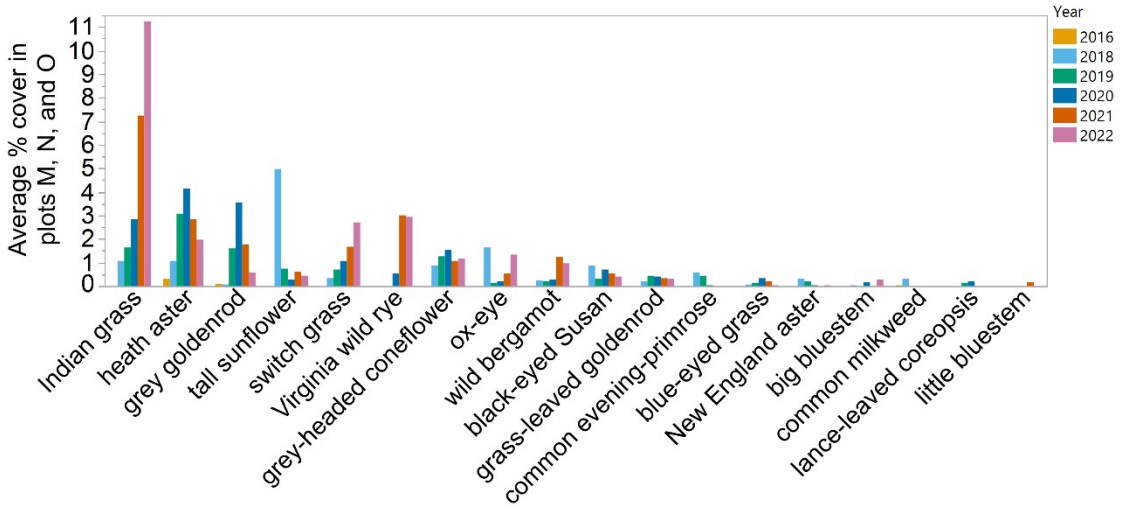

Figure 24. Average percent cover of seeded species that germinated in plots M, N, and O between 2018 and 2022.

Experimental seeding trial plots

In 2019, two sets of experimental seeding trial plots were set-up in section 1.2. The broad goal of the study was to determine factors affecting seeding success in The Meadoway by answering the following questions:

- Is hand seeding or seeding using a seed drill more effective?
- Is seeding in the fall, winter, or spring most effective?
- Is spraying or not spraying (with glyphosate) more effective?

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

In order to answer these questions, each treatment combination was replicated in the design of the experimental plots including the timing of seeding (fall, winter, spring), the effectiveness of spraying or not spraying and seeding method (hand seeding vs. seed drill). Vegetation plot monitoring occurred in September 2020 to assess seeding success. We set-up 36 1 x 1 m quadrats (plus 6 control 1 x 1 m quadrats), one in the centre of each treatment replicate (9 x 2 m section) or just outside the hand seeded areas (Figure 25 and Figure 26).

In 2020, 2021, and 2022 we counted the number of stems and estimated the percent cover of all native species within each quadrat. We also counted the number of stems of a select list of invasive species that would be targeted for management within each quadrat including creeping thistle, bull thistle (*Cirsium vulgare*), DSV, knapweeds (*Centaurea* spp.), tansy, common reed, Manitoba maple (*Acer negundo)*, black locust (*Robinia pseudoacacia*), Japanese knotweed (*Reynoutria japonica* var. *japonica* (Poljapo)), garlic mustard (*Alliaria petiolata*), and common burdock (*Arctium minus*). Within the larger, 9 x 2 m sections, a species list was created but only included species suspected to have been in the seed mix along with specific asters and goldenrods and targeted invasive species listed above. This analysis only included a comparison of species seeded in the seed mix to species occurring within the 1 x 1 m quadrats along with stem counts of seeded species.

One set of plots, called the butterfly mix plots, were located in the west end of section 1.2 (Figure 25). These plots had butterfly mix seeded in various combinations of treatments including hand seeding in either winter 2019-2020 or spring 2020, seed drilling in spring 2020, and areas that were sprayed or not sprayed. Plots were again seeded with butterfly mix in fall 2021 using a broadcast seeder and spot spraying of invasives occurred in summer 2021.

The other set of plots, dry mix plots, were located in the east end of section 1.2 (Figure 26). These plots had dry mix seeded in various combinations of treatments including hand seeding in either fall 2019, winter 2019-2020 or spring 2020 and areas that were sprayed or not sprayed. Plots were seeded with butterfly mix in fall 2021 using a broadcast seeder and spot spraying of invasives occurred in summer 2021.

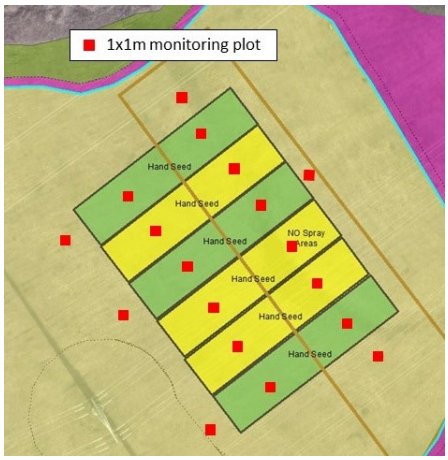

Figure 25. Butterfly seed mix trial plot area showing areas with various treatment combinations. Green = hand seeded in spring, yellow = hand seeded in winter, large gold box indicates no spray areas while all other areas were sprayed, light beige area outside of yellow and green boxes indicates areas seeded with the seed drill in the spring.

Figure 26. Dry seed mix trial plot area showing areas with various treatment combinations. Green = hand seeded in spring, blue = hand seeded in winter, pink = hand seeded in fall, large teal box indicates the no spray area while all other areas were sprayed.

Butterfly mix test plots

We used a full factorial model to examine the effect of seeding season (winter or spring), spraying (sprayed or not sprayed), and year (2020, 2021, 2022) on seeding success of the butterfly mix. We used a second model to examine the effect of seeding method (hand or seed drill), spraying, and year on seeding success since seed drilling only occurred during the spring.

There was a significant effect of both seeding season ($F_{1,1}$=12.4, p=0.001) and spraying ($F_{1,1}$=4.00, p=0.05) on species richness (Figure 27). Species richness was higher when seeds were sown in the winter (7.0±0.58) compared to spring (4.5±0.47) and when the plots were sprayed (6.1±0.51) compared to unsprayed (4.8±0.54). There was no significant effect of year on species richness ($F_{2,2}$=0.780, p=0.466).

There was a significant interaction effect between spraying, seeding season, and year on stem count suggesting that the effectiveness of spraying and seeding season varied by year ($F_{2,2}$=3.9, p=0.04; Figure 27). Stem counts were higher in 2022 for plots that were sprayed and seeded in winter (69±6.1) compared to all other combinations of spraying, season, and year.

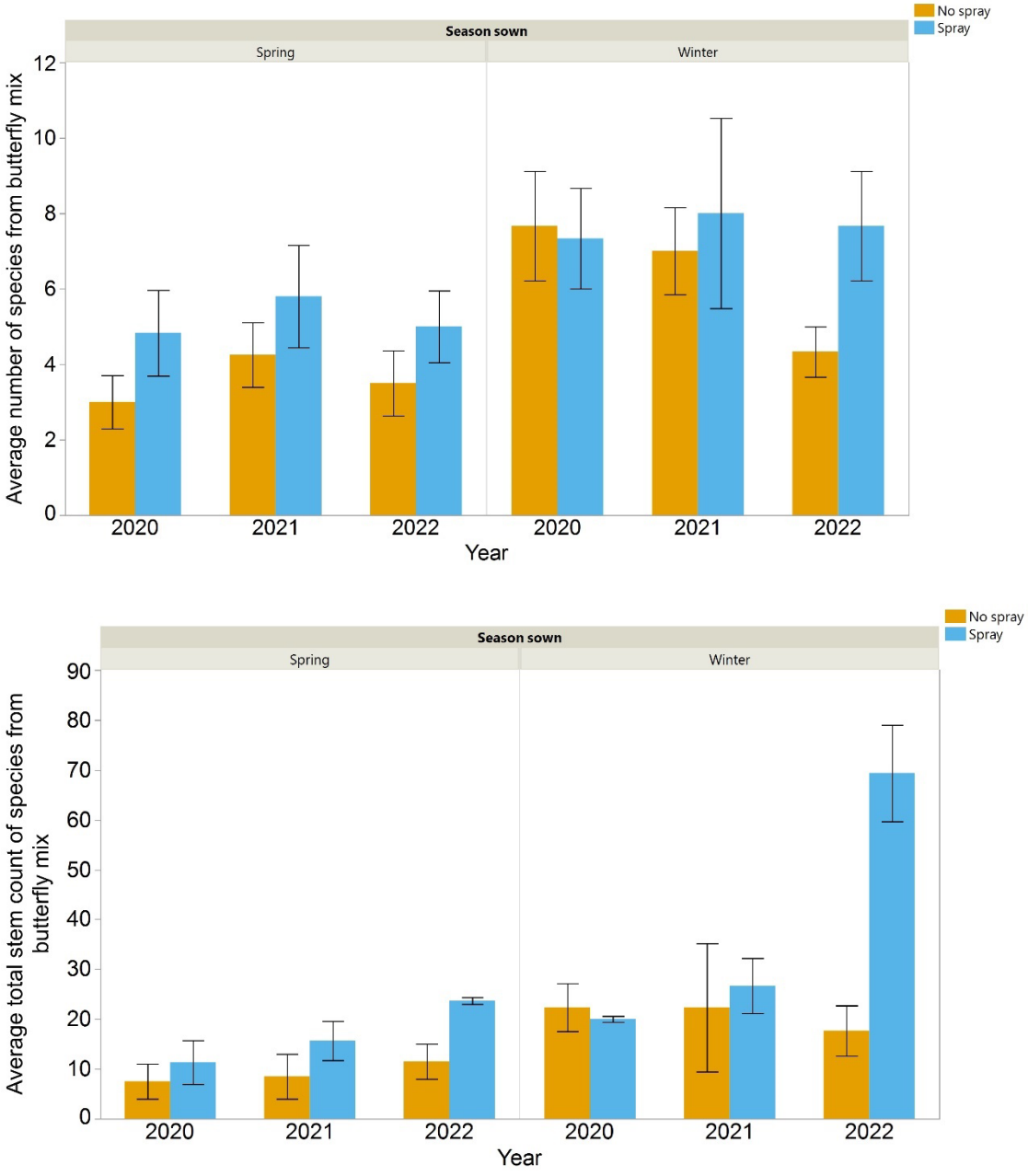

Figure 27. Effect of seeding season and spraying on seeding success (species richness – Top, number of stems – Bottom) in butterfly mix plots monitored between 2020 and 2022. Shown are averages ± 1 standard error for each treatment combination.

There was no significant effect of seeding method (hand or seed drill) or spraying on the number of species observed from the seed mix if sown in the spring (all p>0.14; Figure 28). There were significant interaction effects between seeding method and spraying ($F_{1,1}$=4.67, p=0.046) and also between spraying and year ($F_{2,2}$=4.2, p=0.034). Stem counts were highest when plots were sprayed and sown with a seed drill (41±5.3). Stem counts were also highest in 2022 in plots that were sprayed compared to other years regardless of whether or not plots were sprayed.

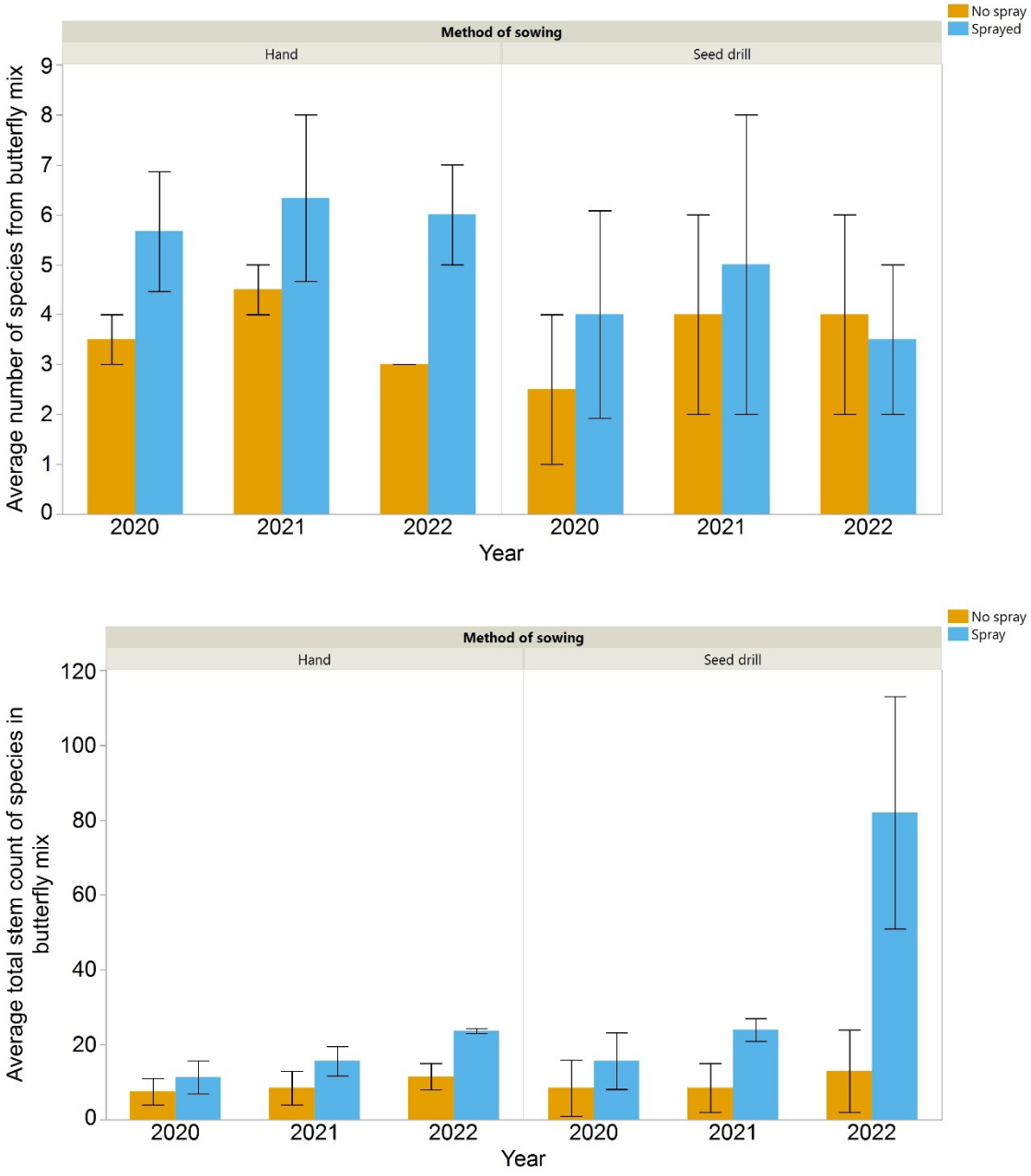

Figure 28. Effect of seeding method and spraying on seeding success (species richness – Top, number of stems – Bottom) in butterfly mix plots if seeded in the spring. Plots were monitored between 2020 and 2022. Shown are average ± 1 standard error for each treatment combination.

In summary, within the plots seeded with butterfly mix, seeding in the winter, spraying, and use of the seed drill were most effective at maximizing both the number of species and total number of stems.

Dry mix test plots

We used a full factorial model to examine the effect of seeding season (fall, winter, spring), spraying (sprayed or not sprayed), and year (2020, 2021, 2022) on seeding success of the dry mix. A different seed mix was used for seed drilling outside of test plots so a comparison between hand seeding and seed drilling was not possible.

There was a significant interaction effect between seeding season and spraying ($F_{2,2}$=10.5, p=0.003; Figure 29). This means that the effectiveness of spraying depended on the seeding season. When seeding occurred in the spring and plots were not sprayed, significantly fewer species from the seed mix were found in the plots compared to all other treatment combinations.

Significantly higher stem counts occurred when plots were sprayed (24±2.6) compared to not sprayed (8±2.6; $F_{1,1}$=19.1, p<0.001; Figure 29). Significantly higher stem counts also occurred in 2021 (23±3.2) compared to both 2020 (13±3.2) and 2022 (13±3.2; $F_{2,2}$=3.68, p=0.04).

In summary, within the plots seeded with dry mix, spraying significantly increased seeding success and stem count and this was most effective when seeding occurred in the spring.

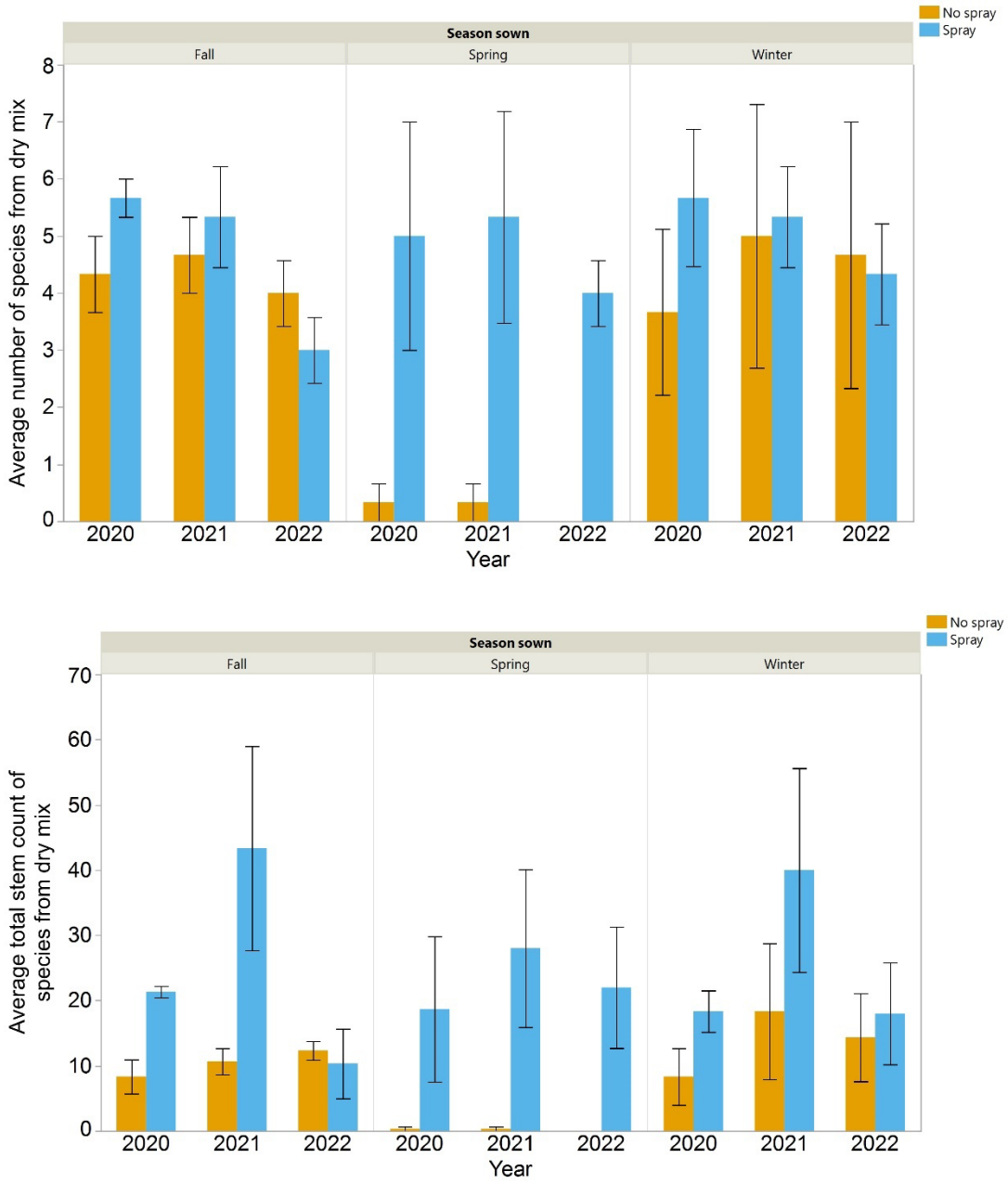

Figure 29. Effect of seeding season and spraying on seeding success (species richness – Top, number of stems – Bottom) in dry mix plots monitored between 2020 and 2022. Shown are averages ± 1 standard error for each treatment combination.

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 (six years). Sections 1, 2, 5, and 6 all have less data and section 2.2 was monitored for the first time in 2022. In sections 1.2, 1.4, and 2.4 there are pre- and post-restoration data for comparisons. One new bird station was added in 2022 (station 15 in section 2.2).

Forty-three bird species were detected during surveys between 2016 and 2022 (Appendix 1). These included four species of conservation concern in the Toronto Region (ranked L3): Eastern Meadowlark (*Sturnella magna*), Wild Turkey (*Meleagris gallopavo*), American Redstart (*Setophaga ruticilla*), and Least Flycatcher (*Empidonax minimus*). Eastern Meadowlark is a meadow 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*) (Figure 30), 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.

Figure 30. Savannah Sparrow (*Passerculus sandwichensis*) in section 7 in 2022.

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. We considered 2016, 2018, and 2019 early post-restoration and 2020, 2021, and 2022 later post-restoration. The earlier restoration time period 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 31). The later time period had several species not found in earlier years or found in a higher abundance including American Restart (AMRE), Orchard Oriole (*Icterus spurius*; ORIO), Cooper's Hawk (*Accipiter cooperii*; COHA), Rose-breasted Grosbeak (*Pheucticus ludovicianus*; RBGR), Field Sparrow (FISP), and Least Flycatcher (LEFL).

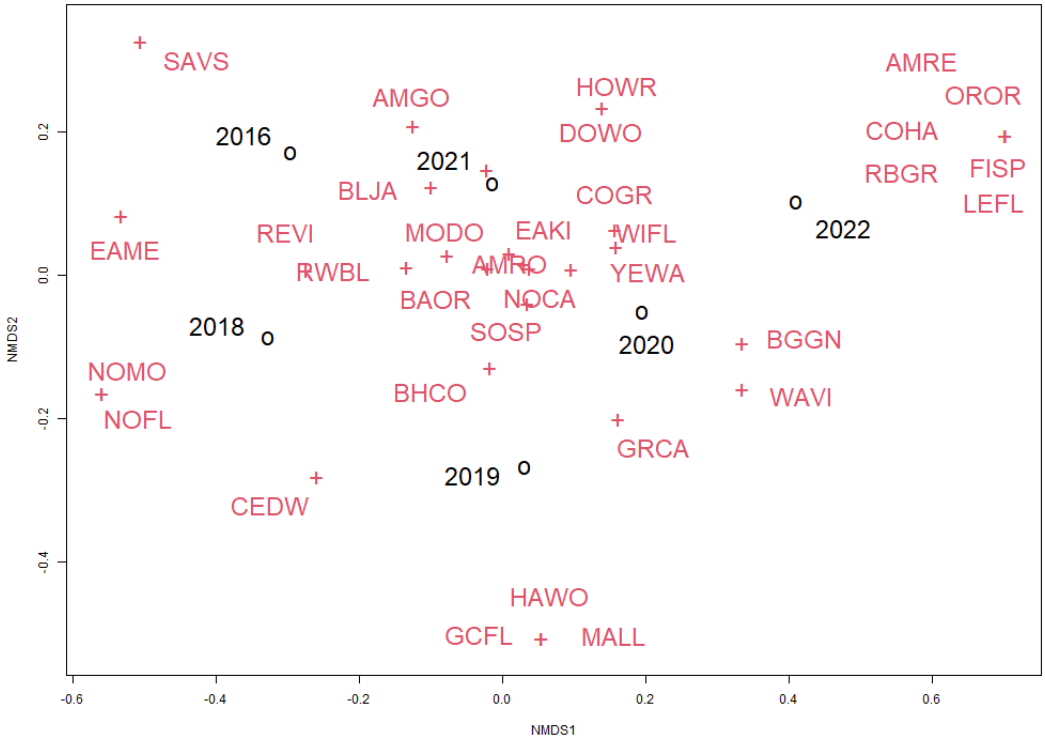

Figure 31. An ordination of bird community composition in sections 4 and 7 comparing between early (2016, 2018, 2019) and later (2020, 2021, 2022) post-restoration time periods. The location of species codes represents their relationship with specific years (e.g. if a species name is located near a year point, that species was found in higher abundance during that year).

Section 2.2

This section was monitored for the first time in 2022 after being seeded in both 2020 and 2021. Species observed included many common species found in other areas of The Meadoway but the Red-breasted Nuthatch (*Sitta canadensis*) was a first record for The Meadoway (Figure 32). Red-breasted Nuthatch is a woodland species likely using The Meadoway for foraging on insect prey.

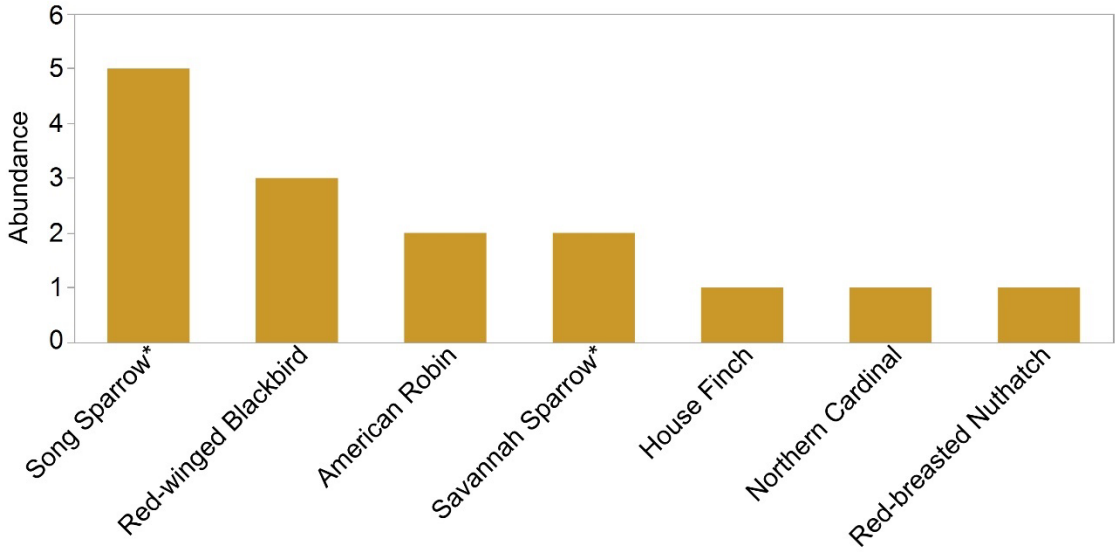

Figure 32. Total bird abundance by species and year at The Meadoway in section 2.2 monitored for the first time in 2022. An asterisk (*) indicates a meadow-dependent species.

Pre- and post-restoration bird communities

We compared pre- and post-restoration bird communities in sections 1.2 (station 8), 1.4 (station 6), and 2.4 (station 7) since both pre- and post-restoration data were available. The years considered pre- or post-restoration varied slightly among section (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

Red-winged Blackbird and Song Sparrow appeared to benefit the most from meadow restoration in sections 1.2, 1.4, and 2.4. The abundance of both Red-winged Blackbird (t_9=2.27, p=0.049) and Song Sparrow (t_9=3.06, p=0.014) increased significantly post-restoration (Figure 33).

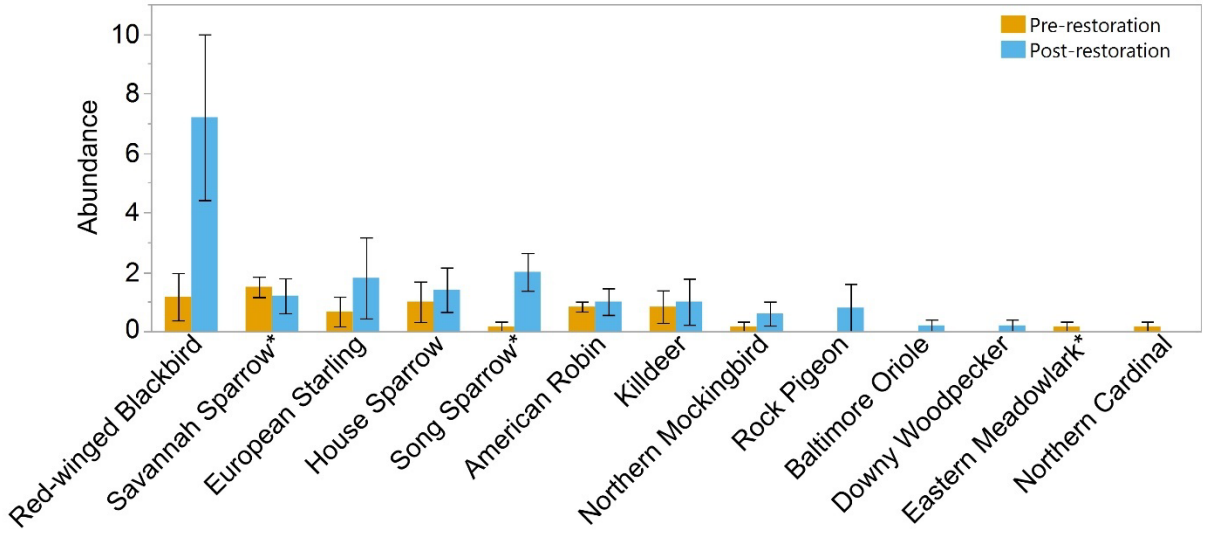

Figure 33. Temporal changes in bird species composition and abundance in sections 1.2, 1.4, and 2.4 (stations 8, 6, and 7) pre- and post-restoration. An asterisk (*) indicates a meadow-dependent species.

Butterfly surveys

Forty-three butterfly species were observed during surveys between 2016 and 2022 (Appendix 2). Of these 43 species, the 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 39 were recorded in 2022.

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 (*Phyciodes tharos*), 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.). Both European Common Blue (*Polymmatus icarus*) and Viceroy (*Limenitis archippus*) increased in abundance between 2016 and 2022 (p=0.08), while Black Swallowtail (*Papilio polyxenes*) decreased in abundance (p<0.05; Figure 34).

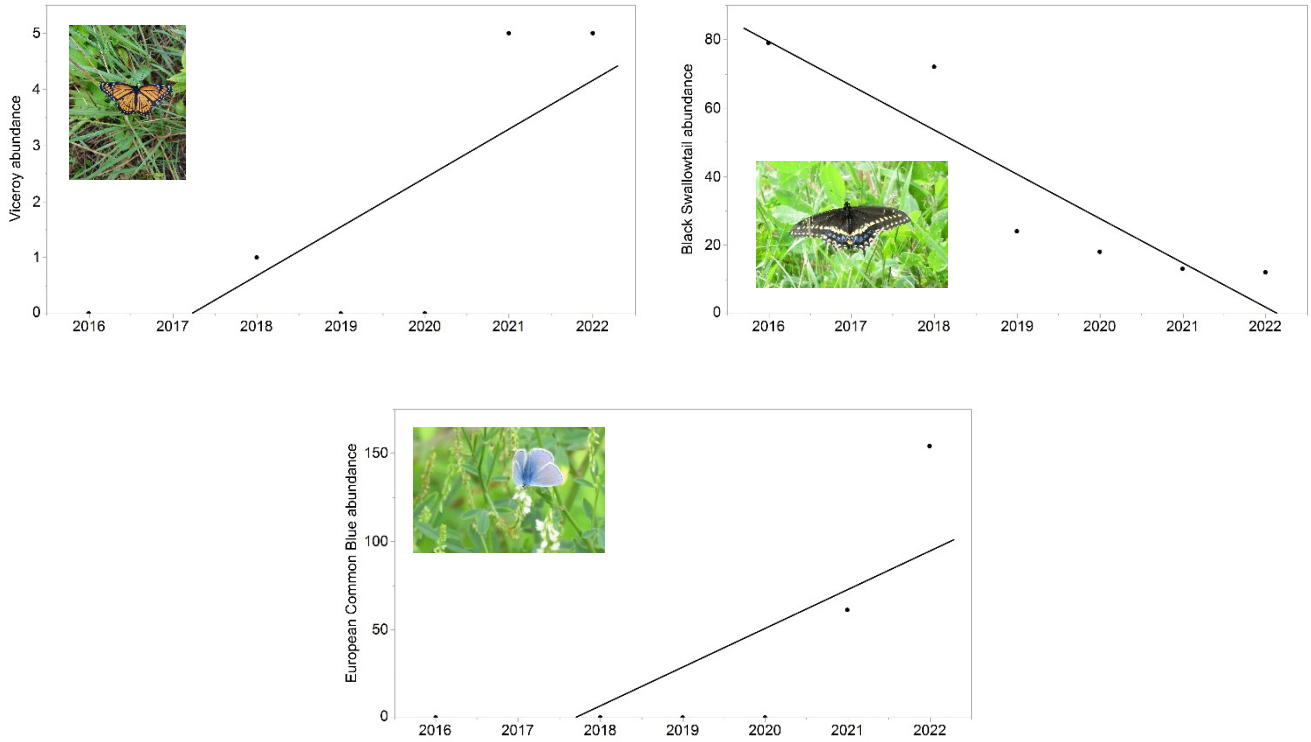

Figure 34. Significant temporal trends (p<0.10) for butterfly species in sections 4 and 7 and between 2016 and 2022.

In addition to sections 4 and 7, European Common Blue has been increasing in abundance across The Meadoway since 2020 (Figure 35). 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.

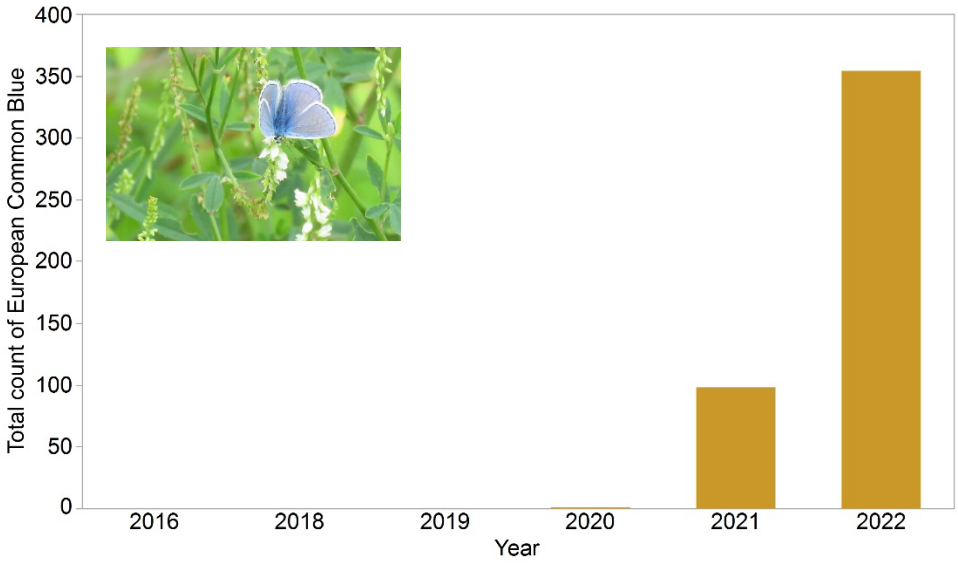

Figure 35. Total count of European Common Blue across The Meadoway since 2016.

Sections 1 and 2

Sections 1.2 (west end) and 2.2 were monitored for the first time in 2022 and while fewer species and individuals were found, the section did support several local, resident breeding species such as Wild Indigo Duskywing (*Erynnis baptisiae*), Common Ringlet (*Coenonympha tullia*), Black Swallowtail, Eastern Tailed Blue (*Cupido comyntas*), and Viceroy (Figure 36, Figure 37). One new resident species, the Hobomok Skipper (*Lon hobomok*), was found for the first time in 2022 in section 1.

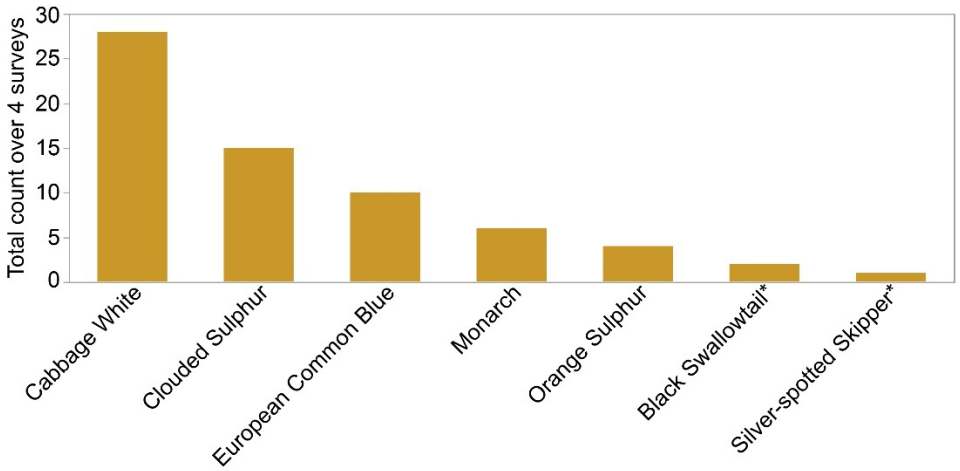

Figure 36. Total butterfly count in section 1.2 at The Meadoway in 2022. An asterisk (*) indicates a resident species.

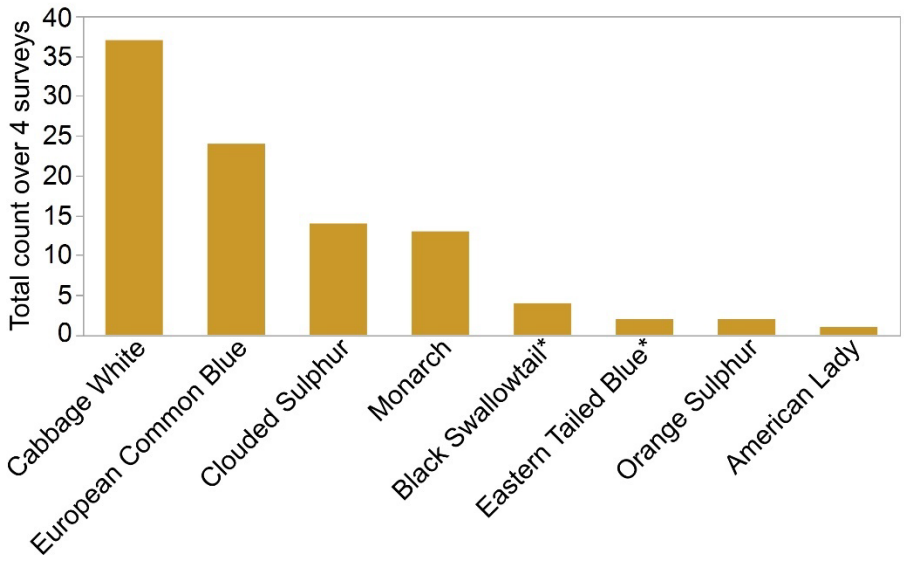

Figure 37. Total butterfly count in section 2.2 at The Meadoway in 2022. An asterisk (*) indicates a resident species.

Butterfly surveys occurred in 2020 (early post-restoration) and in 2021 and 2022 (post-restoration) in section 1.2. Butterfly communities appeared to have changed between 2020 and 2021/2022 by increasing in either species richness or abundance (Figure 38). Early post-restoration in 2020, 6 species were present, post-restoration in 2021 10 species were present, while in 2022, 7 species were present. Several species present in 2021 were not present in 2022 including Eastern-tailed Blue, Red Admiral (*Vanessa atalanta*), Silver-spotted Skipper (*Epargyreus clarus*), and Silvery Blue. Black Swallowtail increased in abundance between 2021 and 2022.

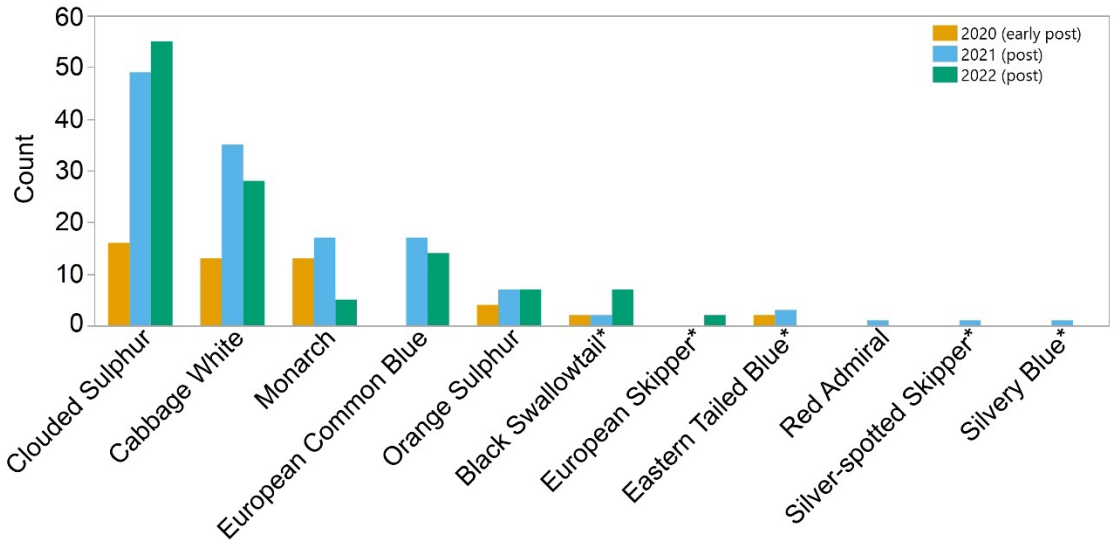

Figure 38. Temporal changes in butterfly species composition and abundance on transect 1F (section 1.2) pre- and post-restoration. An asterisk (*) indicates a resident species.

Butterfly surveys were conducted in 2019 (pre-restoration) and in 2021 and 2022 (post-restoration) in section 2.4 (transect 2K). Butterfly communities appeared to have changed between 2019 and 2021/2022 by increasing in either species richness or abundance (Figure 39). Pre-restoration in 2019, 6 species were present, and post-restoration in 2021 and 2022, 10 species were present. Species only present post-restoration included European Common Blue, Eastern Tailed Blue, Orange Sulphur (*Colias eurytheme*), European Skipper (*Thymelicus lineola*), Silvery Blue, and Great-spangled Fritillary.

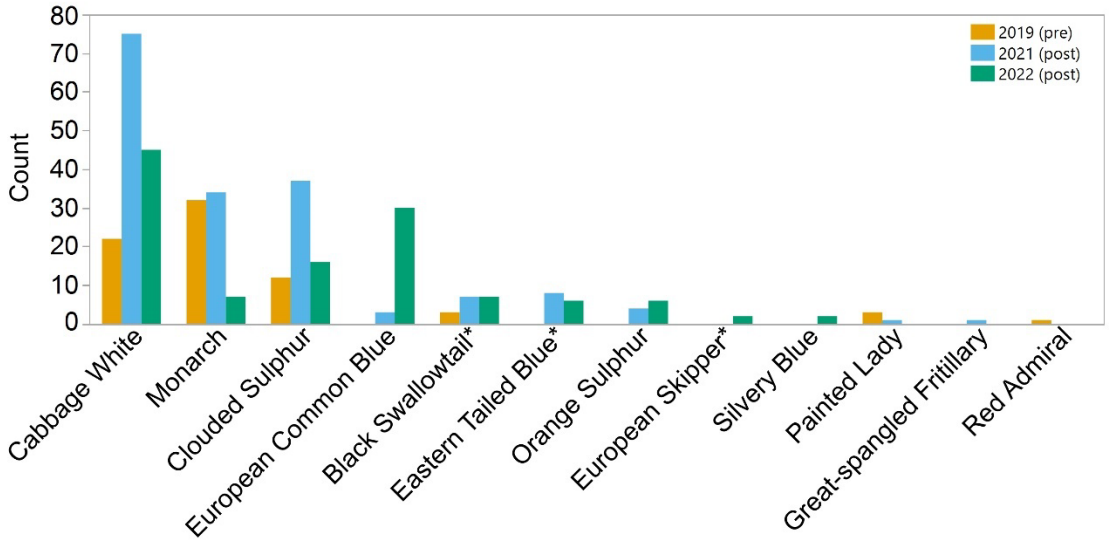

Figure 39. Temporal changes in butterfly species composition and abundance on transect 2K pre- and post-restoration. An asterisk (*) indicates a resident species.

SUMMARY

Meadow monitoring during 2016, and 2018-2022 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. Pre-restoration communities were dominated by meadow fescue, dandelion (*Taraxacum officinale*), and red clover (*Trifolium pratense*). Post-restoration communities contained many seeded species with covers of up to 65% 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 five years of monitoring, several patterns emerged related to the longer term success of restoration efforts. Sections with the longest record of restoration and monitoring (>5 years) 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 2022 including wild bergamot, ox-eye, common milkweed, stiff goldenrod, cup-plant, big bluestem, tall sunflower, and Indian grass.

Figure 40. Foxglove beardtongue (*Penstemon digitalis*) (left); common milkweed (*Asclepias syriaca*) (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 3% in 2022. Overall, current methods appear to be mostly effective for controlling thistle but DSV 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.

After three years of monitoring the experimental seeding plots, results provide several insights into effective seeding techniques. Within the plots seeded with butterfly mix, winter seeding was most effective producing the highest stem counts and number of species. Spraying was not effective if seeding occurred in the winter with similar success observed between sprayed and non-sprayed plots; however, by 2022 spraying in winter resulted in higher stem counts and species richness. There was no difference in seeding success based on whether or not the seed drill was used or the seeds were hand sown; however, by 2022 use of the seed drill combined with spraying in the spring resulted in high stem counts of seeded species. This comparison was only possible in the spring since that was when seeding with the seed drill occurred.

Within the experimental plots seeded with dry mix, the effectiveness of spraying depended on the seeding season. When seeding occurred in the spring and plots were not sprayed, significantly fewer species from the seed mix were found in the plots compared to all other treatment combinations. With three years of monitoring post-seeding, the benefits of continuing to monitor these plots should be considered.

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 and Willow Flycatcher, while Field Sparrow occurred for the first time in 2022. Field Sparrow nest in open habitats with many low perches but generally avoid suburban areas other than during migration. 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. The Meadoway also 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 (*Pieris rapae*) 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 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 in sections 1 and 2 suggest 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. Both Cabbage White and Clouded Sulphur doubled in abundance pre- and post-restoration and their numbers remain high in 2022. Cabbage White is a non-native species and Clouded Sulphur is commonly found in Ontario. Restoration in sections 1 and 2 also resulted in numerous resident species occurring that were not present pre-restoration including Eastern Tailed Blue, European Skipper, Silvery Blue, and Silver-spotted Skipper. These pre- and post-restoration data suggest that restoration efforts are creating habitat for additional butterfly 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, 2018-2022.

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

Appendix 1. (cont'd)

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

Appendix 2. Butterfly occurrence in The Meadoway 2016, 2018-2021.

Common name	Scientific name	S-rank	Section 1						Section 2						Section 4.1						Section 4.2						Host plant
			2016	2018	2019	2020	2021	2022	2016	2018	2019	2020	2021	2022	2016	2018	2019	2020	2021	2022	2016	2018	2019	2020	2021	2022	
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			3	x	7	11	3	5	3	1	1		22	19	7	7	2	4	Carrot family… parsley, dill, celery,Queen Anne's lace
Blue species	Lycaenidae family	n/a					15	3				x	1	3									2		2	4	
Cabbage White	*Pieris rapae*	SNA			8	13	148	151			22	x	75	82	55	90	24	12	36	11	21	51	36	12	72	36	Mustards… cabbage, cauliflower and broccoli
Clouded Sulphur	*Colias philodice*	S5			2	16	105	107			12	x	37	30	5	5	1	7	14	3	32	52	17	33	46	19	Legumes… cultivated crops
Common Buckeye	*Junonia coenia*	SNR (G5)										x															Uncommon breeding migrant
Common Ringlet*	*Coenonympha tullia*	S5			1		2	4				x			2	1			1	1	1	3	7	17	10	18	Kentucky bluegrass
Common Wood-Nymph	*Cercyonis pegala*	S5										x							1		1	1		1	4	1	Grasses (Poaceae)
Crescent species*	*Phyciodes* spp.	n/a										x															
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					x	8	8	4		1			6	6	4	8	5	20	1	Clovers and legumes
Eastern Tiger Swallowtail*	*Pterourus glaucus*	S5										x									1	1			1		Trees… hop tree, cherries and ashes
European Common Blue	*Polymmatus icarus*	SNA					32	87				x	3	54					2	1					4	25	Alfalfa, clover, crown vetch (Burghardt et al. 2001), bird's-foot trefoil (many other legumes black medick)
European Skipper*	*Thymelicus lineola*	SNA					6	6				x		2								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									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						Violets
Lady species	*Vanessa* spp.	n/a										x											1				
Least Skipper*	*Ancyloxypha numitor*	S5					2	8				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			32	x	34	20		6	37	11	16	9	7	217	195	46	86	59	Milkweeds
Mourning Cloak*	*Nymphalis antiopa*	S5										x													2		Trees… willows, elms, cottonwoods and hackberries
Northern Broken-Dash*	*Wallengrenia egeremet*	S5										x															Panic grasses: deertongue
Northern Crescent*	*Phyciodes cocyta*	S5										x			1	2											Asters
Orange Sulphur	*Colias eurytheme*	S5			1	4	20	23				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										x							1					1			Smooth-leaved true asters
Peck's Skipper*	*Polites peckius*	S5					1					x					1	1			2	1	3	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				1	x					13				1	1	15	1	2		Nettles
Silver-spotted Skipper*	*Epargyreus clarus*	S4					3	3				x			2			1		1	1						Legumes… showy tick-trefoil, Am. hog peanut and black locust
Silvery Blue*	*Glaucopsyche lygdamus*	S5					1	1				x		2							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										x													1		Dogwoods, New Jersey tea, meadowsweets and viburnums
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										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	2016	2018	2019	2020	2021	2022	2020	2021	2022	2021	2022	2016	2018	2019	2020	2021	2022	
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	5	x		1	2	3	11	3	3	8	3	Carrot family… parsley, dill, celery and Queen Anne's lace
Blue species	Lycaenidae family	n/a			21		3	3			2		1	6		x						5	1	3	2	
Cabbage White	*Pieris rapae*	SNA	26	56	40	15	34	17	53	86	38	2	44	46	20	x		15	28	61	327	28	36	77	95	Mustards… cabbage, cauliflower and broccoli
Clouded Sulphur	*Colias philodice*	S5	35	37	17	40	38	29	37	62	25	18	30	11	80	x		31	23	24	105	58	57	32	45	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				3	11	18	15	x		8	49	20	66		4	7	14	Kentucky bluegrass
Common Wood-Nymph	*Cercyonis pegala*	S5			1	1	2	2							1	x					1			3		Grasses (Poaceae)
Crescent species*																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	2	1	6	5	23	2	2	x		3	2	13	10			8		Clovers and legumes
Eastern Tiger Swallowtail*	*Pterourus glaucus*	S5							1			1				x										Trees… hop tree, cherries and ashes
European Common Blue	*Polymmatus icarus*	SNA					6	29					7	61	1	x		2	59					42	38	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	5			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							
Hobomok Skipper*	*Lon hobomok*	S5																								Various grasses including panic grasses (*Panicum*) and blue grasses
Great-spangled Fritillary	*Speyeria cybele*	S5														x										Violets
Lady species																x										
Least Skipper*	*Ancyloxypha numitor*	S5														x										Grasses (Poaceae)
Little Wood-Satyr*	*Megisto cymela*	S5														x			1							Grasses (Poaceae)… Kentucky bluegrass and orchard grass
Monarch	*Danaus plexippus*	S2N,S4B	3	46	280	49	68	39	5	28	79	11	44	43	12	x		20	10	4	38	227	7	46	11	Milkweeds
Mourning Cloak*	*Nymphalis antiopa*	S5			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	Legumes… clovers and alfalfas
Painted Lady	*Vanessa cardui*	S5			1						4					x										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		1	1	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					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			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							4	x			4	3	7					Panicgrasses and bluegrasses
Summer Azure*	*Celastrina neglecta*	S5														x									1	Dogwoods, New Jersey tea, meadowsweets and viburnums
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		5	16					3		Purple crown-vetch

Appendix 2. (cont'd)

Legend
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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