Toronto and Region Conservation Authority

The Meadoway: Vegetation, Bird, and Butterfly Monitoring 2016, 2018-2021

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.

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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, 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. Mowing and herbicide application has occurred intermittently in different sections although became a more prominent focus in 2018.

Monitoring activities occurred in 2016, 2018, 2019, 2020, and 2021 to document changes in species composition related to the vegetation, breeding birds, and butterfly presence. This report is an update to the 2020 monitoring report (TRCA 2020) with a similar focus on establishment of seeded species and invasive species management, but also new findings comparing pre- and post-restoration vegetation communities. 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.

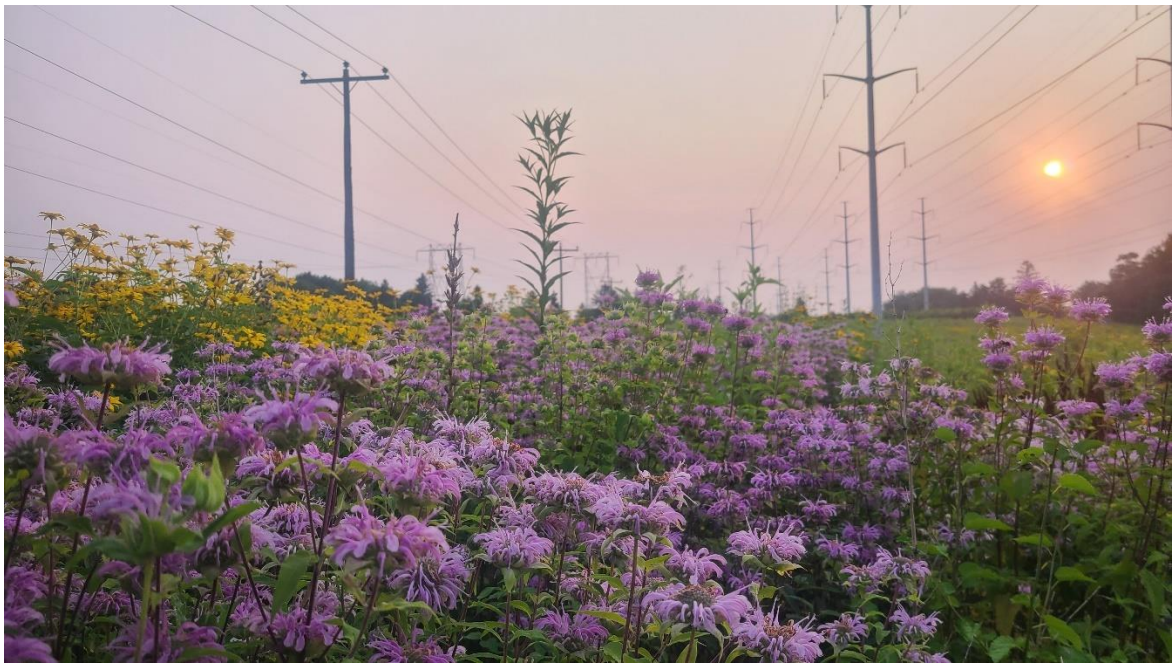

Figure 1. The Meadoway.

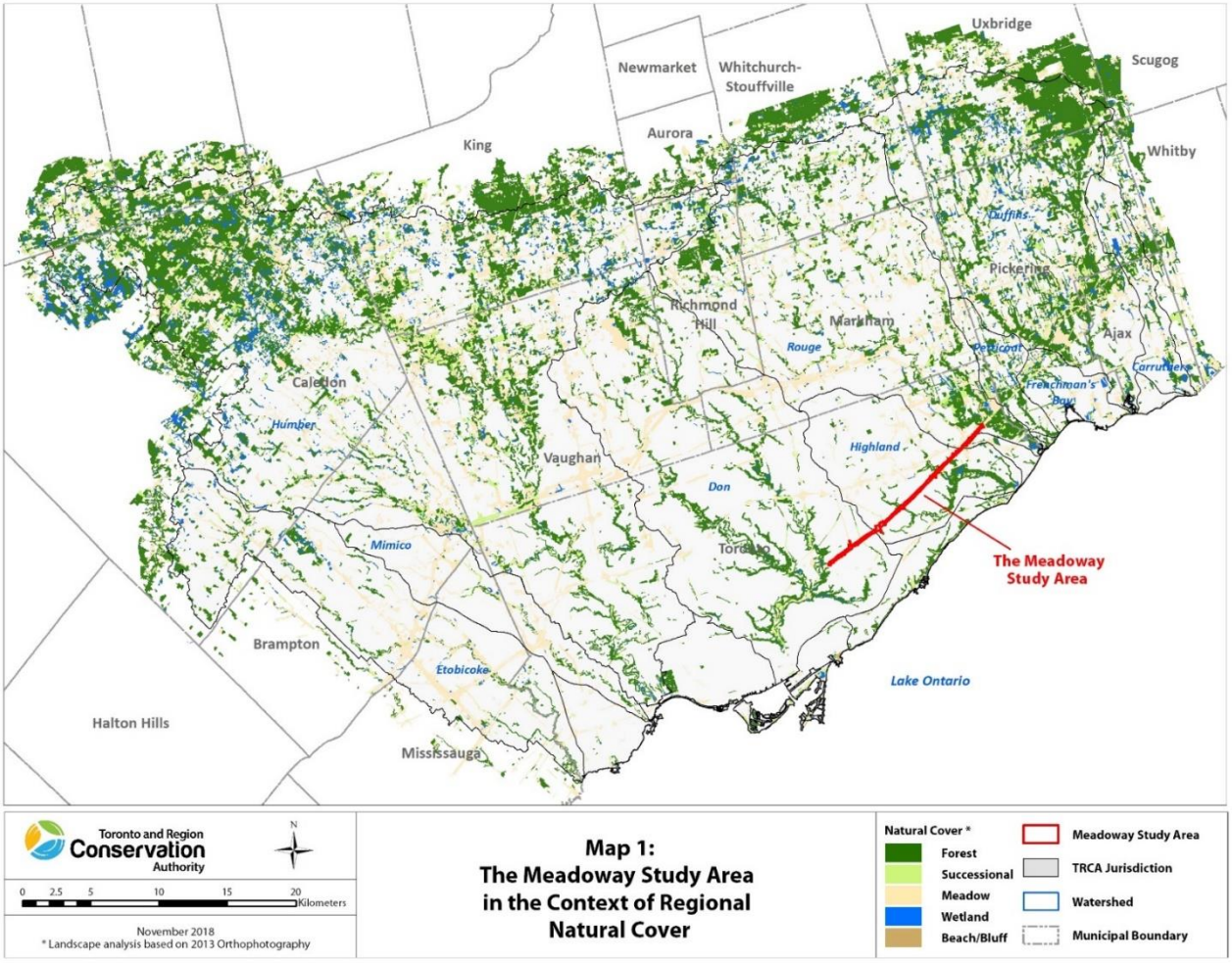

Figure 2. Geographic location of The Meadoway related to TRCA's jurisdiction.

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. Vegetation plot set-up at The Meadoway.

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.

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 Bob Hunter Meadow Management Monitoring Protocol (TRCA 2016).

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, 2018, 2019, 2020, and 2021 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.

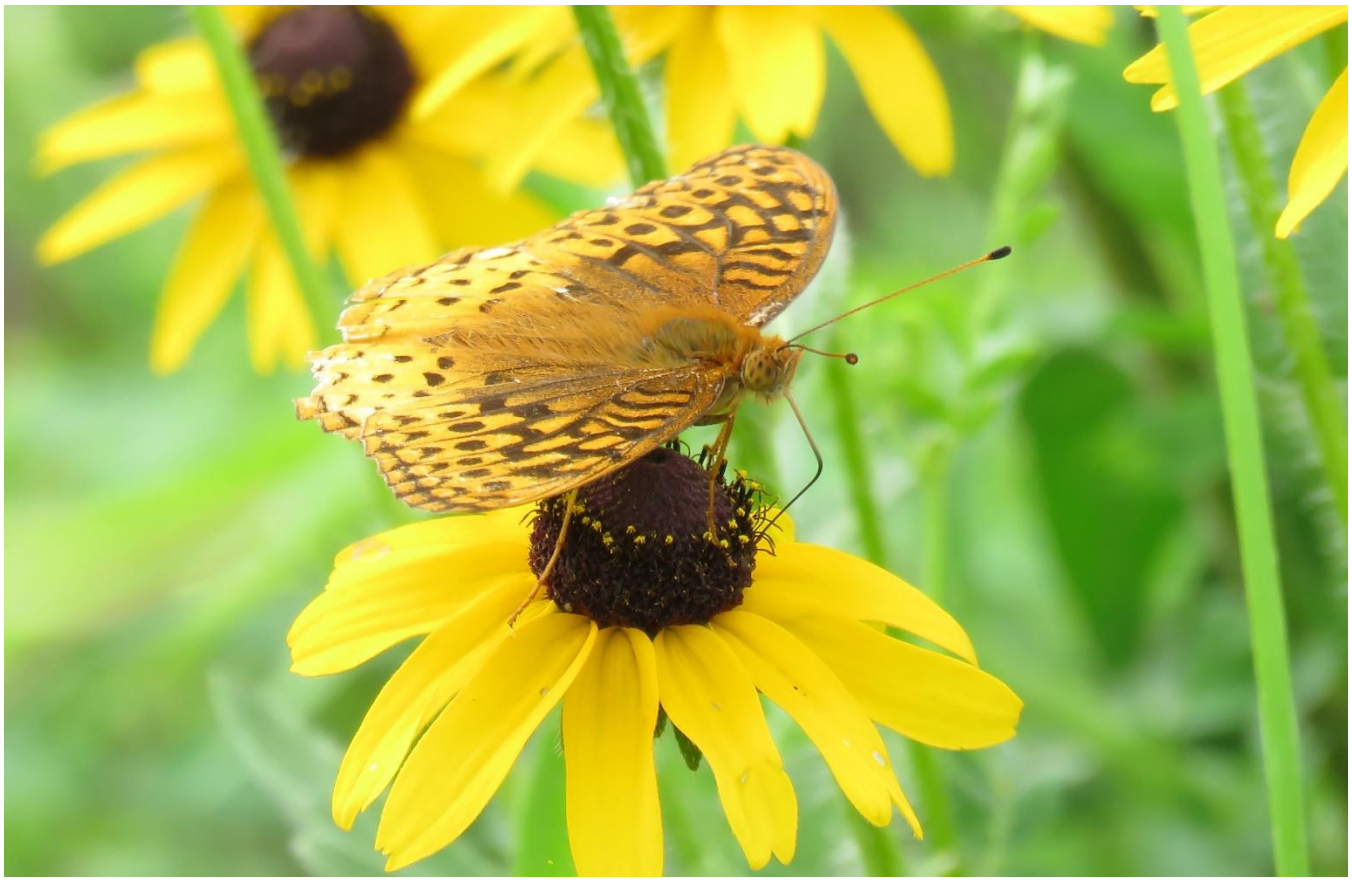

Figure 5. Great-spangled Fritillary (*Speyeria cybele*).

RESULTS

Thirty-three vegetation plots were set-up between 2016 and 2021 (Table 1, Figure 6). Plots were set-up in different years corresponding to the occurrence of management activities. Bird monitoring was completed in 2016, 2018, 2019, 2020, and 2021 with four new stations added in 2021 in sections 1.1, 1.3, 6.2, and 6.4. Butterfly monitoring was completed in 2016, 2018, 2019, 2020, and 2021. In 2016 and 2018, five sections were surveyed 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. In 2021, four new transects were added to sections 1.1, 1.3, 6.2, and 6.4 (Figure 6).

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	11	2021	2021
	MV-24_1.1Y	2020, 2021			
1.2	MV-24_1.2P	2018, 2019, 2020, 2021	8	2020, 2021	2020, 2021
1.3	MV-24_1.3Q	2018, 2020, 2021	12	2021	2021
	MV-24_1.3V	2019 (abandoned post-2019)			
1.4	MV-24_1.4W	2019	6	2018, 2019, 2021	2019, 2021
	MV-24_1.4R	2019 (abandoned post-2019)			
2.2	MV-24_2.2S	2018, 2019, 2021			
2.3	MV-24_2.3T	2018, 2019, 2021			
2.4	MV-24_2.4U	2018, 2019, 2021	7	2018, 2019, 2021	2019, 2021
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	1	2016, 2018-2021	2016, 2018-2021
	MV-24_4.1H	2016, 2018, 2019, (2020 summer only), 2021			
	MV-24_4.1I	2016, 2018, 2019, 2021			
4.2	MV-24_4.2A	2016, 2018-2021	2	2016, 2018-2021	2016, 2018-2021
	MV-24_4.2B	2016, 2018-2021			
	MV-24_4.2C	2016, 2018-2021			
4.3	MV-24_4.3D	2016, 2018-2021	3	2016, 2018-2021	2016, 2018-2021
	MV-24_4.3E	2016, 2018, 2019, (2020 summer only), 2021			
	MV-24_4.3F	2016, 2018, 2019, (2020 summer only), 2021			
4.4	MV-24_4.4J	2016, 2018, 2019, (2020 summer only), 2021	4	2016, 2018-2021	2016, 2018-2021
	MV-24_4.4K	2016, 2018, 2019, (2020 summer only), 2021			
	MV-24_4.4L	2016, 2018, 2019, (2020 summer only), 2021			
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	2021
6.4	MV-24_6.4AH	2020	14	2021	2021
7.1	MV-24_7.1M	2016, 2018-2021	5	2016, 2018-2021	2016, 2018-2021
	MV-24_7.1N	2016, 2018-2021			
	MV-24_7.1O	2016, 2018-2021			

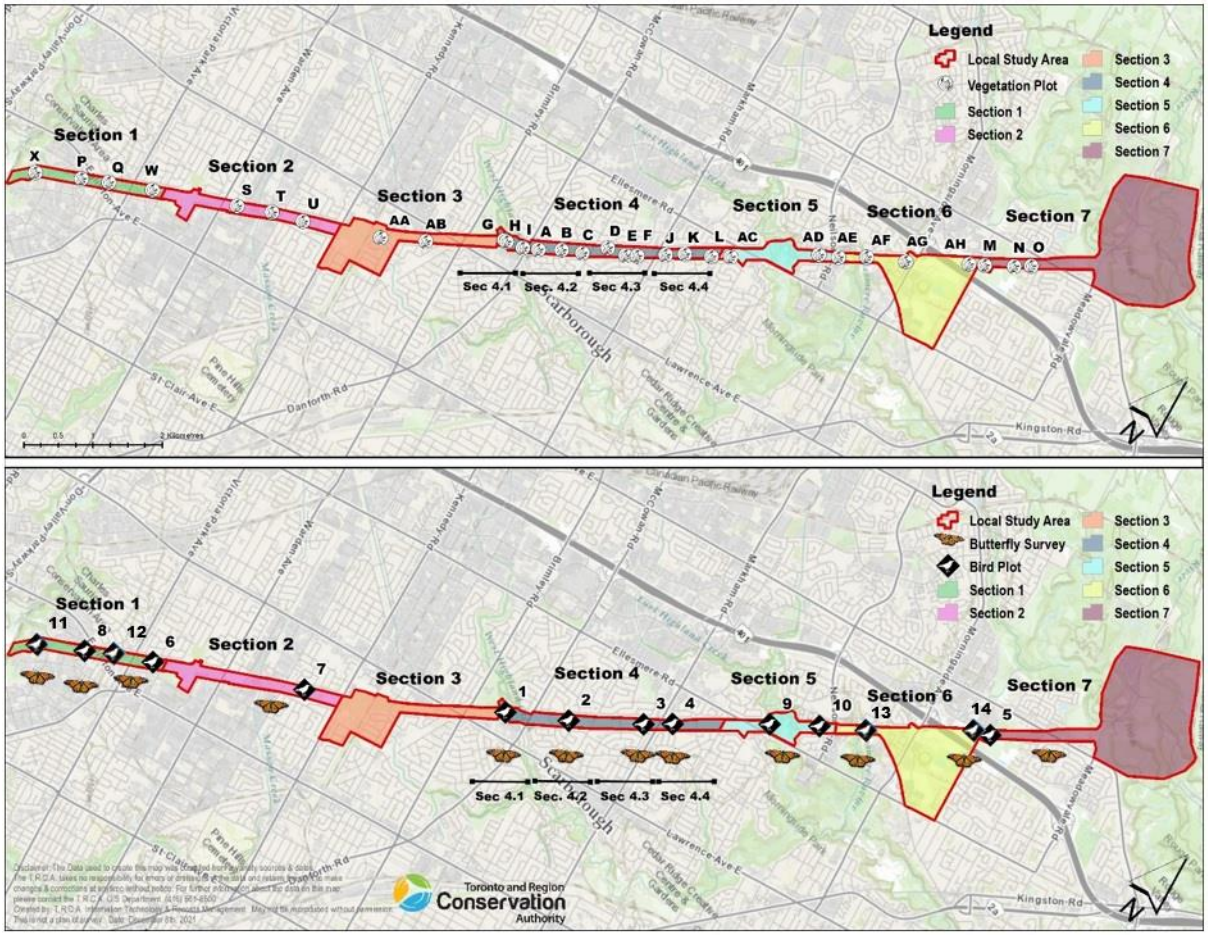

Figure 6. Vegetation plot, bird, and butterfly survey locations at The Meadoway in 2016, 2018-2021.

Vegetation plots

Vegetation monitoring plots were subject to different, and often multiple, management techniques over the past five years of monitoring. Due to this variation, each section 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 was seeded in May 2020.

The number of seeded species that germinated increased between 2019 and 2021. Plot X only contained one of the seeded species in 2019, but in 2020, 13 seeded species were observed and by 2021, 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 2021 (Figure 8). There was a drastic decline in the maximum percent cover of DSV from 90% in 2019 to 2% in 2021 most likely due to management activities.

Figure 7. Photos of plot X in section 1.1 pre-restoration 2019 (left) and post-restoration 2021 (right).

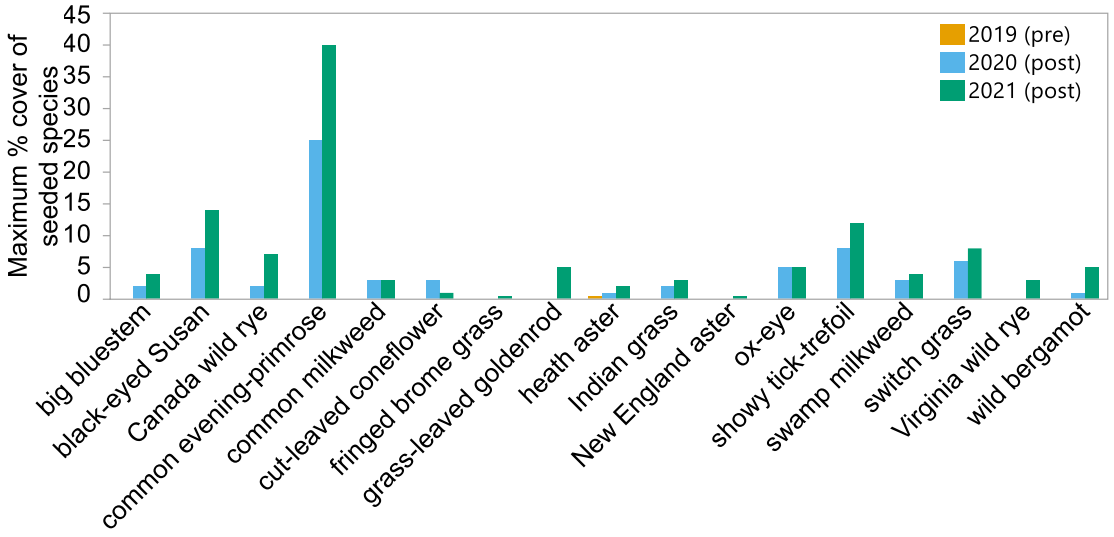

Figure 8. Changes in species occurrence and maximum percent cover of seeded species that germinated in plot X between 2019 and 2021. Note: heath aster occurred naturally in 2019.

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 was seeded in May 2020.

The number of seeded species that germinated increased between 2018 and 2021. Plot Q contained none of the seeded species in 2018, but in 2020, 11 seeded species were observed and in 2021, 10 seeded species were observed (Figure 10). Maximum percent cover of seeded species also increased between 2020 and 2021 for several species including black-eyed Susan (*Rudbeckia hirta*), Canada wild rye (*Elymus canadensis*), common evening primrose (*Oenothera biennis*), ox-eye (*Heliopsis helianthoides*), showy tick-trefoil, and wild bergamot (*Monarda fistulosa*) (Figure 10). Percent cover of seeded species that germinated was generally higher in plot X compared to plot Q. Plot Q had a low maximum percent cover of both DSV and creeping thistle pre- and post-restoration (0-3%).

Figure 9. Photos of plot Q in section 1.3 pre-restoration 2018 (left) and post-restoration 2021 (right).

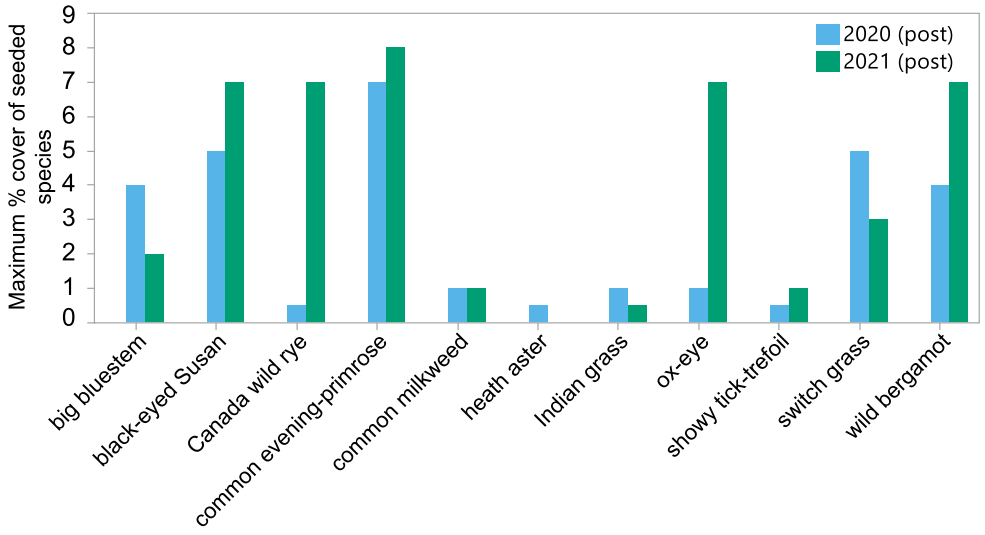

Figure 10. Maximum percent cover of seeded species that germinated in plot Q in 2020 and 2021. None of the seeded species were observed in 2018 (prior to seeding).

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 seeded in November 2020 and April 2021.

The number of seeded species that germinated increased between 2019 and 2021. Plot S contained none of the seeded species in 2019, but in 2021, 13 seeded species were observed with common evening-primrose having the highest percent cover (Figure 12). Maximum cover of DSV was low (<1%) in both years, while creeping thistle was high in 2021 (60%) likely due to an individual plant in the plot but it was noted as seeding. 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 2021 (right).

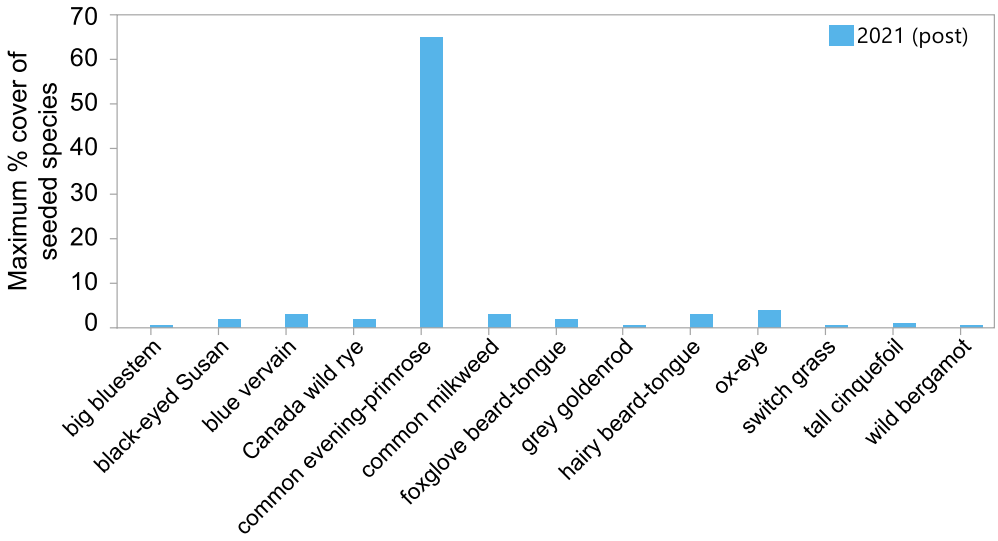

Figure 12. Maximum percent cover of seeded species that germinated in plot S in 2021. None of the seeded species were observed in 2019 (prior to seeding).

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 was seeded in November 2020 and April 2021.

The number of seeded species that germinated increased between 2019 and 2021. Plot T contained none of the seeded species in 2019, but in 2021, 14 seeded species were observed with common evening primrose having the highest percent cover (Figure 14). Common evening primrose is an early successional species usually found on dry or sandy roadsides, fields, clearings, and disturbed ground. Maximum DSV cover decreased from 6% in 2019 to 0.5% in 2021 and creeping thistle percent cover increased from 0% in 2019 to 5% in 2021.

Figure 13. Photos of plot T in section 2.3 pre-restoration 2019 (left) and post-restoration 2021 (right).

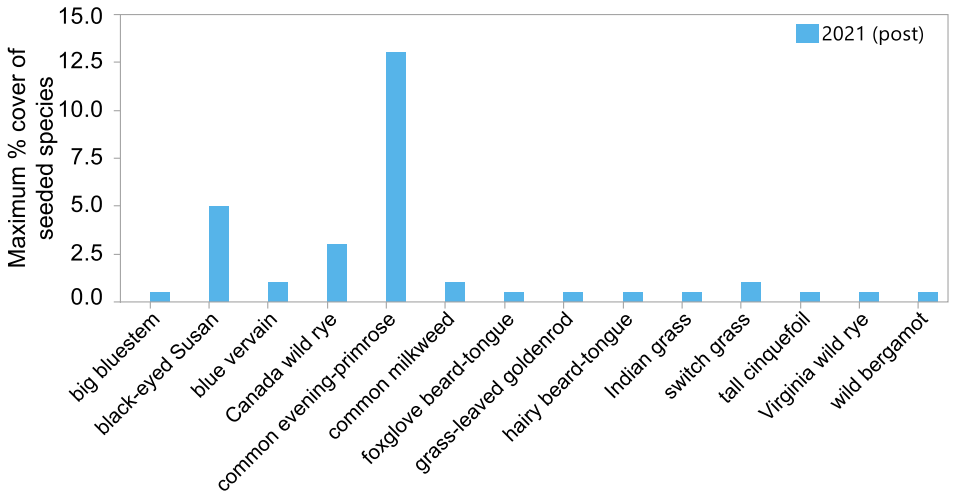

Figure 14. Maximum percent cover of seeded species that germinated in plot T in 2021. None of the seeded species were observed in 2019 (prior to seeding).

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 was seeded in November 2020.

The number of seeded species that germinated increased between 2019 and 2021. Plot U contained none of the seeded species in 2019, but in 2021, 13 seeded species were observed with common evening primrose and switch grass (*Panicum virgatum*) having the highest percent cover (Figure 16). Creeping thistle was not found in plot U and DSV was only found with a cover of <1%.

Figure 15. Photos of plot U in section 2.4 pre-restoration 2019 (left) and post-restoration 2021 (right).

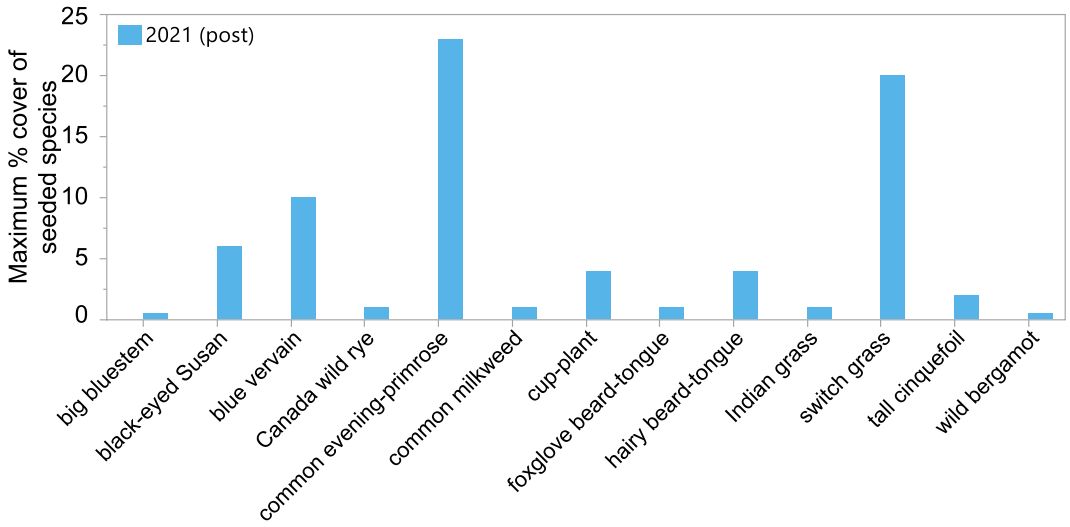

Figure 16. Maximum percent cover of seeded species that germinated in plot U in 2021. None of the seeded species were observed in 2019 (prior to seeding).

Both section 1 (1.1, 1.3) and section 7 (7.1) had vegetation data collected two years post-seeding. Although they were seeded with different mixes, we compared the number of seeded species occurring two years post-seeding. All three sub-sections had a similar seeding success (33-39%) based on the percentage of seeds occurring from the seed mix in year two (Table 2).

Table 2. A comparison of seeding success in year two in sections 1 and 7.

Section	Vegetation plot ID	Seed mix	Year seeded	Year 2	# seeded species occurring in year 2	Total number of seeded species
1.1	X	Wet meadow + resilient	2020	2021	17	44
1.3	Q	Butterfly mix	2020	2021	10	30
7.1	M, N	Mix 1	2017	2018	11	31

Section 3

Sections 3.2 and 3.3 were monitored for the first time in 2020 and represented pre-management, turfgrass communities. Vegetation plots (AA and AB) 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 2021. 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. We compared the cover of seeded species found in plots only if they were found in all years in the sub-plots

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 2018-2021. Invasive species management targeted DSV and thistle.

Cover of seeded species that germinated varied by year and by species (Figure 17). Several species decreased in cover between 2020 and 2021 including black-eyed Susan, common evening primrose, Indian grass (*Sorghastrum nutans*), switch grass, and tall sunflower (*Helianthus giganteus*). Both ox-eye and wild bergamot increased or remained similar between 2020 and 2021.

Cover of DSV was low (0-3%) in all years in plots G and H. In plot G, average cover increased from 0.1% to 1.4% between 2016 and 2021. In plot H, average cover changed from 0.5% in 2016 to 1% in 2021. 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 perhaps suggesting control efforts for thistle have been effective. Invasive species management started in 2018 in this section.

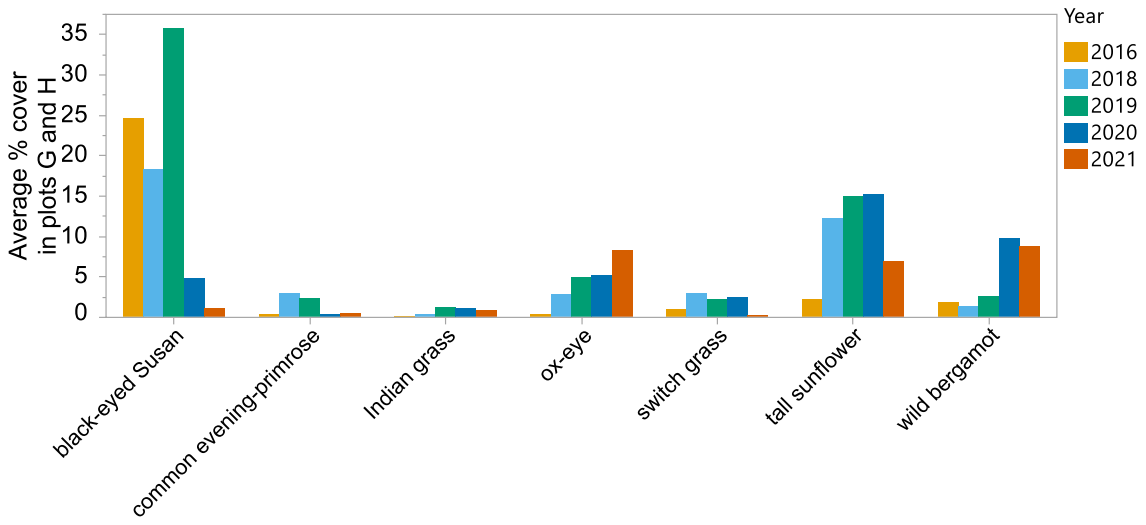

Figure 17. Average percent cover of seeded species that germinated in plots G and H between 2016 and 2021.

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 2018-2021. Invasive species management has targeted DSV and thistle since 2018.

Several species appear to be establishing well in section 4.2 including ox-eye, stiff goldenrod (*Solidago rigida* ssp. *rigida*), tall sunflower, Virginia mountain mint (*Pycnanthemum virginianum*), and wild bergamot (Figure 18). Several species remain present in lower cover including big bluestem (*Andropogon gerardi*), butterfly milkweed (*Asclepias tuberosa*), grey-headed coneflower (*Ratibida pinnata*), and showy tick trefoil.

The average cover of thistle in 2016 was 16% with one sub-plot containing 80% cover of thistle. In 2021, the average cover of thistle was 2%. Average cover of DSV appears to be increasing slightly each year from 0.8% in 2016 to 4% in 2021.

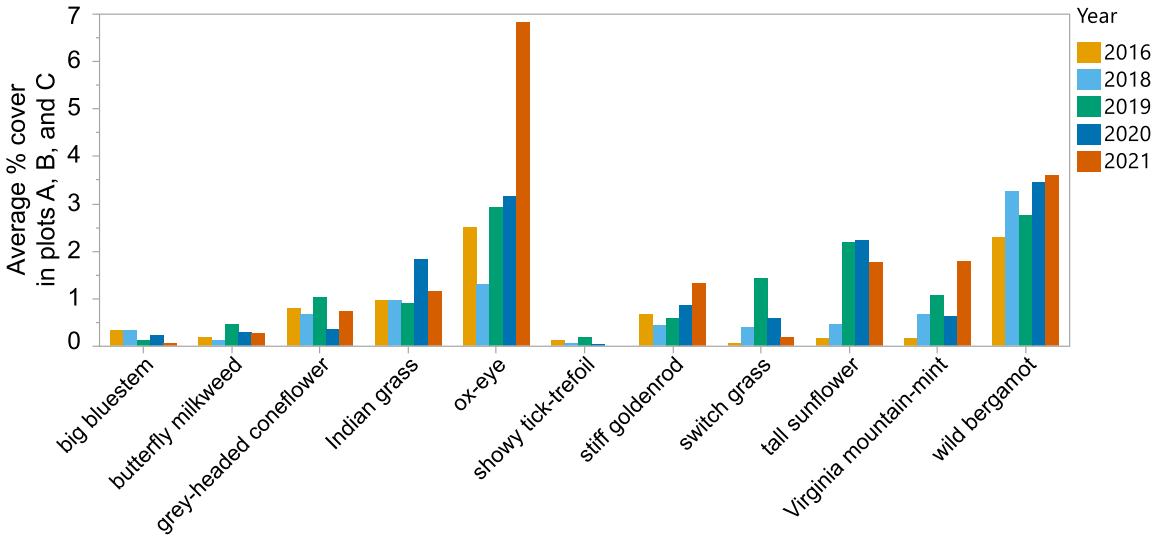

Figure 18. Average percent cover of seeded species that germinated in plots A, B, and C between 2016 and 2021.

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 2018-2021. 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 all other species except big bluestem appear to be showing decreasing trends in cover (Figure 19). Multiple other seeded species are persisting at lower percent covers such as cup-plant (*Silphium perfoliatum*) and grey-headed coneflower.

Average thistle cover was 6% in 2016 and <1% in 2021. A major decrease in cover occurred between 2016 and 2018 when management began. The average cover of DSV was 0.4% in 2021 across all sub-plots. Most sub-plots had either lower or similar covers of DSV in 2021 compared to previous years.

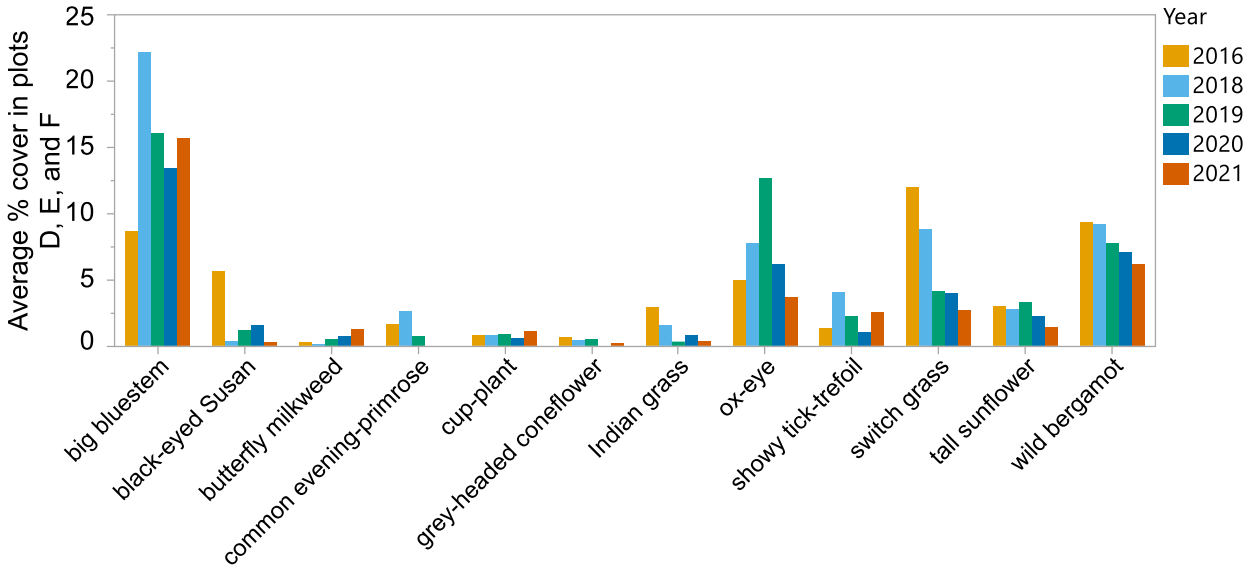

Figure 19. Average percent cover of seeded species that germinated in plots D, E, and F between 2016 and 2021.

In the spring of 2021, a portion of section 4.3 was burned due to an unknown cause (Figure 20). 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.

There were six woody stems in the unburned plots compared to only two stems in the burned plots. Only white mulberry (*Morus alba*) was found in the burned plot, while the unburned plot contained white mulberry, common blackberry (*Rubus allegheniensis*), staghorn sumach (*Rhus typhina*), and riverbank grape (*Vitis riparia*). The burned area contained 42 species including 16 native species (38%) while the unburned area contained 28 species including 14 native species (50%). The average cover of grasses in the burned sub-plots was 31% in the spring visit and 65% for the summer visit. The average cover of grasses was slightly lower in the unburned sub-plots in the spring (25%) and the unburned sub-plots in the summer (59%).

Without pre-burn data it is difficult to determine if these differences are a result of burning or pre-existing conditions. Several general observations were made in the field including that the burned area contained no thatch (dead grasses from previous growing seasons), few shrubs, and that several species were blooming earlier than usual including switch grass, big bluestem, and wild bergamot.

Figure 20. Area within section 4.3 that was burned (unknown cause) (top); Tall grasses (brown) growing post-burn only in burned area (middle); Restoration crews examining grasses in burned areas (bottom).

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 2018-2021. 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 21). Most species had lower or similar percent covers in 2021 compared to 2020. The average cover of thistle was 1.6% in 2016 and 1.4% in 2021 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 0.4% in 2021.

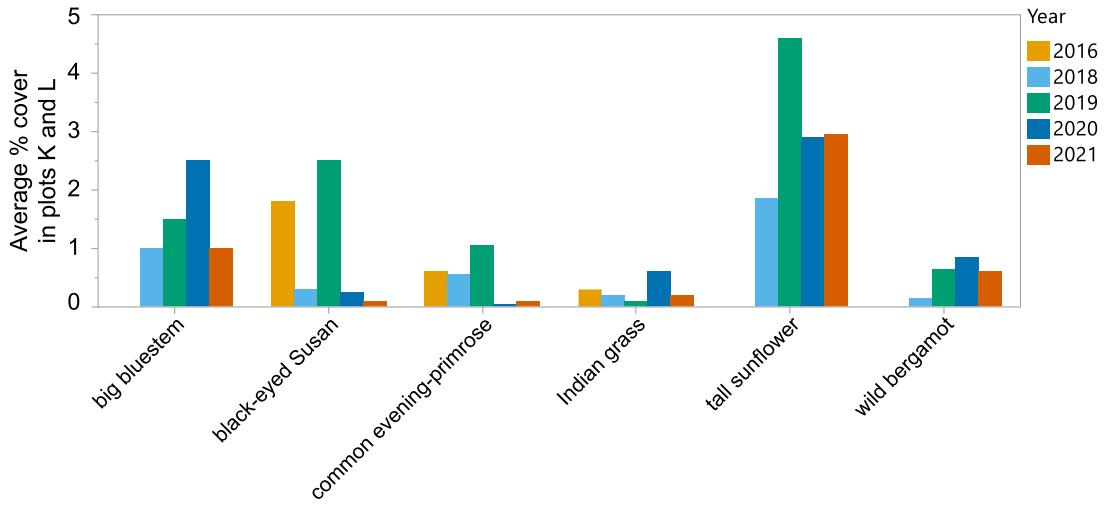

Figure 21. Average percent cover of seeded species that germinated in plots K and L between 2016 and 2021.

Sections 5 and 6

We set up six vegetation plots in sections 5 and 6 and they were monitored for the first time in 2020 (AC, AD AE, AF, AG, and AH). In 2020, the plots represented pre-management, turfgrass communities and were not monitored in 2021 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 and N (west end) were seeded prior to 2020 while plot O (east end) was seeded prior to 2020 and in July 2020. All three plots were again re-seeded in 2021 (Figure 22).

Due to the dry, sandy conditions present in section 7, 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 (Figure 23). Thistle cover was relatively low in this section only occurring in two sub-plots in 2016 and one sub-plot in 2021 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 13%. Different sub-plots display different patterns among years but the overall pattern included small increases in cover of DSV in subsequent years.

Figure 22. Plot N in section 7.1 showing pre-restoration in 2016 (left) and post-restoration in 2021 showing Indian grass and goldenrods (right).

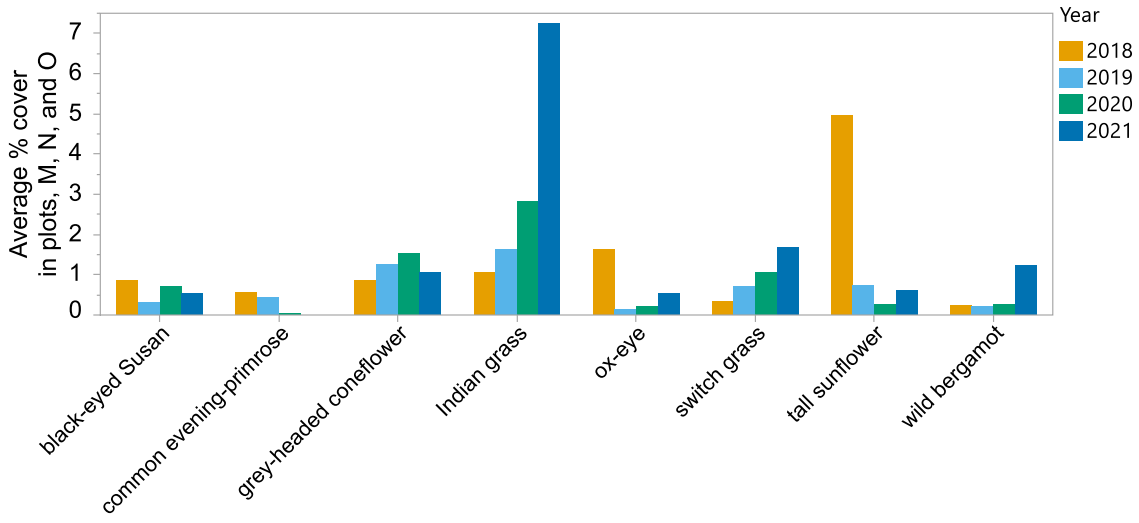

Figure 23. Average percent cover of seeded species that germinated in plots M, N, and O between 2018 and 2021.

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 24 and Figure 25).

In both 2020 and 2021 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 (*Tanacetum vulgare*), 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 24). 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.

The other set of plots, dry mix plots, were located in the east end of section 1.2 (Figure 25). 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.

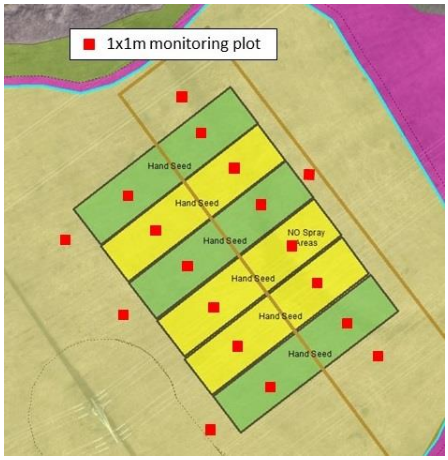

Figure 24. Butterfly seed mix trial plot area showing areas with various treatment combinations. Green = hand seeded in spring, yellow = hand seeded in winter, large gold box indicates no spray areas while all other areas were sprayed, light beige area outside of yellow and green boxes indicates areas seeded with the seed drill in the spring.

Figure 25. 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 two-factor analysis of variance (ANOVA) to examine the effect of seeding season (winter or spring) and spraying (sprayed or not sprayed) on seeding success. We used a separate two-factor ANOVA to examine the effect of seeding method (hand or seed drill) and spraying on seeding success. Seed drilling only occurred during the spring, so hand seeding and seed drilling were only compared in the spring. Data from both 2020 and 2021 were pooled for the analysis.

There was no significant difference in the number of species occurring from the butterfly seed mix when seeds were sown in winter compared to spring ($F=3.41$, $p=0.102$; Figure 26). While significance was assessed at a $p<0.05$ level, it is important to note that the p-value was 0.10 and could indicate that the number of species occurring may have been higher when seeded in the winter although the results were not significant. There was

no significant effect of spraying on the number of species observed from the seed mix (F=1.59, p=0.242; Figure 26).

Significantly higher stem counts of seeded species occurred when seeds were sown in winter compared to spring (F=6.89, p=0.03; Figure 26). There was no significant effect of spraying on the number of stems of seeded species that occurred (F=0.804, p=0.396).

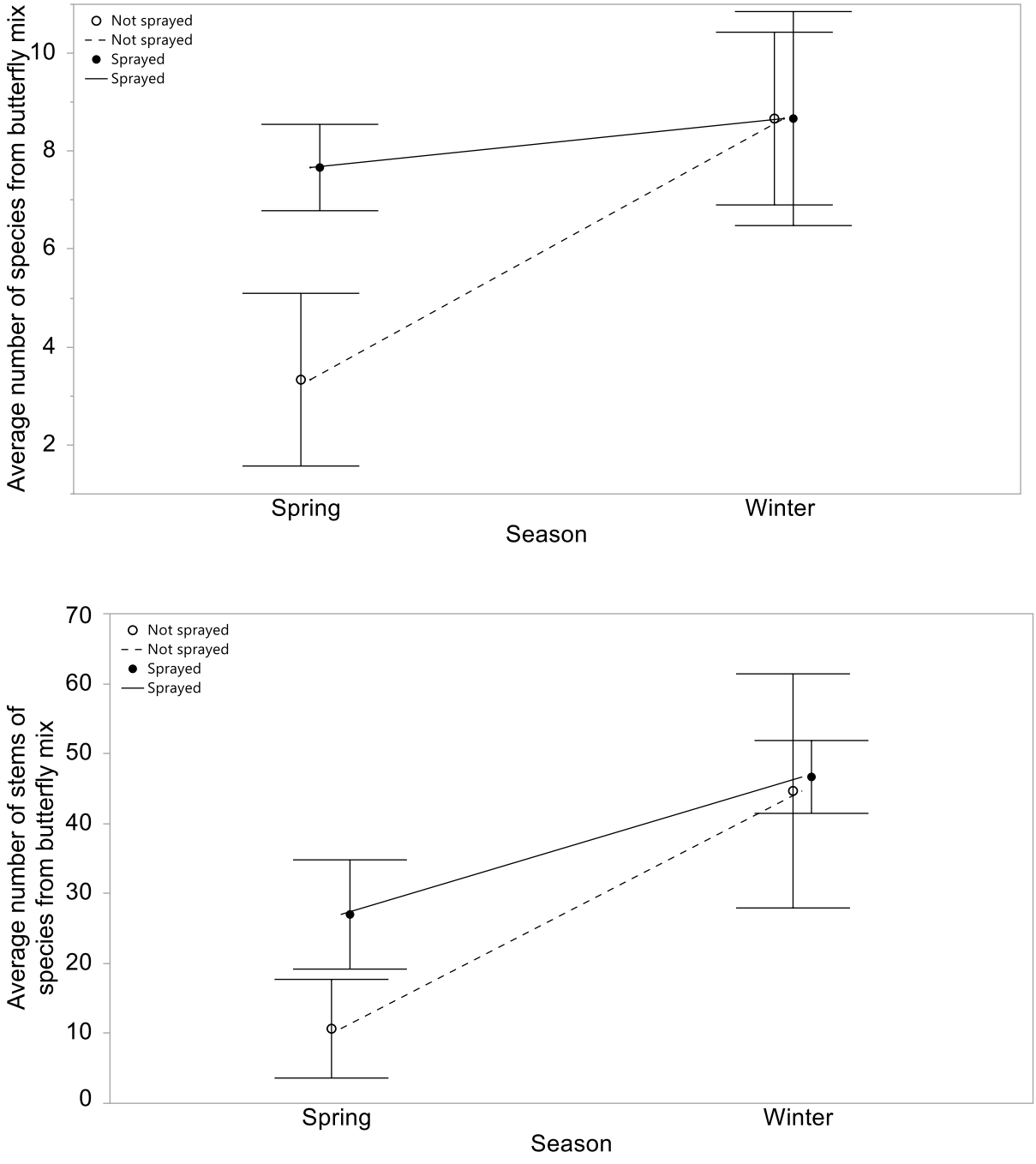

Figure 26. Effect of seeding season and spraying on seeding success (species richness – Top, number of stems – Bottom) in butterfly mix plots monitored in both 2020 and 2021. Shown are averages ± 1 standard error for each treatment combination.

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>0.152; Figure 27). Stem count of species from the seed mix was not significantly affected by seeding method or spraying if sown in the spring (all p>0.123; Figure 27).

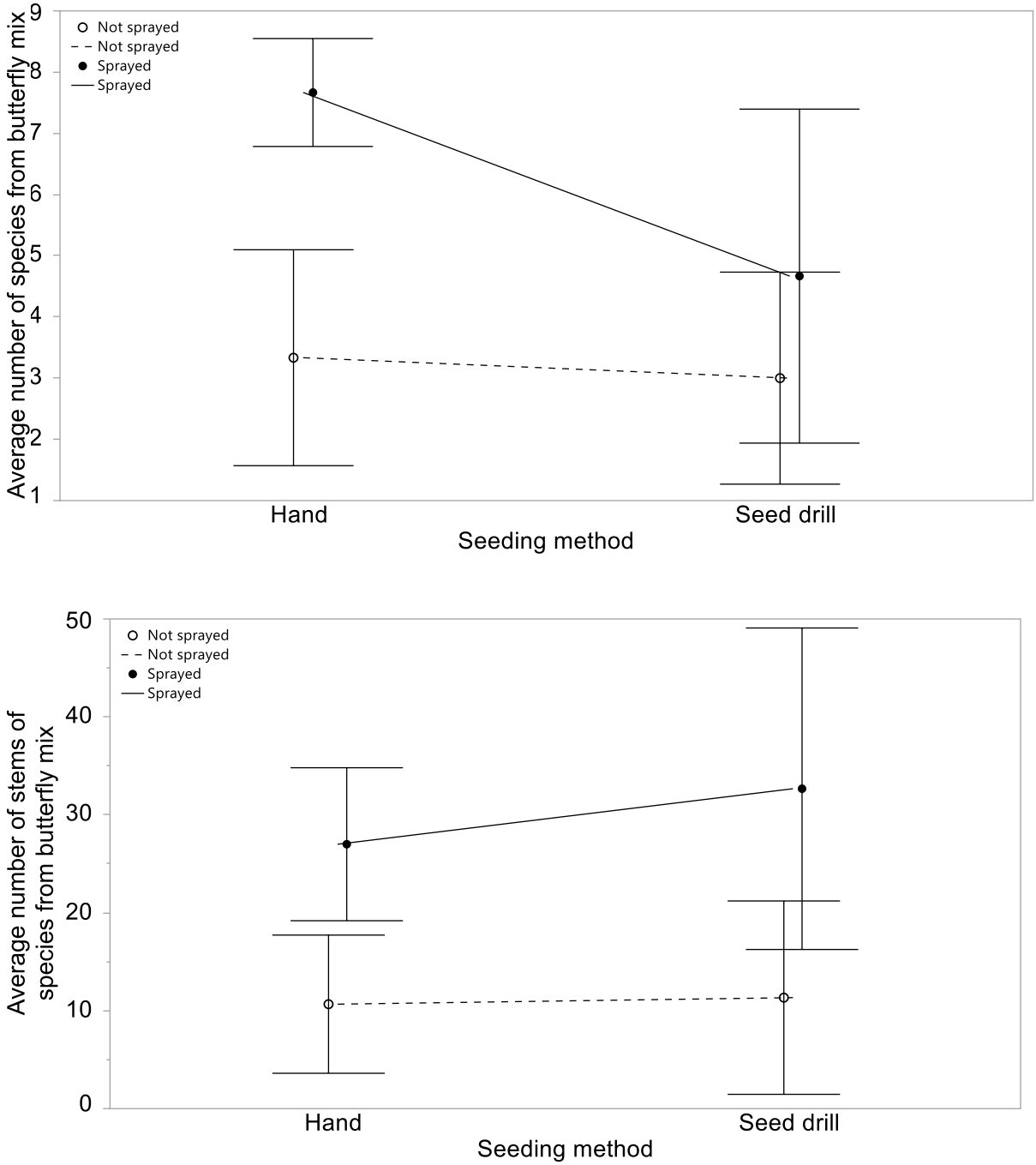

Figure 27. Effect of seeding method and spraying on seeding success (species richness – Top, number of stems – Bottom) in butterfly mix plots if seeded in the spring. Plots were monitored in both 2020 and 2021. Shown are average ± 1 standard error for each treatment combination.

In summary, within the plots seeded with butterfly mix, winter seeding was most effective; however, if seeding occurs in the spring, spraying may be beneficial. There was no difference in the effectiveness of hand seeding or using the seed drill but spraying may improve overall effectiveness.

Dry mix test plots

We used two separate non-parametric tests to analyze results of the dry mix test plots due to non-normal data and unsuccessful transformations. We used a Kruskal-Wallis test to examine the effect of seeding season (fall, winter, spring) and a Mann Whitney test to examine the effect of spraying (sprayed or not sprayed) on seeding success. 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. Data from both 2020 and 2021 were pooled for the analysis.

Significantly more species from the seed mix occurred when plots were sprayed compared to not sprayed (χ^2=5.78, p=0.02; Figure 28). There was no significant effect of seeding season on the number of species observed from the seed mix (χ^2=1.19, p=0.553; Figure 28).

Significantly higher stem counts occurred when plots were sprayed compared to not sprayed (χ^2=8.54, p<0.01; Figure 28). There was no significant effect of seeding season on the number of stems of seeded species that occurred (χ^2=1.64, p=0.440).

In summary, within the plots seeded with dry mix, spraying significantly increased seeding success and stem count in all seasons. There was a small amount of variation in seeding success among seasons although it depended greatly on whether or not the plot was sprayed. For example, if seeds were sown in the winter, spraying didn't provide considerable benefits. If seeds were sown in either the fall or spring, spraying provided clear benefits.

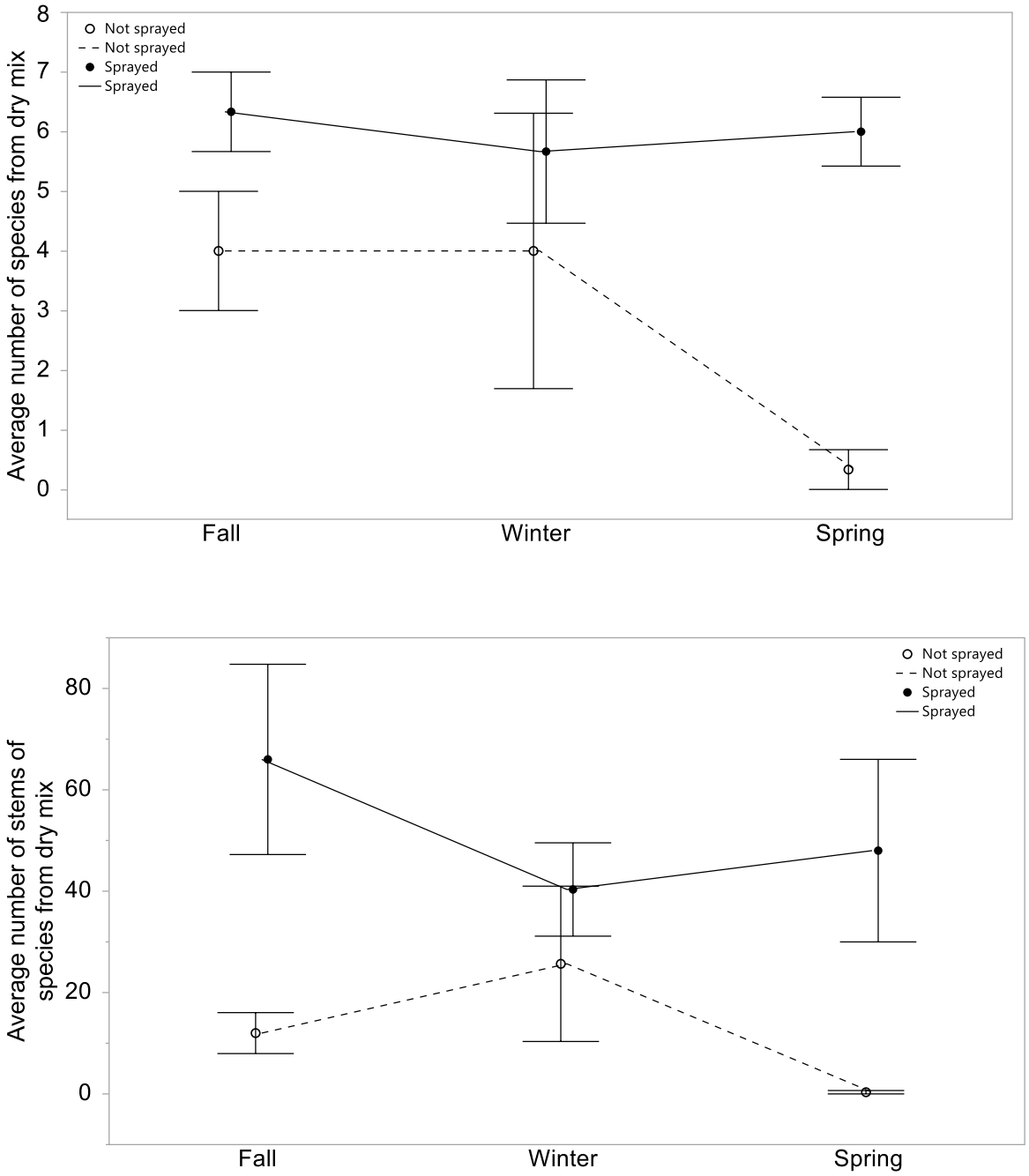

Figure 28. Effect of seeding season and spraying on seeding success (species richness – Top, number of stems – Bottom) in dry mix plots monitored in 2020 and 2021. Shown are averages ± 1 standard error for each treatment combination.

Bird surveys

Bird surveys has been conducted in The Meadoway since 2016. In sections 4 and 7 (all post-restoration), there are five years of data. In sections 6 and 1.4 there are only one or two years of data. In sections 1.2 and 2.4 there are pre- and post-restoration data for comparisons.

Thirty-five bird species were detected during 2016, 2018, 2019, 2020 and 2021 surveys (Appendix 1, Figure 30-33). These included one species of conservation concern in the Toronto Region (ranked L3): eastern meadowlark. Eastern meadowlark is a meadow-dependent species that nests on the ground in grassland habitats and is a species of conservation concern due to declining population trends and sensitivity to disturbance. Even though this species was recorded during the breeding season, it is unlikely to have been successful because they are ground-nesters and are subject to high nest predation rates from urban-related predators (e.g. domestic cats, off-leash dogs, and subsidized predators such as raccoons, opossums and skunks). There were three other meadow-dependent species detected during surveys including Savannah Sparrow (*Passerculus sandwichensis*) (Figure 29), Willow Flycatcher (*Empidonax traillii*), 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.

Four new stations (11, 12, 13, 14) were added in turfgrass/early restoration sites in 2021. Several species not seen elsewhere in The Meadoway or only rarely were observed at these stations including Warbling Vireo (*Vireo gilvus*), Cedar Waxwing (*Bombycilla cedrorum*), and Red-tailed Hawk (*Buteo jamaicensis*). These are primarily edge and woodland species and their presence may be more related to foraging opportunities.

Figure 29. Savannah Sparrow (*Passerculus sandwichensis*).

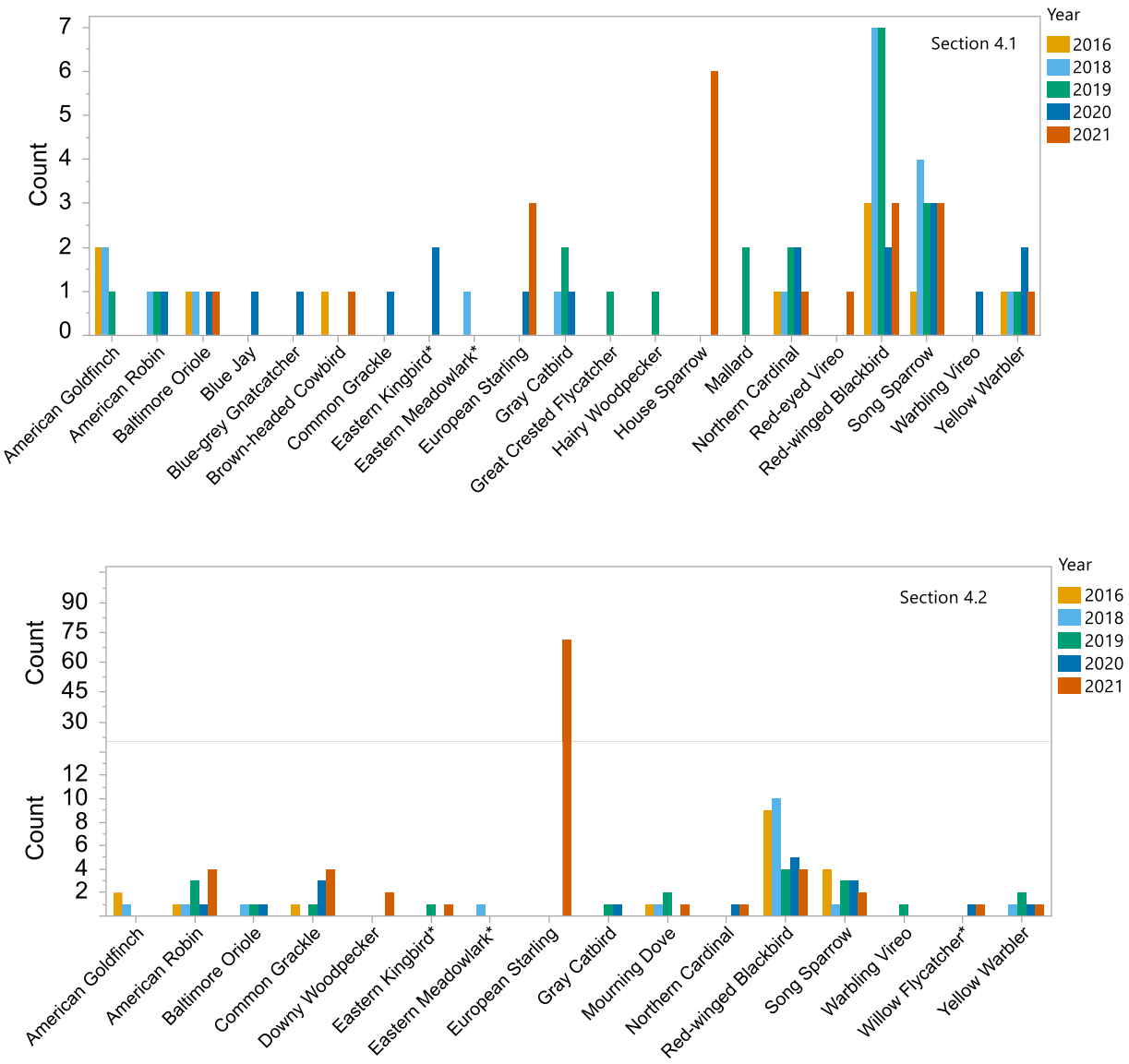

Figure 30. Total bird abundance by species and year at The Meadoway in section 4.1 (top) and section 4.2 (bottom). An asterisk indicates meadow-dependent species.

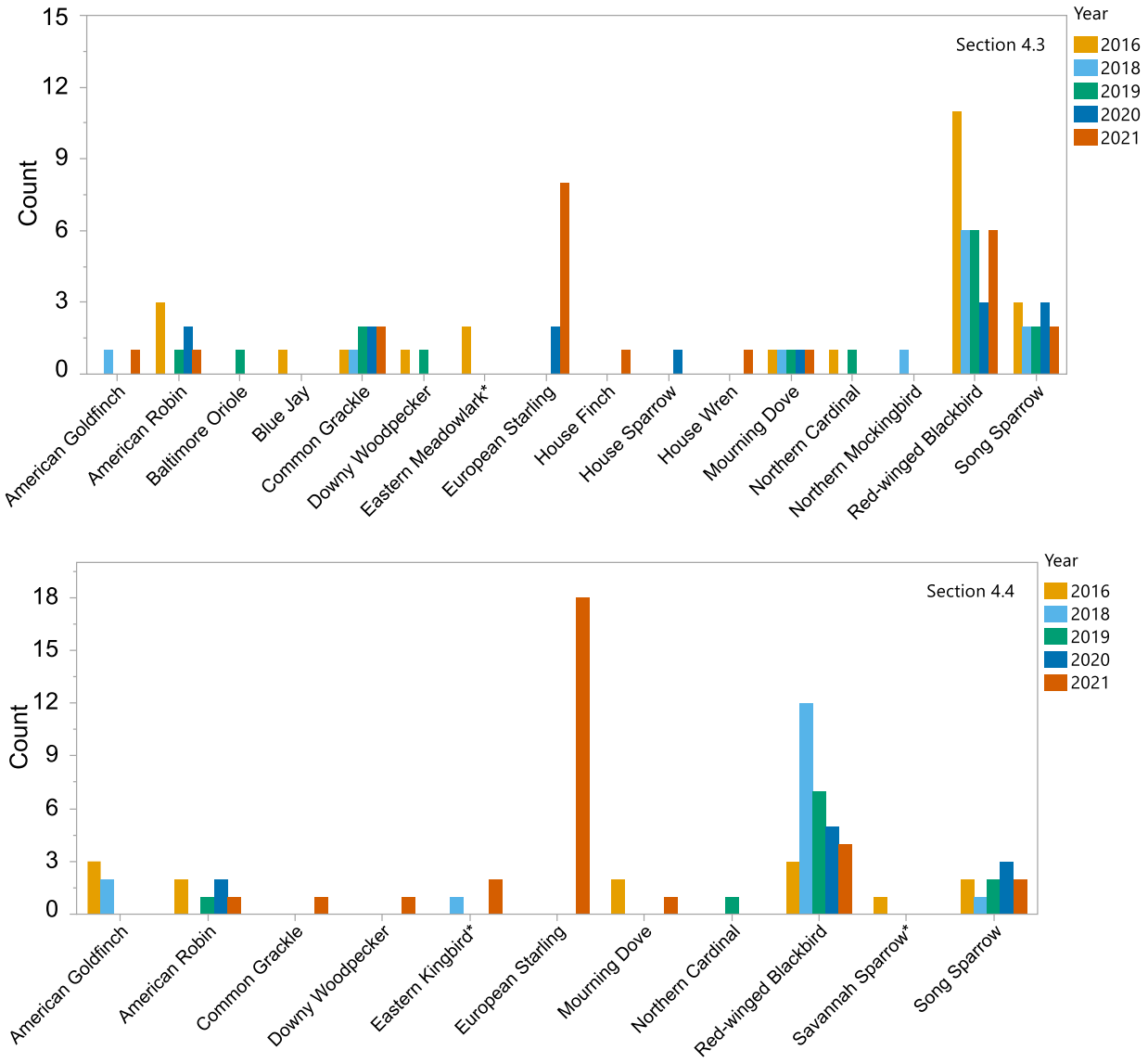

Figure 31. Total bird abundance by species and year at The Meadoway in section 4.3 (top) and section 4.4 (bottom). An asterisk indicates meadow-dependent species.

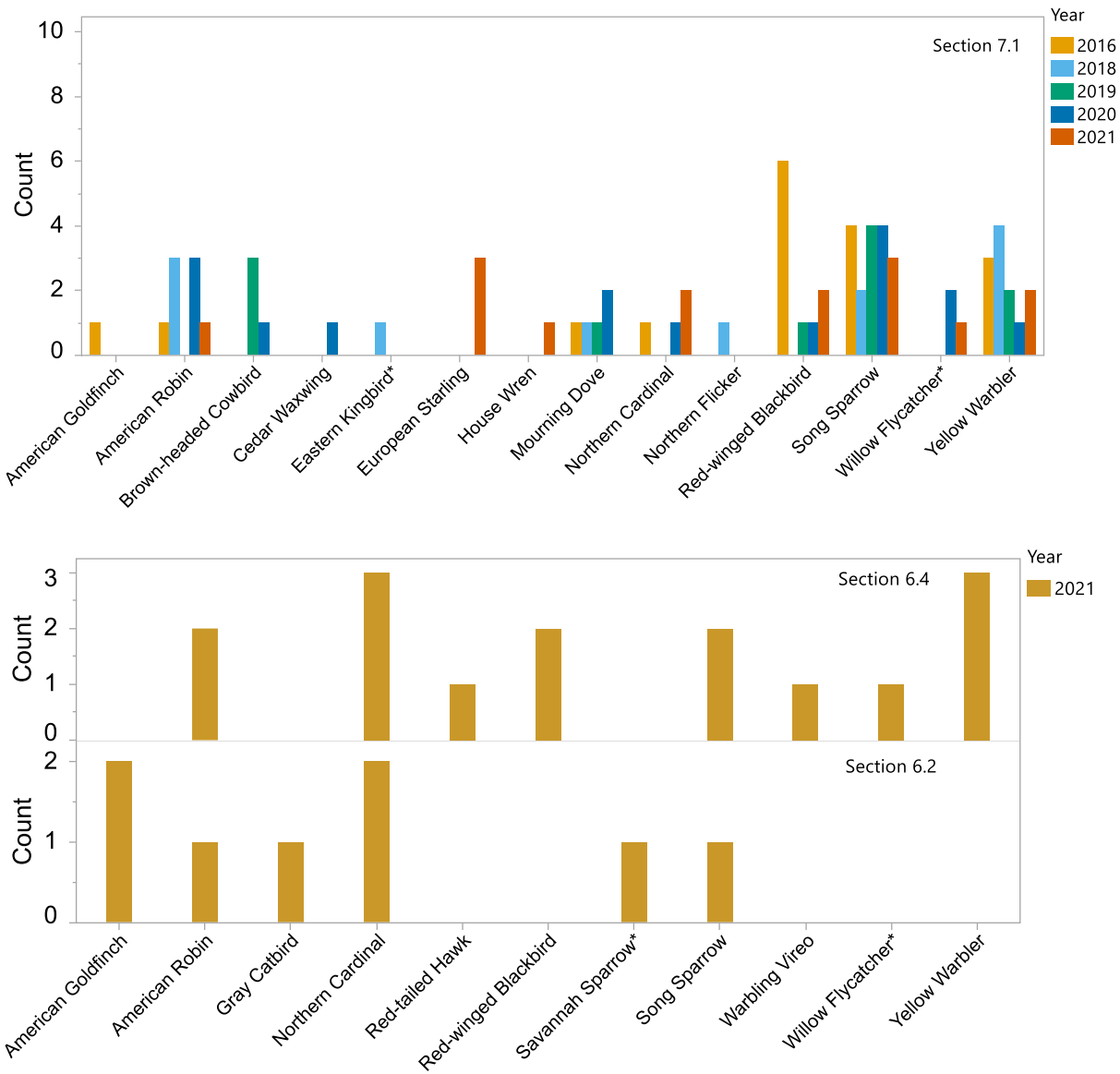

Figure 32. Total bird abundance by species and year at The Meadoway in section 7.1 (top) and turfgrass/pre-restoration sections 6.2 and 6.4 (bottom). An asterisk indicates meadow-dependent species.

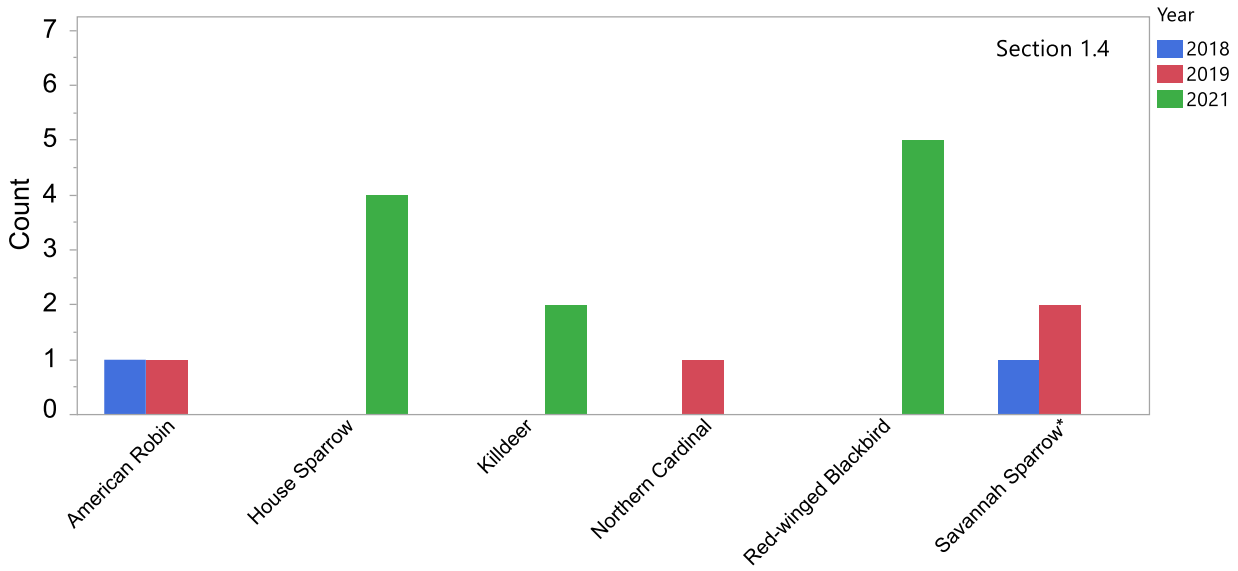

Figure 33. Total bird abundance by species and year at The Meadoway in section 1.4. An asterisk indicates meadow-dependent species.

Bird surveys occurred in both 2020 (pre-restoration) and 2021 (post-restoration) in section 1.2. Bird communities appeared to be similar pre- and post-restoration although there were a few differences (Figure 34). American Robin and House Sparrow (*Passer domesticus*) were present pre-restoration; however, were not observed post-restoration. Also, Northern Mockingbird (*Mimus polyglottos*), Red-winged Blackbird, and Savannah Sparrow increased slightly post-restoration.

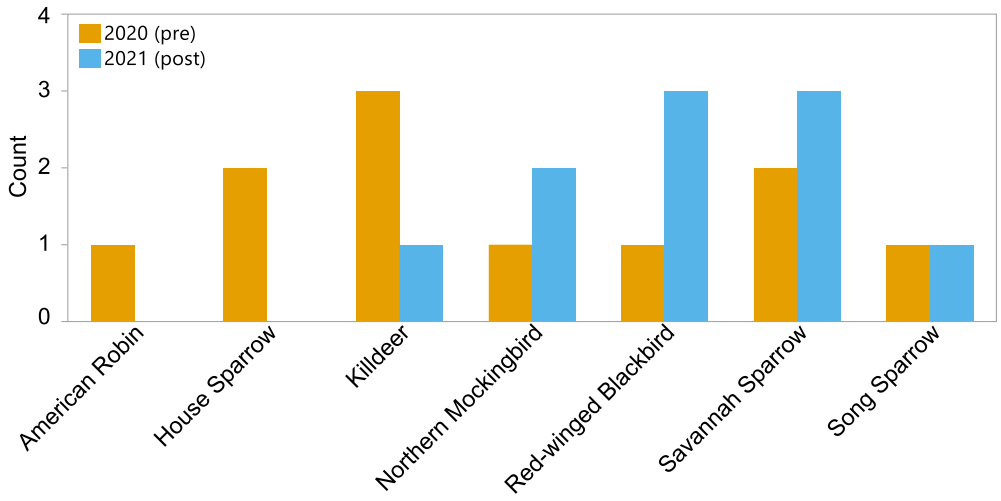

Figure 34. Temporal changes in bird species composition and abundance at station 8 (section 1.2) pre- and post-restoration.

Bird surveys occurred pre-restoration in both 2018 and 2019 and post-restoration in 2021 (station 7). Bird communities appeared to be similar pre- and post-restoration although there were a few differences (Figure 35). Eastern Meadowlark (*Sturnella magna*) (likely non-breeding) and Savannah Sparrow were present pre-restoration; however, were not observed post-restoration. Species only observed post-restoration included House Sparrow, Killdeer (*Charadrius vociferus*), Red-winged Blackbird, Rock Pigeon (*Columba livia*), and Song Sparrow.

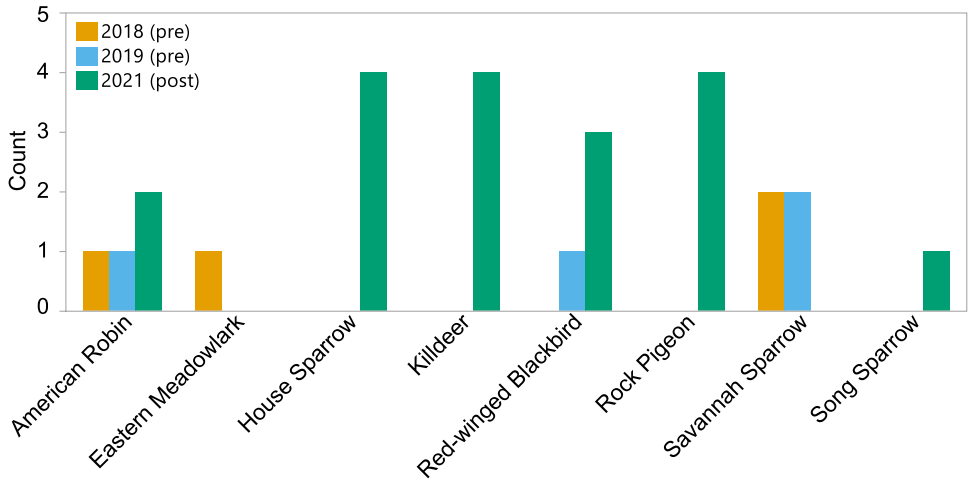

Figure 35. Temporal changes in bird species composition and abundance at station 7 (section 2.4) pre- and post-restoration.

Butterfly surveys

Thirty-six butterfly species were observed during 2016, and 2018-2021 surveys (Appendix 2, Figure 36-38). Of these 41 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 49 were recorded in 2020.

In 2021, section 6 (turfgrass/pre-management) was monitored for the first time and while fewer species and individuals were found, the section did support several local, resident breeding species such as Wild Indigo Duskywing, Common Ringlet (*Coenonympha tullia*), Black Swallowtail (*Papilio polyxenes*), Eastern Tailed Blue (*Cupido comyntas*), and Viceroy (*Limenitis archippus*). We also observed several European Common Blue (*Polymmatus icarus*; Figure 39) in section 6. This species was first observed in The Meadoway in 2020 with one individual but in 2021, almost 100 were observed. This species was first identified in North America in 2005 at Mirabel Airport, Montreal.

Several other new resident species were found in 2021 in other sections including Summer Azure (*Celastrina lucia*) in section 4.2, and Least Skipper (*Ancyloxypha numitor*) and Little Wood-Satyr (*Megisto cymela*) in section 1.

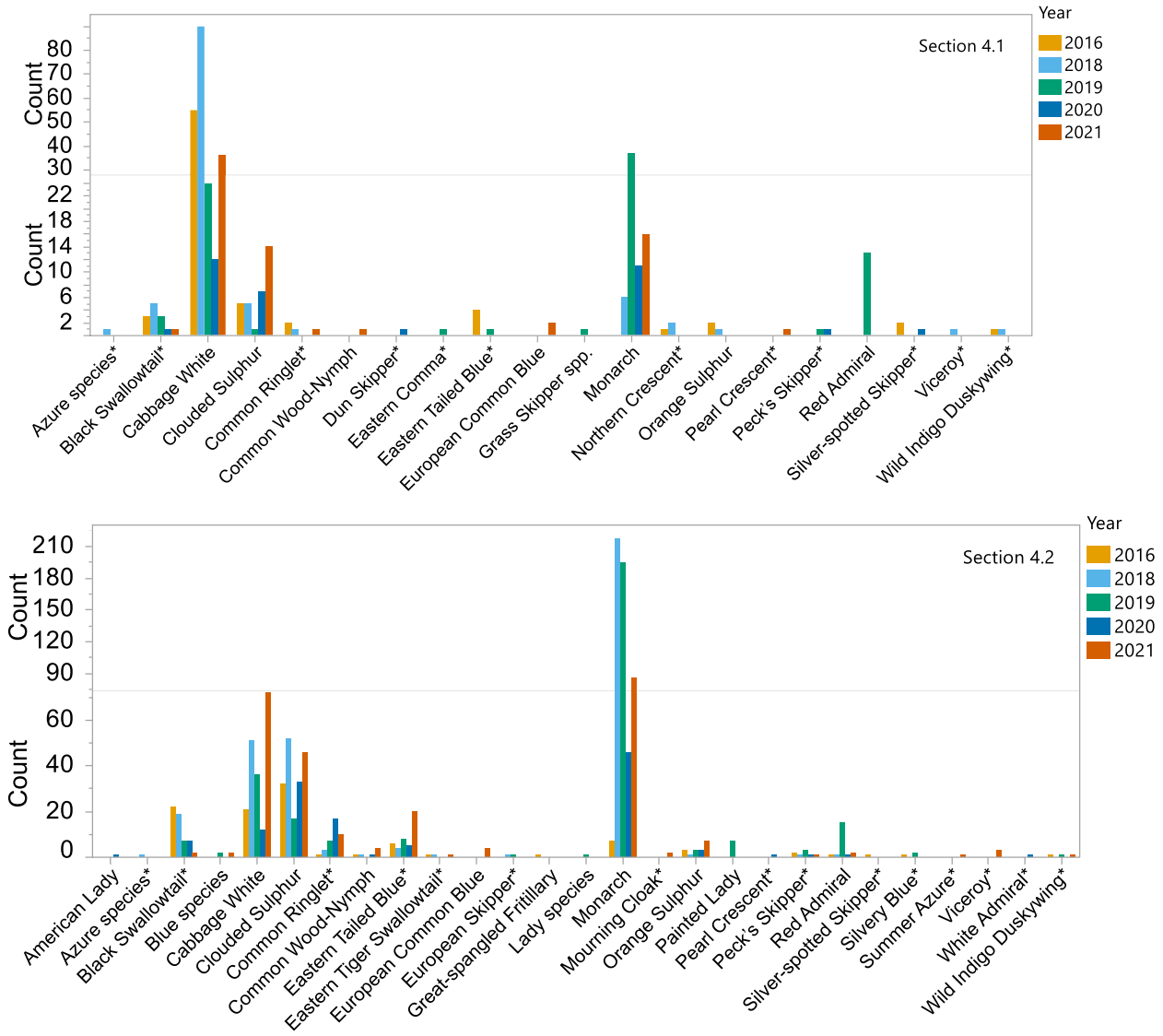

Figure 36. Total butterfly abundance per year at The Meadoway in section 4.1 (top) and section 4.2 (bottom). Note that there is a scale-break to facilitate viewing less abundant species at the same time as more abundant species. An asterisk (*) indicates a resident species.

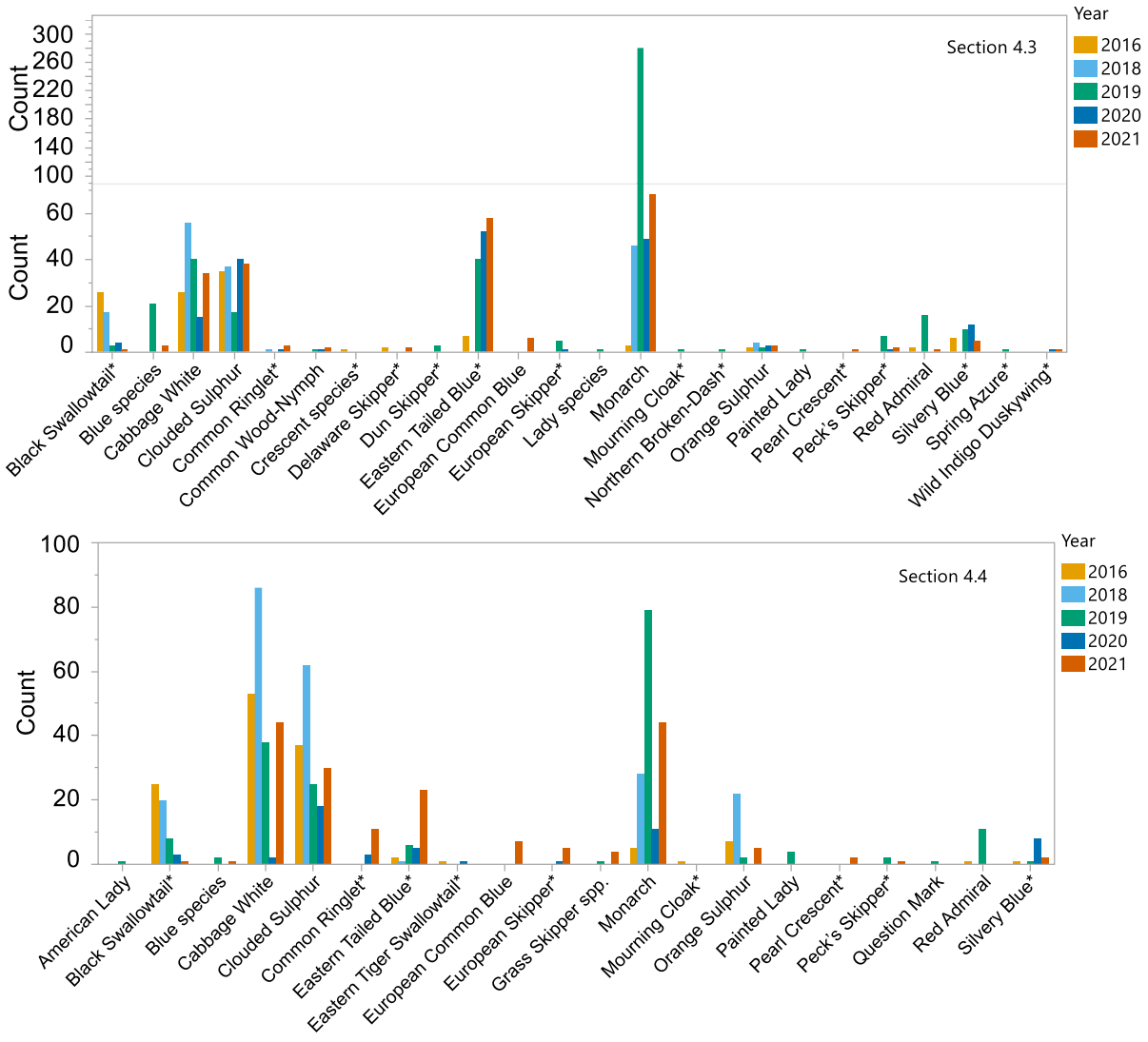

Figure 37. Total butterfly abundance per year at The Meadoway in section 4.3 (top) and section 4.4 (bottom). Note that there is a scale-break to facilitate viewing less abundant species at the same time as more abundant species. An asterisk (*) indicates a resident species.

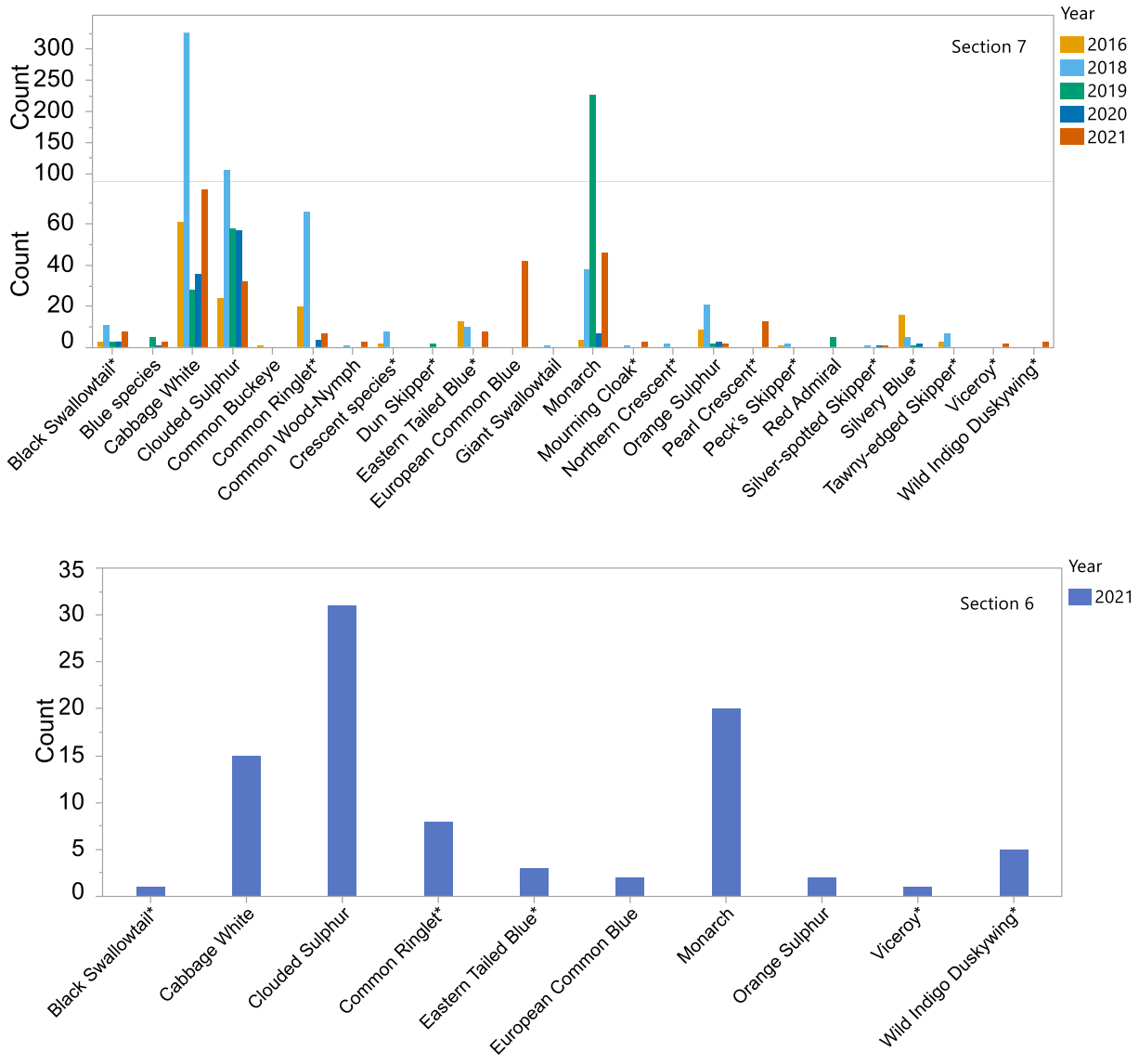

Figure 38. Total butterfly abundance per year at The Meadoway in section 7 (top) and in section 6 (turfgrass/pre-restoration; bottom). Note that there is a scale-break to facilitate viewing less abundant species at the same time as more abundant species. An asterisk (*) indicates a resident species.

Figure 39. European Common Blue (*Polymmatus icarus*) feeding on white sweet clover (*Melilotus albus*).

Butterfly surveys occurred in both 2020 (early post-restoration) and 2021 (post-restoration) in section 1.2. Butterfly communities appeared to have changed between 2020 and 2021 by increasing in either species richness or abundance (Figure 40). Early post-restoration in 2020, 6 species were present, and post-restoration in 2021, 10 species were present. Species only present in 2021 included European Common Blue, Red Admiral (*Vanessa atalanta*), Silver-spotted Skipper, and Silvery Blue (*Glaucopsyche lygdmus*).

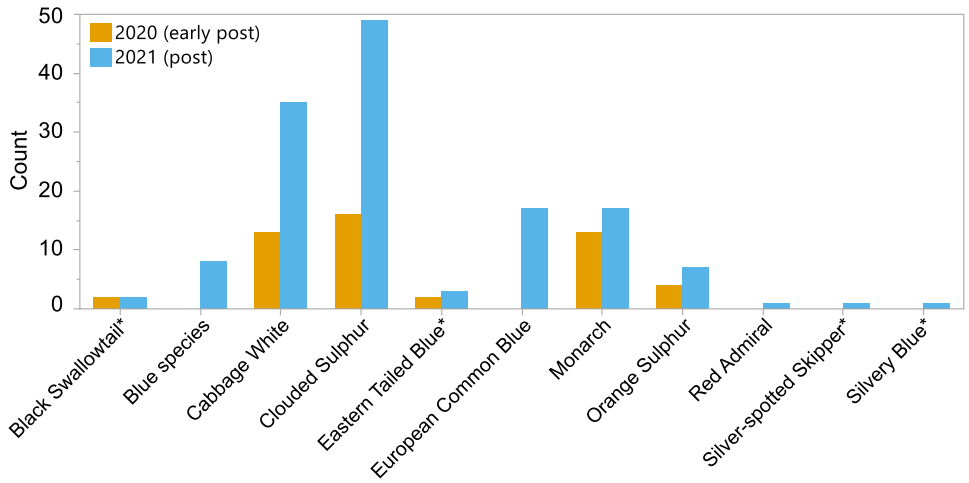

Figure 40. Temporal changes in butterfly species composition and abundance on transect 1F (section 1.2) pre- and post-restoration. An asterisk (*) indicates a resident species.

Butterfly surveys were conducted in both 2019 (pre-restoration) and 2021 (post-restoration) in section 2.4 (transect 2K). Butterfly communities appeared to have changed between 2019 and 2021 by increasing in either species richness or abundance (Figure 41). Pre-restoration in 2019, 6 species were present, and post-restoration in 2021, 10 species were present. Species only present post-restoration included Eastern Tailed Blue, European Common Blue, Great-spangled Fritillary (*Speyeria cybele*), and Orange Sulphur (*Colias eurytheme*). Changes in butterfly communities in both sections 1.2 and 2.4 are likely due to an increase in the diversity of host plants and food plants.

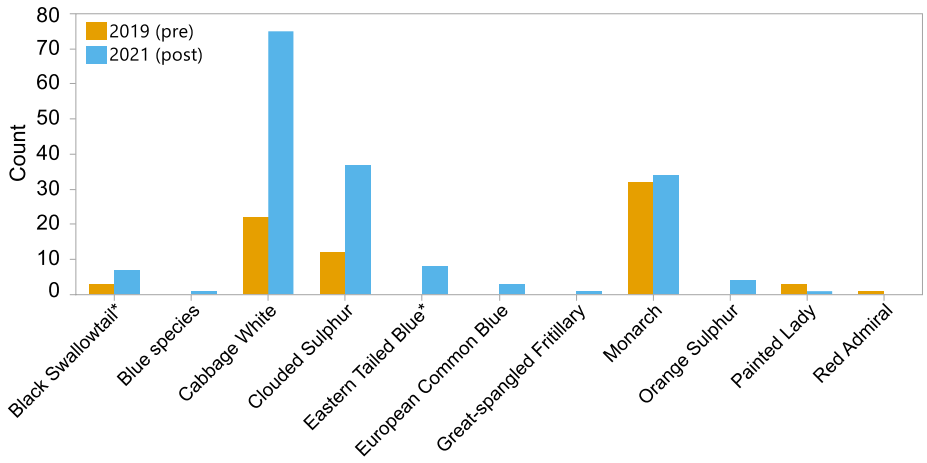

Figure 41. Temporal changes in butterfly species composition and abundance on transect 2K pre- and post-restoration. An asterisk (*) indicates a resident species.

SUMMARY

Meadow monitoring during 2016, and 2018-2021 generally indicated that restoration work in The Meadoway has successfully introduced a variety of meadow flora through seeding, provides habitat used by meadow 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 suggest 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 approximately 35% of the 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. Bird communities did not appear to respond as strongly to changes although Savannah Sparrow was absent post-restoration while Song Sparrow only occurred post-restoration at one of the sites 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. There were increases in cover for Indian grass, ox-eye, tall sunflower, switch grass, and wild bergamot in multiple restored sections while in other sections (e.g. section 4.3), several of these species along with others, may be decreasing in cover.

Figure 42. Indian grass (*Sorghastrum nutans*) (left); wild bergamot (*Monarda fistulosa*) (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 extensive, decreasing from 90% in 2019 to 2% in 2021. 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 two 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. There was no difference in seeding success based on whether or not the seed drill was used or the seeds were hand sown. 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, spraying significantly increased seeding success and stem count in all seasons. There was a small amount of variation in seeding success among seasons although it depended greatly on whether or not the plot was sprayed. For example, if seeds were sown in the winter, spraying did not provide considerable benefits. If seeds were sown in either the fall or spring, spraying provided clear benefits. With two 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 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. 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) occurred in more sections in 2021, and in a higher abundance, than in 2020. The Meadoway also provides habitat for several relatively uncommon native resident species such as Delaware Skipper, 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 or improved nectaring opportunities. Both Cabbage White and Clouded Sulphur doubled in abundance pre- and post-restoration. 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 Least Skipper, Little Wood-Satyr, Peck's Skipper (*Polites peckius*), Silver-spotted Skipper, Eastern Tailed Blue, and Silvery Blue. Little Wood-Satyr was observed for the first time at The Meadoway in section 1 (post-restoration). 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, 2018-2021.

Common name	Nesting guild	L-rank	Section 4.1					Section 4.2					Section 4.3					Section 4.4					Section 7.1					Section 1.4					Section 2.4				
			Station 1					Station 2					Station 3					Station 4					Station 5					Station 6					Station 7				
			2016	2018	2019	2020	2021	2016	2018	2019	2020	2021	2016	2018	2019	2020	2021	2016	2018	2019	2020	2021	2016	2018	2019	2020	2021	2016	2018	2019	2020	2021	2016	2018	2019	2020	2021
eastern meadowlark	meadow low-level nester	L3		1					1				2															-			-		-	1		-	
American kestrel	generalist upper-level nester	L4																										-			-		-			-	
blue-grey gnatcatcher	forest upper-level nester	L4				1																						-			-		-			-	
eastern kingbird	meadow upper-level nester	L4				2				1		1							1			2		1				-			-		-			-	
gray catbird	generalist mid-level nester	L4		1	2	1				1	1																	-			-		-			-	
great crested flycatcher	forest upper-level nester	L4			1																							-			-		-			-	
hairy woodpecker	forest upper-level nester	L4			1																							-			-		-			-	
northern flicker	generalist upper-level nester	L4																						1				-			-		-			-	
red-eyed vireo	forest mid-level nester	L4					1																					-			-		-			-	
savannah sparrow	meadow low-level nester	L4																1										-	1	2	-		-	2	2	-	
willow flycatcher	meadow mid-level nester	L4								1	1															2	1	-			-		-			-	
American goldfinch	generalist mid-level nester	L5	2	2	1			2	1					1			1	3	2				1					-			-		-			-	
American robin	generalist mid-level nester	L5		1	1	1		1	1	3	1	4	3		1	2	1	2		1	2	1	1	3		3	1	-	1	1	-		-	1	1	-	2
Baltimore oriole	generalist upper-level nester	L5	1	1		1	1		1	1	1				1													-			-		-			-	
blue jay	generalist upper-level nester	L5				1							1															-			-		-			-	
brown-headed cowbird	special case	L5	1				1																		3	1		-			-		-			-	
cedar waxwing	generalist mid-level nester	L5																								1		-			-		-			-	
common grackle	generalist mid-level nester	L5				1		1		1	3	4	1	1	2	2	2					1						-			-		-			-	
downy woodpecker	forest-edge mid-level nester	L5										2	1		1							1						-			-		-			-	
house wren	generalist mid-level nester	L5															1										1	-			-		-			-	
killdeer	generalist low-level nester	L5																										-			-	2	-			-	4
mallard	wetland low-level nester	L5			2																							-			-		-			-	
mourning dove	generalist mid-level nester	L5						1	1	2		1	1	1	1	1	2					1	1	1	1	2		-			-		-			-	
northern cardinal	generalist mid-level nester	L5	1	1	2	2	1				1	1	1		1					1			1			1	2	-		1	-		-			-	
northern mockingbird	generalist mid-level nester	L5												1														-			-		-			-	
red-tailed hawk	generalist upper-level nester	L5																										-			-		-			-	
red-winged blackbird	generalist mid-level nester	L5	3	7	7	2	3	9	10	4	5	4	11	6	6	3	6	3	12	7	5	4	6		1	1	2	-			-	5	-		1	-	3
song sparrow	generalist low-level nester	L5	1	4	3	3	3	4	1	3	3	2	3	2	2	3	2	2	1	2	3	2	4	2	4	4	3	-			-		-			-	1
warbling vireo	generalist upper-level nester	L5				1				1																		-			-		-			-	
yellow warbler	generalist mid-level nester	L5	1	1	1	2	1		1	2	1	1											3	4	2	1	2	-			-		-			-	
European starling	generalist mid-level nester	L+				1	3					71				2	8					18					3	-			-		-			-	
house finch	generalist mid-level nester	L+															1											-			-		-			-	
house sparrow	generalist mid-level nester	L+					6									1												-			-	4	-			-	4
rock pigeon	generalist mid-level nester	L+																										-			-		-			-	4

Appendix 1. (cont'd)

Common name	Nesting guild	L-rank	Section 1.2					Section 5.2					Section 5.3					Section 1.1					Section 1.3					Section 6.2					Section 6.4				
			Station 8					Station 9					Station 10					Station 11					Station 12					Station 13					Station 14				
			2016	2018	2019	2020	2021	2016	2018	2019	2020	2021	2016	2018	2019	2020	2021	2016	2018	2019	2020	2021	2016	2018	2019	2020	2021	2016	2018	2019	2020	2021	2016	2018	2019	2020	2021
eastern meadowlark	meadow low-level nester	L3	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
American kestrel	generalist upper-level nester	L4	-	-	-			-	-	-	1	-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
blue-grey gnatcatcher	forest upper-level nester	L4	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
eastern kingbird	meadow upper-level nester	L4	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
gray catbird	generalist mid-level nester	L4	-	-	-			-	-	-	1	-	-	-	-	1	-	-	-	-	-	1		-	-	-		-	-	-	-	1	-	-	-	-	
great crested flycatcher	forest upper-level nester	L4	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
hairy woodpecker	forest upper-level nester	L4	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
northern flicker	generalist upper-level nester	L4	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
red-eyed vireo	forest mid-level nester	L4	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
savannah sparrow	meadow low-level nester	L4	-	-	-	2	3	-	-	-	1	-	-	-	-	1	-	-	-	-	-		-	-	-	-		-	-	-	-	1	-	-	-	-	
willow flycatcher	meadow mid-level nester	L4	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	1
American goldfinch	generalist mid-level nester	L5	-	-	-			-	-	-		-	-	-	-	2	-	-	-	-	-		-	-	-	-		-	-	-	-	2	-	-	-	-	
American robin	generalist mid-level nester	L5	-	-	-	1		-	-	-	1	-	-	-	-		-	-	-	-	-	1	-	-	-	-	2	-	-	-	-	1	-	-	-	-	2
Baltimore oriole	generalist upper-level nester	L5	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
blue jay	generalist upper-level nester	L5	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
brown-headed cowbird	special case	L5	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
cedar waxwing	generalist mid-level nester	L5	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-	1	-	-	-	-		-	-	-	-	
common grackle	generalist mid-level nester	L5	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-	1	-	-	-	-		-	-	-	-		-	-	-	-	
downy woodpecker	forest-edge mid-level nester	L5	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
house wren	generalist mid-level nester	L5	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
killdeer	generalist low-level nester	L5	-	-	-	3	1	-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
mallard	wetland low-level nester	L5	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
mourning dove	generalist mid-level nester	L5	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
northern cardinal	generalist mid-level nester	L5	-	-	-			-	-	-	1	-	-	-	-	1	-	-	-	-	-	1		-	-	-	1		-	-	-	-	2	-	-	-	-	3
northern mockingbird	generalist mid-level nester	L5	-	-	-	1	2	-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
red-tailed hawk	generalist upper-level nester	L5	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-	1	-	-	-	-		-	-	-	-	1
red-winged blackbird	generalist mid-level nester	L5	-	-	-	1	3	-	-	-	1	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	3	-	-	-	-		-	-	-	-	2
song sparrow	generalist low-level nester	L5	-	-	-	1	1	-	-	-	1	-	-	-	-		-	-	-	-	-	2	-	-	-	-	2	-	-	-	-	1	-	-	-	-	2
warbling vireo	generalist upper-level nester	L5	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	1
yellow warbler	generalist mid-level nester	L5	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-	2	-	-	-	-		-	-	-	-	3
European starling	generalist mid-level nester	L+	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-	2	-	-	-	-		-	-	-	-	
house finch	generalist mid-level nester	L+	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	
house sparrow	generalist mid-level nester	L+	-	-	-	2		-	-	-		-	-	-	-		-	-	-	-	-	1	-	-	-	-		-	-	-	-		-	-	-	-	
rock pigeon	generalist mid-level nester	L+	-	-	-			-	-	-		-	-	-	-		-	-	-	-	-		-	-	-	-		-	-	-	-		-	-	-	-	

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	2016	2018	2019	2020	2021	2016	2018	2019	2020	2021	2016	2018	2019	2020	2021	
American Lady	*Vanessa virginiensis*	S5									x										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			3	x	7	3	5	3	1	1	22	19	7	7	2	Carrot family… parsley, dill, celery,Queen Anne's lace
Blue species	Lycaenidae family	n/a					15				x	1								2		2	
Cabbage White	*Pieris rapae*	SNA			8	13	148			22	x	75	55	90	24	12	36	21	51	36	12	72	Mustards… cabbage, cauliflower and broccoli
Clouded Sulphur	*Colias philodice*	S5			2	16	105			12	x	37	5	5	1	7	14	32	52	17	33	46	Legumes… cultivated crops
Common Buckeye	*Junonia coenia*	SNR (G5)									x												Uncommon breeding migrant
Common Ringlet*	*Coenonympha tullia*	S5			1		2				x		2	1			1	1	3	7	17	10	Kentucky bluegrass
Common Wood-Nymph	*Cercyonis pegala*	S5									x						1	1	1		1	4	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
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	4		1			6	4	8	5	20	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				x	3					2					4	Alfalfa, clover, crown vetch (Burghardt et al. 2001), bird's-foot trefoil (many other legumes black medick)
European Skipper*	*Thymelicus lineola*	SNA					6				x								1	1			Grasses (Poaceae) prefers common timothy
Giant Swallowtail	*Papilio cresphontes*	S4									x												Common prickly ash and common hop tree
Grass Skipper spp.	Hesperiinae family	n/a					2				x				1								
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				x												Grasses (Poaceae)
Little Wood-Satyr*	*Megisto cymela*	S5					1				x												Grasses (Poaceae)… Kentucky bluegrass orchard grass
Monarch	*Danaus plexippus*	S2N,S4B			29	13	50			32	x	34		6	37	11	16	7	217	195	46	86	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				x	4	2	1				3	1	3	3	7	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	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				x		2			1		1					Legumes… showy tick-trefoil, Am. hog peanut and black locust
Silvery Blue*	*Glaucopsyche lygdamus*	S5					1				x							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				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	2016	2018	2019	2020	2021	2020	2021	2021	2016	2018	2019	2020	2021	
American Lady	*Vanessa virginiensis*	S5								1				x							Sunflower family, pearly everlasting, plantain-leaved pussy toes, wormwood, ironweed, burdock
Azure species*	*Celastrina* spp.	n/a												x							
Black Swallowtail*	*Papilio polyxenes*	S5	26	17	3	4	1	25	20	8	3	1	5	x	1	3	11	3	3	8	Carrot family… parsley, dill, celery and Queen Anne's lace
Blue species	Lycaenidae family	n/a			21		3			2		1		x				5	1	3	
Cabbage White	*Pieris rapae*	SNA	26	56	40	15	34	53	86	38	2	44	20	x	15	61	327	28	36	77	Mustards… cabbage, cauliflower and broccoli
Clouded Sulphur	*Colias philodice*	S5	35	37	17	40	38	37	62	25	18	30	80	x	31	24	105	58	57	32	Legumes… cultivated crops
Common Buckeye	*Junonia coenia*	SNR (G5)												x		1					Uncommon breeding migrant
Common Ringlet*	*Coenonympha tullia*	S5		1		1	3				3	11	15	x	8	20	66		4	7	Kentucky bluegrass
Common Wood-Nymph	*Cercyonis pegala*	S5			1	1	2						1	x			1			3	Grasses (Poaceae)
Crescent species*	*Phyciodes* spp.	n/a	1											x		2	8				
Delaware Skipper*	*Anatrytone logan*	S4	2				2							x							Big bluestem and old switch panicgrass
Dun Skipper*	*Euphyes vestris*	S5			3									x				2			Sedges: chufa flatsedge, sun sedge
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	2	1	6	5	23	2	x	3	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					7	1	x	2					42	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 spp.	Hesperiinae family	n/a								1		4	1	x							
Great-spangled Fritillary	*Speyeria cybele*	S5												x							Violets
Lady species	*Vanessa* spp.	n/a			1									x							
Least Skipper*	*Ancyloxypha numitor*	S5												x							Grasses (Poaceae)
Little Wood-Satyr*	*Megisto cymela*	S5												x							Grasses (Poaceae)… Kentucky bluegrass and orchard grass
Monarch	*Danaus plexippus*	S2N,S4B	3	46	280	49	68	5	28	79	11	44	12	x	20	4	38	227	7	46	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							Panic grasses: deertongue
Northern Crescent*	*Phyciodes cocyta*	S5												x			2				Asters
Orange Sulphur	*Colias eurytheme*	S5	2	4	2	3	3	7	22	2		5	3	x	2	9	21	2	3	2	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						13	Smooth-leaved true asters
Peck's Skipper*	*Polites peckius*	S5			7	1	2			2		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		11				x				5			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											4	x		3	7				Panicgrasses and bluegrasses
Summer Azure*	*Celastrina neglecta*	S5												x							Dogwoods, New Jersey tea, meadowsweets and viburnums
Viceroy*	*Limenitis archippus*	N5												x	1					2	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					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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