The Meadoway
COMMUNITY POWERED GREEN SPACES

A Blueprint for Naturalizing Infrastructure Corridors

A program of:

Toronto and Region Conservation Authority

As a groundbreaking initiative, The Meadoway project has transformed a hydro corridor in Scarborough into a vibrant 16-kilometre stretch of urban greenspace and meadow habitat that has become one of the largest naturalized linear urban corridors in Canada, linking key community and tourism destinations across the region.

The Meadoway, which is a vital component of Toronto and Region Conservation Authority's (TRCA) Trail Strategy for the Greater Toronto Region and the City of Toronto's Cycle Network Plan, is an innovative city building initiative that will provide a naturalized link between Rouge National Urban Park and downtown Toronto, stitching together more than 15 parks/greenspaces, seven watercourses, tourist destinations (including the Toronto Zoo), employment centres, education facilities (including Centennial College and the University of Toronto Scarborough Campus) and transportation hubs. A multi-use trail network enhances the connectivity of the existing urban fabric, and is complemented by meadow habitat restoration.

With the knowledge gained on The Meadoway, TRCA has emerged as experts in the field of meadow restoration. "A Blueprint for Naturalizing Infrastructure Corridors" has been written as a 'how-to guide' for right of way restoration based on the lessons we have learned. Our hope is that we can share this knowledge far and wide for application across North America and beyond.

The Meadoway is the kind of ecological-based, community-building project TRCA is thrilled to be a part of. I am incredibly proud of the efforts spanning multiple teams across TRCA and the Toronto and Region Conservation Foundation (TRCF). We are thankful for the generous support of the Weston Family Foundation and partners, including the City of Toronto and the federal government through Parks Canada (Rouge National Urban Park), Housing, Infrastructure and Communities Canada, and Environment and Climate Change Canada. We are also thankful for the efforts of Hydro One Network Inc. and Infrastructure Ontario to facilitate restoration and trail work on provincially owned and managed lands. All these agencies, numerous schools and institutions across Scarborough and thousands of community volunteers in local organizations have also played critical roles in achieving the vision of The Meadoway.

TRCA is honoured to continue to advance this work for the natural environment and the citizens of the Greater Toronto Region.

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1 Introduction

Urban expansion and intensification are placing increased pressure on the remaining green spaces of the Greater Toronto Area (GTA). Loss of natural habitat is the most significant factor contributing to the reduction of biodiversity, including native plants, birds, pollinators and other wildlife. Meadow habitats have been in decline throughout Ontario due to the expansion of urban areas, intensification of agriculture and the suppression of natural disturbances such as fire. The loss of meadow habitat has led to the loss of food sources, migratory staging areas, and overwintering or nesting areas for several bird and pollinator species.

However, across southern Ontario there are thousands of kilometres of infrastructure corridors maintained by private companies, government agencies and other entities. Showcasing alternative land management options like meadow restoration within these infrastructure corridors could help promote beneficial habitat that requires minimal maintenance compared to full removal of trees and shrubs during typical corridor maintenance.

Urban, suburban and rural areas in the GTA are crisscrossed by a complex network of infrastructure corridors – accommodating electric power lines, pipelines, telephone and fibre optics, and buried water and sewer lines. Many of these corridors feature non-native plants that must be mowed six to eight times a year to limit plant height and woody stem growth and facilitate access by utility vehicles to service site equipment. The result is lengthy swaths of low-quality habitat and underused manicured areas that provide little benefit to biodiversity, ecosystem function and ecosystem services.

Many of these corridors also offer an opportunity to expand and connect the trail network across the GTA, providing a wide range of recreational possibilities, including hiking, biking, jogging and other modes of active transport, as well as bird and butterfly watching, art and photography, nature study, and outdoor education (either group or self-guided).

Collectively, these corridors represent thousands of hectares of greenspace that could be better utilized to promote biodiversity, support climate change resiliency, and meet active transportation needs, while simultaneously meeting their primary infrastructure-related roles in, potentially, a more cost-effective manner. The naturalization and revitalization of infrastructure corridors is a "win-win-win" situation for municipal and utility stakeholders, residents and the natural environment.

With proper planning and ongoing maintenance and monitoring, many of these corridors have the potential to be transformed into vital pathways connecting natural heritage systems and supporting wildlife movement, while promoting biodiversity, natural functions and ecosystem health.

The infrastructure corridors in the GTA, southern Ontario and across North America provide an opportunity to rethink urban and near urban greenspaces by replacing kilometres of biologically barren, mown turf or low-quality non-native vegetation communities with ecoregion-appropriate native meadow habitats. The Meadoway restoration project offers an illustrative blueprint of how to do this in your area.

The purpose of this document is to provide practitioners with a behind-the-scenes look at how decisions were made, the strategies used, and insight into tips and tricks that The Meadoway project team has learned over the years.

1.1 A SHORT HISTORY OF THE MEADOWAY PROJECT

Walking and biking trails within infrastructure corridors are already a significant component of the Greater Toronto Region Trail Network, as set out in Toronto and Region Conservation Authority (TRCA) Trail Strategy for the Greater Toronto Region. Approximately 182 kilometres, or some 38 percent, of the total trail opportunities identified in the Trail Network in 2019 are located within infrastructure corridors. The Meadoway is a key component of that network.

The Meadoway grew out of the Scarborough Centre Butterfly Trail (SCBT) project, launched in 2012, that saw a 40-hectare (99-acre) section of under-utilized space within the Gatineau Hydro Corridor lands transformed into a thriving native meadow community supporting a variety of butterflies, other pollinators, birds and wildflower species. The original SCBT stretched from Thomson Memorial Park (near McCowan Road and Lawrence Avenue East) 3.25 kilometres northeast to Scarborough Golf Club Road.

The success of the SCBT spurred its supporters and sponsors to investigate and advocate for a more ambitious revitalization program. As a result, The Meadoway project was launched in 2018. Led by TRCA, in partnership with City of Toronto (the City), and The Weston Family Foundation, The Meadoway project continues to transform 16 kilometres (comprising 200 hectares) of that same hydro utility corridor in Scarborough into one of the largest urban linear greenspaces in Canada.

The Meadoway connects seven watercourses and more than 15 parks, passes through 13 neighbourhoods, and provides an attractive, active transport link between the Don River ravine in downtown Toronto and Rouge National Urban Park in the east (i.e., west of Bermondsey Avenue to Meadowvale Road).

The Meadoway project is one of the most innovative meadow restoration and outreach projects in Canada. The Environmental Assessment (EA) for the trail network was completed in December 2019. Since this time trail construction has progressed on an annual basis with all trail gaps currently in the design or implementation stage. By the fall of 2020, half of The Meadoway was already seeded, and by the end of 2024, the entire 16-kilometre stretch of utility corridor was planted with native meadow species.

Throughout the planning and implementation, TRCA has worked to make The Meadoway project a model of how to successfully revitalize and repurpose utility corridors in both a local and international context. While the bulk of this manual is devoted to the processes used to plan, create and maintain meadow habitats, it also provides a short summary of some of the community outreach, consultation and educational components that are vital to such a project's ultimate success.


BEFORE


AFTER

1.2 BENEFITS OF MEADOW RESTORATION IN A UTILITY CORRIDOR

As urbanization continues to expand and encroach into natural areas that are critical for the survival of wildlife, meadow habitats are often the first to be lost. Meadows are usually located on unprotected tableland that is easy to service and build on. In addition, meadow habitats have been in decline across Ontario due to the intensification of agriculture and the suppression of fire and other natural disturbances.

Meadows are a unique ecological community dominated by herbaceous plants, such as grasses, sedges and forbs. Characterized by deep soils and a lack of trees and shrubs, a stable meadow has a maximum of only 25 percent tree canopy cover.

The loss of meadow habitat has led to a decline in food sources – as well as a loss of migratory staging, overwintering and/or nesting areas – for many bird, butterfly and pollinator species. Habitat loss is a primary reason that many native plant and animal species have been listed under the Endangered Species Act, 2007.

Creating meadows within infrastructure corridors is an excellent example of transforming underutilized or degraded habitat into thriving ecosystems. Meadow restoration promotes the return of native bird and pollinator species to the local area and improves connectivity to existing natural habitats with resulting beneficial impacts on neighbouring communities, regional biodiversity and climate change resiliency.

The Meadoway project is delivering a wide range of benefits:

- Enhance ecological services (e.g., pollination) through increased biodiversity resulting in ecosystem resilience.
- Increase flora diversity (and, therefore, local genetic diversity) creating site resilience.
- Improve wildlife habitat and enhance natural corridors supporting species movement.
- Increase water infiltration and groundwater recharge due to the deep roots of meadow plants. Meadows can withstand a 100-year storm event and help decrease surface water runoff, minimizing flooding (Qin, 2022)
- Improve flood attenuation via surface water uptake and reduced runoff, resulting in reduced soil erosion and compaction.
- Reduce pollution through air filtration by plant species.
- Increase carbon sequestration as meadow plants capture and store carbon in their extensive root systems.
- Increase the cooling effect of native meadow vegetation. Thermal imagery shows a 4-9° C difference between meadows and adjacent turfgrass. This can help mitigate the heat island effect of cities, contributing to climate goals and green infrastructure.
- Reduce maintenance costs and lower air emissions due to decreased mowing.
- Create a smaller carbon footprint through reduced annual mowing.
- Enhance recreational and active transportation opportunities, including biking, walking, running, bird watching, etc. promoting residents' overall health.
- Improve aesthetic values throughout the seasons, with greater local access to "nature in the city" promoting residents' mental health and spiritual well-being.
- Provide educational opportunities for community and school groups.
- Provide opportunities for residents and the wider general public to establish a stronger environmental connection through stewardship of these lands.
- Provide ongoing research opportunities.

Integrating The Meadoway with neighbourhoods, parks, public access points, and other trail systems will promote community connectivity and augment the city's bikeways network. Restoration of the existing corridor with meadow habitat will contribute to the city's urban greenspace and improve ecological diversity.

2 Restoration Planning

Planning The Meadoway restoration project involved a series of steps, including:

- Determining and outlining project goals
- Obtaining permits and partnership agreements
- Undertaking field and desktop surveys and investigations
- Compiling data and detailed maps
- Designing and executing an implementation strategy

2.1 THE GOALS OF THE MEADOWAY PROJECT

Identifying project goals helped determine The Meadoway's restoration design, practices and procedures. All projects must align with TRCA's Strategic Plan, which sets out TRCA's vision, mission, guiding principles and strategic directions.

Applicable to this project is TRCA's goal of ecological restoration, which aims to protect and restore ecosystem structure and processes to improve ecosystem function.

The Meadoway goals include:

- Connections
- Natural Environment and Education
- Recreation
- Transportation
- Community and Public Realm
- Blueprint for Revitalization

Each goal comes with a unique array of potential challenges and solutions that impact the restoration practices and procedures used for the site.

2.2 LAND OWNERSHIP AND PARTNERSHIP AGREEMENTS

The Gatineau Hydro Corridor lands are owned by Infrastructure Ontario (IO) and managed by Hydro One Networks Inc. (HONI). The City of Toronto has a Master Park License Agreement with HONI for The Meadoway portions of this corridor.

In 2012, with the launch of the Scarborough Butterfly Trail, TRCA determined that this corridor would benefit from meadow naturalization (including shrub node features) to complement the existing multi-use trail that was installed by the City of Toronto between Thomson Memorial Park and Scarborough Golf Club Road. A meadow ecosystem was deemed ecologically beneficial, as well as compatible with the management requirements of the hydro corridor. Hydro corridors within the city are typically mowed six to eight times a year to maintain access to hydro towers/lines and to limit tree growth. Creation of a meadow habitat would not impede access to the towers and fits with management practices of HONI. The establishment of natural meadow habitat would reduce the frequency and extent of future mowing, creating cost savings/ reducing management costs and reducing emissions.

A conceptualization of the project was created using a compilation of a detailed site inventory, including landscape features (hydrological and soil systems), soil analysis, invasive species, etc. Preparation of comprehensive site maps using commercial software was used to support project designers. These activities are described in more detail on the following pages.

2.3 SITE INVENTORY / ANALYSIS

In planning The Meadoway restoration work, TRCA employed its Integrated Restoration Prioritization (IRP) and Restoration Opportunity Planning (ROP) process to identify and record site-level information. The goal of ecological restoration is to protect and restore ecosystem function, which can lead to enhanced natural system resiliency and can maximize the benefits provided through ecological goods and services. The goal of the IRP framework is to create consistent and replicable processes to facilitate effective ecological restoration. IRP prioritizes restoration opportunities based on multiple objectives and benefits and will help guide restoration planning and effective resource investments to ensure healthy and functioning ecosystems throughout the GTA. The following activities were undertaken to assess the site and create an informed strategy and operational plan, as described below.

2.3.1 Field Assessment

A comprehensive on-site field analysis inventories the abiotic, biotic and cultural conditions of the site. This information helps classify the site's current conditions (to analyze the steps and effort required to transition the lands to a meadow) and informs the meadow design process (such as seed species selection).

The analysis of landscape features using ROP and IRP tools helps to provide a better understanding of hydrology, groundwater recharge, potential growing conditions and the overall natural heritage system. This information can then be used to inform decisions about restoration objectives, including meadows, wetlands, low impact development (LID) restoration projects, shrub nodes and species selection. Knowledge of soil type, depth, current vegetation cover, climate and geographic area can be used to determine the Ecological Land Classification (ELC), Ecozone, Ecoregion and Plant Hardiness Zone. Vegetation monitoring protocols can help assess current vegetation levels and can give clues as to what the abiotic components of the site can support. Documenting invasive species populations or areas that contain native species to be retained is also necessary.

Soil tests for chemicals and nutrients help to characterize the types of soil in the targeted area and provide insights on pH, fertility, organic matter content, prior herbicide use/residues, and salt residues.

Standard agricultural soil test:

- A trowel and a bucket are all that are needed to collect the soil.
- Randomly in the field, take three samples of soil and record sample locations in the field.
- Mix the soil in a clean bucket and put approximately one cup of soil into a resealable plastic bag. Label the bag.
- Package and send the samples to an agricultural test laboratory (e.g., the Agriculture and Food Laboratory at University of Guelph, guelphlabservices.com). Typical tests include: NPK (i.e., ratio of nitrogen/phosphorus/potassium), pH level and soil organic matter, as well as tests to determine the presence of certain persistent chemicals (that can affect germination).

Seedbank and germination tests for chemicals and seedbank:

- Collect enough soil to fill two nursery trays.
- Outside or in a greenhouse, fill the two trays and pack them down.
- In one tray, seed ½ radish and ½ lettuce (seeds that are fast germinating and sensitive to chemicals).
- In the other tray, leave ½ unseeded for a control (to see what weeds come up naturally which helps provide information on the soil's seedbank).
- In the other ½ tray, seed your native seed mix to see how they perform in the site's soil.
- Water regularly to get the ideal germination.

Topography of the site

It is important to understand the natural cover, topography and hydrology of the site before planning restoration activities. Steep slopes and wet areas can impact what equipment can be used and limit what activities are possible on the site. In addition, restoration activities creating soil disturbance are not advisable on steep gradients due to the increased potential for soil erosion unless erosion control measures are in place. In these instances, LID projects may be a better fit to help slow the speed of stormwater runoff and manage the impacts of flooding. The slopes are also more prone to drought, so selecting drought-resistant species for these areas will help increase survival.

Planning for wet areas

Prior to moving forward with a meadow restoration project, review restoration opportunities tied to wetlands, wet pockets or other LID projects to improve altered hydrology and manage runoff. When moving forward with meadow restoration, wet areas should be identified to determine native species suitability and determine appropriate implementation strategies and maintenance procedures. Ephemeral or vernal wet areas collect or hold water for only a certain time during the year and prairies and meadows can occur in these areas, but species choices must be adapted to match the conditions. These areas may be characterized by higher concentrations of clay soils, plants that favour or tolerate moist-wet soil conditions, and seasonal standing water.

Awareness of the hydrologic conditions, water table heights and patterns, and topographical features, including man-made drainage features (e.g., ditches), should help to predict where LID projects can occur. Once identified, wet areas should be mapped so maintenance procedures and implementation strategies can be adapted. These wet areas should be prepared in similar ways to drier areas but will have different native species targeted for the final seeding, including species adapted to wetter soil conditions. Also, care should be taken for these wet areas during site preparation and management, as the timing of procedures becomes more important to avoid damage to equipment and lost time.

Planning for dry sandy soil and rocky areas

Dry, sandy soil and rocky areas should be identified to determine suitable native species and suitable implementation strategies. These soil types can produce large volumes of dust and have the potential to damage site preparation equipment, so careful consideration is needed to determine the best methods when planning a meadow project. In addition, choosing species that are adapted to well drained soils with poor nutrients will ensure higher germination and success rates for the created meadow.

Planning the shape of the meadow

During a field assessment, it can be helpful to place markings (such as pin flags) to indicate the outline of the future meadow. When designing the meadow shape, account for restoration implementation equipment, as well as long-term management activities. Frequent curves or sharp angles may be difficult to implement with large farming equipment. Consider the width of the equipment being used both for meadow and outer turfgrass border maintenance (like turfgrass mowers or woodchippers) as well as the turning radius of the equipment when determining what the edges will look like. See Section 5.3 for more information regarding the turfgrass buffer areas surrounding the meadows.

Consider how the public will interact with the space, whether there are designated walking paths, and where those paths are in relation to the proposed meadow footprint (e.g., if the meadow covers previous informal walking trails). Design of the meadow should not impede regular foot traffic. Working with pre-existing trails and consulting local community members to develop a footprint that works for all parties is important. When designing the meadow footprint, it is advised to make the footprint as large and unbroken as possible; narrow, small habitats are prone to low biodiversity and invasive species pressure, increasing the negative effects of habitat fragmentation.

2.3.2 Mapping

Field mapping was conducted using the ArcGIS Field Maps software to calculate the correct dimensions of the site, enhance understanding, and determine the location of features and hydro towers that would affect implementation goals (i.e., natural or man-made features, such as culverts, garbage dumping areas, high traffic areas, etc.).

Mapping with the ArcGIS software can also be used:

- As a visualization tool to help project designers
- To record permanent photo monitoring points for vantage continuity
- To track changes and developments on-site
- To capture hazards or workflow impediments that would need to be considered in the implementation plan
- To map wildlife, invasive species and any habitat structures placed
- To plan out turfgrass buffer areas surrounding the meadow
- To identify areas requiring further management activities, invasive species controls, research trials, prevention of garbage dumping, etc.
- To calculate the quantity of seed needed for both cover crop and for native seeding

2.3.3 Project Proposal Package

When working in a utility corridor, meadow restoration implementation requires unique considerations and approvals from facility owners and land managers. Some details to include in the project proposal package (composed of the concept plan and project outline) are as follows:

- The location of all utility facilities (towers, centerlines of conductors, poles, etc.) potentially affected by the proposal to be shown and clearly labeled. The sag/sway of power lines must be considered for built infrastructure, such as bridges
- The planned installation and location of any structures above or in-ground, including design drawings for typical structures (that also shows any grounding rods if required by infrastructure company), such as bird boxes, shrub and meadow habitat, wetlands, etc.
- It is preferable that trails and structures are located where there are gaps in the lines, not directly under utility lines if possible
- Native shrubs, forbs and grass species mixes need to be reviewed as height restrictions with utility lines may be in place
- Utility companies may have fencing to restrict public access to the corridor which can block restoration activities from occurring. Site access should be discussed with the property owners and land managers. The fencing and related signage can help reduce illegal dumping and trespassing on the site but requires maintenance to be effective. Trespassing of unauthorized vehicles can lead to site damage, increase hazards for the public and workers, as well as create public discontentment. Work with property managers to notify them of damage and issues.

2.3.4 Consultation

Public and stakeholder consultation is a necessity from the start and throughout the entire course of the project in order to build appreciation and support. At The Meadoway, consultation was initiated as a component of the Class Environmental Assessment (EA) process. A variety of engagement tools were used throughout the EA process including the completion of a Visualization Toolkit. The Toolkit provided the public and stakeholders with a compelling image of the plan's concepts and how they may ultimately appear on the landscape.

3 Implementation

3.1 IMPLEMENTATION PLANNING

Once the overall project plan has been created and approved, implementation becomes the main focus. Some of the main activities during the start of the implementation phase include scheduling the activities, hiring necessary staff or contractors, obtaining pertinent equipment and materials, and ensuring appropriate permits are acquired and valid. Before starting any work, a site walk is important to complete to assess the hazards on site, remove garbage, and plan exact work locations.

3.1.1 Implementation Schedule

Project management tools are helpful for planning and tracking work activities, as well as meeting timelines during the field season. Gantt charts were used for The Meadoway project (see an example below). Due to the successive nature of meadows, as well as the duration and size of the project, thorough planning was needed to ensure deliverables and objectives were achieved on time. Each activity needs to be well understood to ensure the accurate prediction of duration and timing.

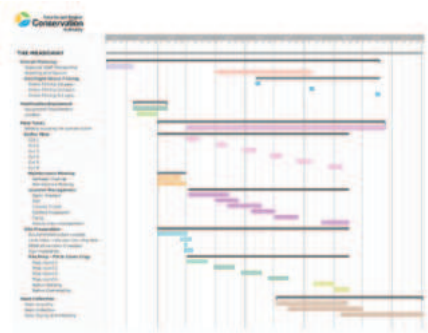


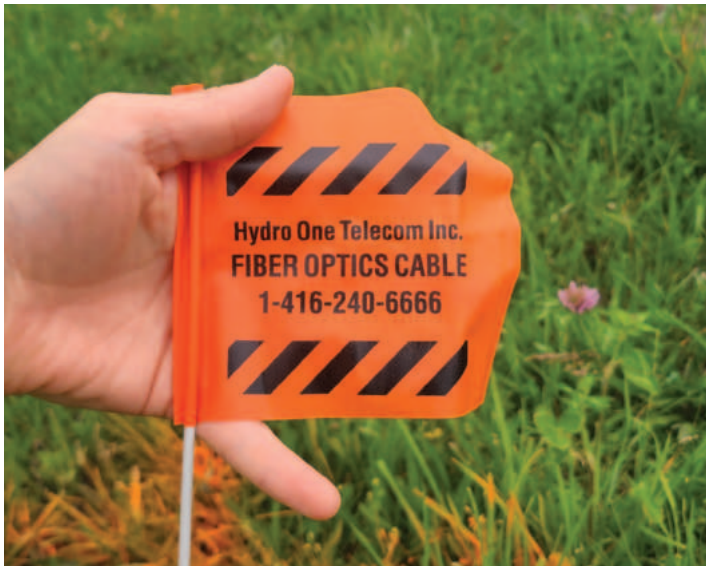
Figure 1: Sample project schedule using the Team Gantt tools.

3.1.2 The Location of Buried Infrastructure

Before starting any excavation, detailed buried infrastructure locates must be completed to ensure the safety of staff and prevent potential damage to infrastructure and equipment. It is important to keep these updated/valid as the restoration process will span long time periods.

Meadow restoration work generally occurs at shallow soil depths; however, some infrastructure, such as buried vital gas mains, have specific regulations restricting excavation within a certain setback. For example, a vital gas main occurs in some sections of The Meadoway and precludes any soil disturbance within 3.5 metres (11.5 ft) of the pipeline; therefore, alterations were made to the restoration plan to employ no-till techniques within these setbacks.

In Ontario, most locates on infrastructure corridors can be completed through the Ontario One Call website. However, if the worksite includes sections of privately-owned land, separate private locates may be required.



3.1.3 Equipment Considerations

Site safety is imperative in any restoration process both for staff and members of the public with access to the space. Place signage and/or fencing to inform the public of the work and to delineate safe distances. Staff operating machinery need to be properly trained and must follow specific policies and procedures regarding equipment, particularly around the public. If work is occurring in areas that have public access or high amounts of traffic, ensure there is additional staff to act as spotters. Other helpful tips include:

- Working in urban utility corridors may require moving a lot of equipment along corridors crossed by roads, railways, bridges and ravines. To reduce costs, select equipment that is narrow enough for single lane travel and that can be driven on the road.
- When choosing equipment, look at access points and note potential impediments, such as utility poles, light posts, road-crossing fixtures, bollards, signage and low wires that may limit access by larger/taller equipment. This information will help in planning potential routes or alternative movement options that may need to be considered.
- Equipment storage and availability is a determining factor in the pace/timing of the project. Meadow restoration involves many activities; access to a variety of equipment is needed to complete these tasks. Budgets and stakeholder partnerships may influence these decisions.
- Equipment should be well maintained and in good working order. Daily inspections should be undertaken, particularly in urban areas where the public has access to the equipment overnight and vandalism may occur. If possible, store on-site equipment away from roads or access points to reduce the risk of it being stolen. Lock up equipment to prevent movement and vandalism.
- Spill kits should be kept on hand in case of incidents; fueling should take place on non-permeable surfaces in case of accidental spillage.
- Fuelling of equipment within the corridor footprint might be restricted due to the potential risk of arcing and fires. Check on this regulation prior to bringing your equipment onto site.
- Clean equipment protocols should be followed to minimize the spread of invasive species, contaminated soils or other pathogens.

3.1.4 Garbage Cleanup

At the beginning of the implementation phase of the project, remove all the garbage within the work area. Garbage removal will prevent equipment damage and foster greater public and neighbourhood acceptance of the restoration project. This is a great opportunity for community engagement and to connect people to the space. To discourage the illegal dumping of trash on a site, try to eliminate areas hidden from public view, increase visibility of the site, and post signage. If possible, limit access to the site for vehicles (using fencing and gates) to prevent large dumping piles. Garbage removal will likely be an ongoing task as garbage may blow in from adjacent roads and spaces.

3.1.5 Site Delineation

Once garbage collection has been completed, delineate the site boundary by placing temporary pin flags to help field-fit the design and make changes to the boundary as necessary. Posts with temporary signage can be installed every 50 metres (164 ft) around the meadow footprint boundary. This will help mark the site border and inform the public on the meadow restoration process. The posting of bold "No Mow" signs will also help prevent accidental meadow mowing (for examples of such signage, see Appendix 1).

3.2 SITE PREPARATION

Site preparation is the most critical step in ensuring the ultimate success of a meadow revitalization project, as well as reducing future maintenance efforts. The goal of site preparation is to create the ideal conditions for the establishment of native wildflower and grass seeds. Other benefits of good site preparation, especially in an urban meadow restoration project, include the removal of undesirable or invasive plant species from the seedbank to reduce competition for the native planted species. Without good site preparation, undesirable weeds may outcompete the native meadow seedlings, requiring more extensive and expensive invasive species management in the future.

Site preparation can also be used to remediate the soil by adding nutrients and reducing soil compaction. Additionally, site preparation can help to remove hazards (such as garbage, buried metal or rocks) that may pose a safety issue to equipment or people. All these actions will improve conditions to plant and establish native species and allow for a more successful restoration effort. The overall goal of site preparation is a flat, firm seedbed, with little to no weed/invasive species growth remaining. The time and amount of work involved may vary depending on current site conditions, but proper preparation is a necessity.

There are multiple ways that site preparation can be accomplished by using a variety of equipment types, techniques, and repetition of soil preparation practices. One method is not inherently better than the other, and site-specific factors may help decide what method to use.

Factors to consider when choosing what site preparation method to use include:

- the size of the site
- site access
- budget
- available equipment
- timing (how long you have and time of year)
- soil type and structure
- historic uses of the site
- site topography
- initial flora inventories
- invasive species presence
- permits required
- and site restrictions/hazards

You may have to use a combination of methods to best manage all these factors. Practitioners must be adaptable to challenges with each site and use or change to a method that fits the site-specific conditions. Context matters, and there is no "one-size-fits-all" model for site preparation. Everything is contextually specific, so learning to adapt and use a variety of methods can ensure higher success rates.

Completing site prep over multiple seasons is beneficial in depleting the seedbank, because it targets the removal of species that germinate at different times of year. Completing site prep in a second year allows those weed species whose seed is brought up to the surface to go through a cold stratification process, meaning more seeds will be able to germinate and thus be eliminated. This allows for less surprises the following year during germination.

3.2.1 Clearing/Mowing

Once the layout of the site is marked and you have received valid locates, some initial clearing may be required, including the removal of invasive species, grubbing of the site (which entails the removal of undesirable trees, shrubs, stumps and excess thatch), and undertaking an initial mow. Before any work can begin, the area should be fully mowed to achieve better results and prevent strain on machinery and equipment.

Ideas and tips for tree and shrub removal include:

- Use a tractor or skid steer with a bucket for light grading and removing small shrub stumps.
- Use an excavator with a thumb attachment for larger brush that needs removal or to pile wood debris. Be sure to get approval from utility companies prior to using an excavator in the corridor; there may be concerns about proximity to infrastructure. The removal of any large standing trees needs prior approval from the utility company due to the hazard of contacting overhead lines. Line clearing crews conduct regular maintenance efforts on trees within proximity limits to the lines.
- With approval, wood debris may be stored on site and used for a variety of habitat features, such as brush piles and snake hibernacula. For utility corridors that require emergency access, this may not be permitted, as issues with habitat features hidden by vegetation may potentially create vehicle collisions, safety concerns and equipment damage.

- Chainsaws can be used to fell trees, but stumps should be either removed or marked as they could pose a potential hazard to vehicles, equipment and people. At minimum, cut stumps flush to the ground to prevent damage to vehicles and reduce the tripping hazard. Use of a stump grinder to remove the stumps within the meadow footprint prior to site preparation is greatly beneficial, as stumps left in the ground will become invasive species hotspots and hazards to mowers (valid locates are required for this due to potential buried infrastructure).
- Invasive trees and shrubs should be removed before berry/seed production to prevent the spread of seeds. All parts of the invasive trees and shrubs should be removed from site to prevent potential regrowth.
- When removing or pruning trees or shrubs, consider the next steps for the exposed soil beneath it. If the tree is within the meadow footprint, the area can now be included in ongoing meadow site preparation activities. If it is in the turfgrass buffer area surrounding the meadow, consider seeding the exposed soil with turfgrass seed to match its surroundings and reduce possible invasions.

- If the site is in a highly public area with trails or open grassed/treed areas that will remain manicured, pruning of tree limbs to the height of the mowing equipment will make future management easier. Tree bases will often become hotspots for invasive vegetation and access will allow easier management. This work should be completed before the meadow is seeded to allow ease of access for necessary equipment and minimize invasive species management. Elevation pruning of trees should be undertaken to the height of the tallest piece of equipment used to create and maintain the meadow, to help maintain access and prevent damage to the trees and equipment. The same work should also be done along adjacent fence lines to ensure access along the boundaries of the project.
- Be aware that private landowners adjacent to the project may have planted their own trees and shrubs in your work area. Consider light pruning measures on these trees, and work with the homeowner to determine the next steps.
- If a tree is to be preserved on site, ensure that its root system is protected from restoration activities by following Tree Protection Zone guidelines enforced by municipalities. This includes keeping restoration work outside of the dripline of the tree and preventing equipment from compacting the soil within that area.

Depending on the initial site status, mowing with a heavy-duty brush mower can be beneficial. This will reduce the residue for tillage work, prevent equipment binding and aid herbicide application (if such use is planned). Care must be taken to avoid hidden hazards on site that may damage mowing equipment (for example, hidden garbage, buried metal, stumps, etc.). Mowing should also be conducted outside of the breeding bird window to avoid damage to ground nesting birds.


TRCA

3.2.2 Site Preparation Methods

Below is a list of site preparation methods, an overview of how they work, the advantages and disadvantages of each, and what type of site each method might be most useful on. A table (Figure 2, Site Preparation Methods) is included to summarize these discussion points.
It should be noted that there are multiple other options for site preparation, but the restrictions of utility corridors can limit what activities are feasible. Examples of some other methods that have not been used in The Meadoway include prescribed burning, solarizing and grazing.

Cultivation/Rototilling
Most of The Meadoway has been prepared using multiple rounds of rototilling. This is the process of using a rototiller to break up, loosen and aerate the soil, as well as to bring buried, dormant seeds and plant roots to the top of the soil. The uprooted vegetation and root structures will breakdown through sun exposure, while the seeds will have an opportunity to germinate and start to grow before being terminated by the next round of tillage, thus reducing the seedbank.

Following cultivation, a low-density cover crop should be seeded. This can be done effectively using a broadcast seeder or by hand (see Section 3.2.3 on cover crop). A chain harrow or roller can then be used to increase seed-to-soil contact and achieve higher germination rates.

It is recommended that several repeated rounds of rototilling and cover cropping be completed throughout an entire growing season or stretched between multiple years/growing seasons. Each round should allow the cover crop and seedbank to germinate and grow for a three-to-five-week interval, or before weeds and cover crop reach a height of 15 cm (6″), followed by additional tillage to terminate them. Do not let cover crops grow over 25 cm (10″) to discourage ground-nesting birds from nesting between rounds of rototilling, and to avoid having to mow the area prior to another round of tilling.

If completed with enough frequency (i.e., three to five cycles from April to October), the seedbank can be dramatically reduced and result in good establishment of native seed through fall or spring seeding. Ideally, splitting this between two growing seasons would be best as it encourages undesirable seeds that require winter stratification time to germinate and grow.
Project budget will greatly affect the number of cycles accomplished and the timing of these applications.

Some of the advantages of this method are that it:

1. does not rely on large quantities of herbicides;
2. creates a level seedbed; and
3. works to deplete undesirable seed reservoirs in the soil.

However, the disadvantages are the high cost to run the machinery multiple times a year, the slow speed, the disturbance to the soil layers, and the inability of this method to control undesirable plant species with long root systems. For example, rototillers will not manage field bindweed, as the root system of the plant can go down almost one meter (3 ft) into the soil, so smaller herbicide treatments may still be required. In addition, rototilling and harrowing leave the soil highly aerated, which is not ideal for drill seeding, so the soil will need to be compressed (using a roller) before a drill can be run on it. Lastly, rototilling is not suitable on steep slopes due to issues with erosion and safety, and it cannot be done over certain types of buried infrastructure (e.g., large gas lines). Depending on the moisture in the soil, tilling and harrowing can be dusty, so avoid undertaking these activities close to houses or roads under very dry conditions to minimize the impact of dust.

Other methods of soil cultivation can be used in combination with rototilling (e.g., chisel plows, spring harrows, sweep cultivators). For large sites, use of a moldboard plow is ideal to invert the soil on the first round, followed by using a set of discs to break apart the furrows. Additional rounds of rototilling will help control invasive species that regrow following this. The site conditions play a major role in deciding if this method is useful, as plowing/discing should only be done in dry soil, as wet soil clumps and gets stuck on the plow and disk, causing delays. Additionally, plowing is fast for long, straight stretches, but becomes more difficult if the site has a variety of obstacles (like trees or shrubs) or small tight spaces/boundaries.

Soil Inversion

This method was developed by The Xerces Society for Invertebrate Conservation (Portland, OR) as a method of site preparation that minimally impacts pollinators. This method is achieved using a moldboard plow to invert the soil, placing the seedbank and growing plants on the bottom and bringing cleaner subsoil to the surface. After this, a disc harrow is run over the site to break apart dirt clods and smooth out the soil, and native seed can be placed by hand.

The advantages of this method are its minimal cost requirements and quick turnaround. Some of the challenges with this method include issues with invasive species, damage to the soil profile, and site condition requirements. This method is best used on sites with minimal invasives, as it does not work well at removing persistent perennial weeds (these plants are able to regrow after soil inversion, requiring extensive management after restoration).

Soil inversion involves flipping soil layers so that the nutrient-poor subsoil is at the surface and the nutrient-rich organic material gets buried (with the seedbank). This inversion can cause damage to soil health and soil microbial communities and changing its suitability for plants. Lastly, plowing does not work well on sites with heavy moisture content, as the soil clogs the plow. Plowing is also best suited for long straight areas and becomes a lot more difficult/less effective on a site with a variety of obstacles (like trees or shrubs) or small tight spaces/boundaries. This method is best done in the spring for grass dominated seed mixes, whereas for seed mixes with species that require cold-moist stratification, this method should be done in the fall.

Blanket Spray Herbicide Applications
The application of herbicide to the entire designated meadow footprint is primarily done to remove the existing vegetation and can be a low-cost option for site preparation. A variety of herbicides are available, but systemic herbicides are most frequently used to ensure that the entire plant is affected, and non-selective products allow for a wide variety of target species.

Herbicide applications as a site preparation method can be done in combination with another method, or as a stand-alone option. Generally, multiple applications are necessary to ensure adequate coverage and depletion of the weed source. Before choosing an herbicide, a deeper understanding of the targeted non-desirable species is needed to understand application timing and rates of application. To choose the best herbicide for the job, ensure you are reading the label to match up target species and application rates. Herbicide applicator licenses may be required for this method.

In The Meadoway, a truck-mounted boom sprayer was used to perform blanket herbicide applications, but tractor mounted, or stand-alone vehicles can also be used. Target vegetation should be low in height to prevent plants from contacting the nozzles. Assess site layout, slopes and obstacles to determine viable driving speeds during equipment calibration. Nozzles may leak slightly during application and damage non-target areas, so ensure all maneuvers are completed within the application area. For areas that are too small or awkward for a truck to fit into, bring a backpack sprayer with a fan nozzle or use a hose attachment from the truck-mounted tank.

Like tilling and plowing, the site should be seeded with cover crops after a blanket spray application to reduce exposed soils, prevent erosion, and return nutrients to the soil. The cover crop should be applied two weeks after the herbicide to avoid contaminating the seed with the chemical residues. Drill seeding the cover crop into the soil works better than broadcast seeding as the drill puts the seed deeper into the soil.

Advantages of multiple blanket herbicide applications are that they are fast, relatively inexpensive, can effectively remove plants with deep root systems and target the seed source on the surface of the soil. This method is best used for soils that are very rocky (where other mechanical methods cannot be safely used), or for areas where soil disturbance cannot be accomplished due to buried infrastructure or steep slopes. However, the negative aspects of repeated large volume herbicide applications must be considered. Boom spraying also requires very specific weather conditions (low wind speed), as the chance of spray drift, pressure inversions and hazards to human health are much higher.

Method	How To	Best Used For	Advantages	Disadvantages
Repeated Cultivation Method	Rototill area and apply cover crop. Repeat 3-5 times in one or more growing seasons. Can use a furrow plow for the first round, then rototilling in remaining rounds.	• Soils that are relatively clear of rocks and other debris. • Mostly flat, open areas with minimal obstacles • Herbicide-free sites	• Aerates soil and reduces compaction • Easily maneuverable • Herbicide-free • Reduces seedbank in soil • Exposes non desired weeds and invasive species (to better understand species hidden in the soil)	• Slow, requires multiple rounds • Labour-intensive • Expensive • Will not kill deep-rooted plants • Cannot be used over buried infrastructure or steep slopes • Erosion concerns with bare soil
Soil Inversion Method	One round of plowing, followed by discing to even out the surface and break up clumps of soil. Plant native species directly into disked soil	• Sites with low invasive pressure • Dry soil • Mostly flat, large sites	• Fastest method • Low budget • Buries seedbank under furrows • Reduces soil compaction	• Does not remove most perennial invasive species. May require more maintenance in future years in urban areas. • Will not work in wet conditions
Herbicide Applications Method	Blanket spray area, then seed with cover crops. Repeat 3-4 times or until no more invasives come up through summer to fall	• Rocky soils • Sites with underground infrastructure/ buried utility lines • Slopes • Limited site preparation timing • Small budget	• Kills off non-native weeds • Deplete surface seeds • Fast • Relatively inexpensive • Viable option for areas where you can't disturb the soil (steep slopes, buried infrastructure) • Can be used over Roundup Ready crops	• Herbicides can stay in the soil for a few weeks • Negative views surrounding herbicide usage • Negative effects on pollinators • Requires ideal weather conditions

Figure 2: Site Preparation Methods

3.2.3 Cover Crop Protocols

Following soil disturbance or the removal of vegetation, a cover crop is seeded in the prepared soil bed. Seeding of a cover crop is intended to reduce the impact of soil erosion by wind or rain, while still allowing space for the undesirable seeds within the seedbank to germinate and grow. These seedlings will then be targeted during the next round of site preparation, with the aim of depleting the seedbank of unwanted seeds before the native species are planted. The use of a cover crop also improves the aesthetics of the site, increases soil moisture retention due to shading and, when tilled under during the next round of preparation, acts as green manure to return nutrients to the soil.

Generally, annual oats (*Avena sativa*), proso millet (*Panicum miliaceum*) or buckwheat (*Fagopyrum esculentum*) serves as a cover crop, depending on temperature and the time of year seeding occurs. Separate trials using either oats or millet were undertaken and reviewed during The Meadoway project. For The Meadoway project, oats were the preferred cover crop due to their rapid germination and maturation timing, low cost, and tolerance of various soil conditions.

Best management practices (BMPs) for seeding, as set out by the Ministry of Agriculture, Food and Agribusiness (OMAFA), are to broadcast cover crop seed, and then harrow the seed into the soil. This helps break up soil clumps and incorporates the seed so that germination is faster, and the length of time soils are exposed to wind erosion is minimized.

The Meadoway project conducted a variety of trials on cover crop application processes involving various combinations of methods, including seeding by hand, using a seed drill, broadcast seeder, harrow and tow-behind roller. These trials found that the use of a broadcast seeder combined with a chain harrow or a packer roller worked best to increase seed-soil contact. This combination also produced the most successful germination rates and required minimum staff/equipment time. Both the harrow and the packer will break up dirt clumps and incorporate the seed into the soil, speeding germination time, as well as reducing the amount of seed lost to wildlife predation.

Harrowing

Chain Harrows are a simple implement that do not require connection to hydraulics and can be dragged behind a tractor. They work to prepare the soil by levelling the ground and pulling out root wads and are often used in tandem with other techniques.

Chain harrows are useful in:

- Levelling the ground to prepare the seedbed
- Pulling up root wads to assist in desiccation (especially if the tilling is done in damp/wet soil)
- Incorporating the cover crop seed

Chain harrows do not help with compacting the soil to ensure good seed-soil contact, so they may need to be used in conjunction with a packer before using a seed drill. Be aware that harrowing can be very dusty. Consider the soil moisture and weather conditions prior. A chain harrow also cannot be used on wet soils, as the soil sticks to the harrow and creates a large mound in front of it.

Rolling/Packing

The use of a roller or packer is not necessary with each round of site preparation but is a good alternative to using the chain harrow after broadcasting a cover crop. Cultipacker rollers (with knobs/spikes) help to incorporate seed into the soil in addition to compressing the soil and removing air pockets to create a seedbed that has uniform density. Air pockets, large dirt clods and an uneven planting surface can all negatively impact seeding success. The cultipacker rollers (knobbed or spiked roller) are effective at both firming the soil and incorporating the broadcast cover crop seed, which is essential for fall seeding with a seed drill.

Drill Seeding Cover Crops

Drill seeding should be used when the site preparation method does not involve soil disturbance (such as herbicide spraying). With no soil disturbance, cover crop seeds will not be incorporated into the soil at an appropriate depth for germination, and seedling success may go down with just a broadcast application. In addition, because the soil has not been disturbed, it is moderately compacted and prevents the cover crop from ever being incorporated into the soil. The seed drill will help cut through the dead layer of thatch and will plant the cover crop seeds into the soil at appropriate depths for germination.

4 Native Flora Establishment

4.1 PLANNING/DEVELOPMENT OF SPECIES MIXES

Careful development of the species mix is important to ensure that the restoration is a success, and it can be influenced by a variety of factors. To ensure that the restoration is successful, use plant species native to the area the restoration is located in. Using a variety of different species can provide increased diversity and ecosystem resilience.

Other important factors to consider when deciding on the species to include in your restoration include:

- Historical land use
- Abiotic conditions
- Reference vegetation communities
- Project goals
- Cost of species and project budget
- Ongoing site management capacity

Previous uses of the planned restoration site can impact site conditions. Soil disturbance, weed pressure, soil contamination, altered topography/slopes/hazards can all impact what species will do well on a site. On-going or projected site uses can also impact species choices, as high disturbance levels can be detrimental to some species.

Species selection should be determined by the abiotic conditions of the site, including moisture level, precipitation amounts, local weather/climate, soil type and texture, soil pH and light conditions. Species preferences and tolerances need to match these site-specific elements to ensure the best chance of germination and survival. Use of different seed mixes in other areas can help promote adaptation, diversity and germination.

In The Meadoway, multiple seed mixes were created to suit a variety of different abiotic conditions. For example, wet areas received seed mixes containing a mesic/wet-mesic mix of meadow species, chosen for their tolerance to wet/moist soils. Areas with high amounts of gravel, sand and compaction received a seed mix with hardy, drought-resistant species that tolerate full sun and well-drained soils. A mix of the hardiest and fast-growing native meadow plants were chosen for areas with high amounts of invasive species to better combat their spread and establishment (see Appendix 2: The Meadoway Seed Mixes).

Using the findings of the site inventory and habitat assessments, you can determine the ecosystem community that best reflects the project area and can serve as references for the project. For The Meadoway, two comparable healthy areas close to the project site were selected for further investigation of species diversity: (1) the High Park Black Oak Savannah, and (2) the Rice Lake Plains. Good species inventories were available for both communities and were compared to the species identified in the TRCA flora monitoring data for the Toronto region. The reference community can help to illustrate types of species associated with the ecosystems you want to build and provide local species list examples.

The goals of the site and restoration objectives will have a major impact on species selected for the seed mix. Consider what ecosystem services this place will be providing, and align the species mix with the project goals. A decision on percentages of forbs vs grasses should be made before selecting individual species. This percentage will depend on the meadow habitat type you are trying to achieve. Mixes should have a component of both grasses and forbs to promote a resilient ecosystem. This can range from a forbs-dominated mix (containing 70 percent forbs) to a grass-dominated mix (70 percent grasses), depending on the goals of the project. Increased biodiversity requires a variety of habitat types and high species compositions.

Some potential goals and their considerations are listed below:

- Species Diversity: A variety of flowering plant species should be chosen to provide a wide range of flowering times throughout the entire growing season (from early spring through to fall). This way, food/nectar sources for pollinator species will be continuously available throughout the growing season, especially during crucial shoulder season months (March to April and October to November) when there is a lack of abundant food types available.
- Habitat for Pollinators: Look to plant host species that align with local butterfly and moth species to increase beneficial use of meadow habitat through larval feeding (e.g., monarch butterfly to milkweed species).
- Species at Risk (SAR): Choose species that reflect the habitat of the species at risk you are targeting. For example, Bobolink require short grass meadows and hayfields to raise their young, so a site targeting them would have a species mix that reflects these requirements.
- Grass Mixes: Grass species are important to meadow habitats as they are long-lived plants that provide suitable nesting habitat for grassland birds, act as a food source for insects and birds, and can help outcompete non-native species due to their robust growth and longevity. They are also a larval food source for some butterfly species.
- Ecosystem Resilience: Knowledge of the growing patterns of each species will help managers anticipate the timeframe for occurrence and maturation within the restored meadow site. Some species are short-lived pioneer species that appear early on in restoration, while others are long-lived climax species that take multiple years to mature. Selecting a variety of species with different colonization and maturation times creates successional growth within the meadow, allowing for different habitat elements throughout its evolution. Ensure your seed mix has both long-lived slow-growing climax species and short-lived, pioneer species.
- Invasive Species and Competition: In areas with high competition, emphasis should be on species that grow aggressively and can successfully compete with undesirable species.

In the early stages of The Meadoway project, seed mixes were originally dry and wet mixes composed of 60 to 70 percent forbs and 30 to 40 percent grasses. Over time, additional seed mixes were created to:

- Increase species diversity.
- Better match the various soil characteristics found across the project area.
- Increase the benefit to wildlife and pollinators.

The final considerations for species selection are the amount of budget allocated to plant material and the amount of ongoing management for the site. Some plant species are inherently rare or are difficult to grow and produce in a nursery setting, driving up the costs. Others are easily mass produced and more readily available. Get an understanding of what species are expensive and use that information along with your requirements for the site to create a mix that is within budget but meets the diversity you require.

4.2 SEED PURCHASING

Seed availability is often a limiting factor for many native species; there are few native seed suppliers, and demand for native seed is rising. If you are going to start a large project, it is worth trying to talk to your local seed vendors to see what species they have available at the quantities you want. The earlier you have this talk, the more likely they could scale up production for you on the species you would like. Ensure you find out where the seed vendor is sourcing their species to understand its compatibility to your site.

The following factors should be considered when selecting species/seed:

- Native Species: Focus should be on native species that are indigenous to the area. Do not use cultivars or non-native plants, as they do not provide the same benefits to the ecosystem.
- Genetic Diversity: Aim for genetic diversity in the seed stock. Ask vendors where they source their seed from, and how frequently they are renewing the genetics of their stock to prevent inbreeding and genetic bottlenecks.
- Locally Adapted: Acquisition of local stock or plants from within the same seed zone should be researched and considered. Seed from local sources is better adapted to local climatic conditions.
- Climate Change: Keep in mind potential environmental changes associated with climate change by looking outside your seed zone. Plants from a variety of sources and microclimates may be better at adapting to changing ranges and conditions. These plants would be from different ecotypes and would have a wider range of growing conditions, which could contribute to increased adaptability and resilience.
- Species Diversity: Avoid the tendency to use only easy-to-grow species and/or avoiding rarer species that have more specific requirements. This leads to large areas dominated by the same species and does not reflect the diversity of naturally occurring ecosystems. To increase diversity of species, consider adding potted plants of species that are difficult to locate or grow. Community plantings and infilling these species can enhance the diversity of the site.

Seeding rates will vary depending on the mix but should aim for a consistent cover based on the number of total seeds per square meter rather than weight of seed (as there is a large variety of seed sizes). Based on the results of The Meadoway seeding practices, a mix with approximately 650 seeds/m2 will produce a good stand. At this rate, mixes would be put down at the following rates:

- 13 kilograms/hectare (11.6 lb/acre) for forb-dominated mixes containing mostly small seed
- Nearly 20 kg/ha (17.8 lb/acre) for mixes with a greater portion of larger grass seed

4.3 NATIVE PLANT PLANTING METHODS

Many methods of planting can be employed to introduce new vegetation to a site, including hand or mechanical seeding and the transplanting of potted plants. For a project the size of The Meadoway, native plant species are planted using seed, as it is easier to obtain large quantities, does not require as much labour to install and maintain, and is more cost effective. Smaller projects may be able to use potted plants, which have the benefit of having already established root systems. Seed can be placed manually or using a mechanical applicator.

4.3.1 Seed Drill

The use of a seed drill is the best option for large projects, as it can; cover larger areas, ensure even distribution of fine seeds, and provide good seed-soil-sun contact necessary for germination. The drill must be specially adapted or designed for native seeds (such as a Truax or Land Pride native seed drill). Unlike standard agricultural drills, these have special agitators, feed adjustments and different bins that will distribute fluffy native grasses and fine forbs at even rates. Understanding the species of seed within the seed mix is imperative when using a seed drill, to help understand seed sizing, rates of application, and the seed requirements for each species. Many species require surface seeding, so it is important to ensure that the drill does not place the seeds too deeply into the soil. Prior to seeding, ensure that the drill is calibrated to disperse seed at the correct rate for the specific mix used.

Tips for using a seed drill include:

- Seed must be clean to be used in the seed drill, as large seed hulls and chaff can clump and clog up the feeder tubes.
- Do not leave seed inside the drill overnight as it can freeze or get wet, causing the tubes to clog and prevent seed from being evenly distributed. Vacuum the seed out after use and use a tarp to cover the seed boxes and keep moisture out of the drill if it is left outside.
- When using the drill, the top of the seed boxes should be parallel to the ground for optimal seeding results. You may need to adjust the tilt of the drill when seeding hills or when using it on frozen ground to help cut through the soil.
- Always read the manual of the seed drill prior to use to find more information on calibration, operation and maintenance needs.
- Drill seeding works best on a layer of firm, bare soil, as you can see your lines easily and can ensure even application. Try to avoid seeding over layers of thatch or an area with established ground cover, as this will lower the chances for seed-to-soil contact and make it more difficult to see the drill lines.
- A seed drill should not be used after rain or a heavy dew, as the moisture will cause the soil to stick to the discs or rollers, picking up seed and/or causing the cutters to stop spinning.
- For sites with loose, soft soils, drilling should be done when the ground is frozen to ensure that seeds are not planted too deeply.
- Drill seeding into a thin layer of snow can help with visibility of your lines, however, it does not work if the ground becomes too wet or slushy.
- Steep slopes, navigating around obstacles, and small tight areas are challenging to accomplish with a seed drill, so many be best done by hand.
- Ensure that the area to be seeded is free of hazards, such as large rocks or buried metal. These can damage the blades of the drill and impact seeding. Avoid running the drill over rocky areas to minimize damage.

4.3.2 Broadcasting Seed

Seed can be broadcasted directly on the site by hand or a power-driven broadcaster. This method is less expensive than a custom seed drill, it is easier to use on steep slopes or over rocky areas and can be done in tight areas. Native seed does not have to be as clean for broadcasting as it does for drill seeding, as the openings on broadcast seeders are larger and can accommodate some chaff. Broadcasted seeds sit on the surface of the soil and are directly exposed to environmental conditions, such as wind and water, creating potential issues with erosion. However, many species prefer their seeds on the surface of the soil, as it increases sunlight availability. Predation of native seed by small mammals or rodents may also occur, as seed sits directly on top of the soil.

For smaller sites (e.g., less than one hectare), hand seeding may be a preferred option to reduce equipment costs. When broadcasting seed, one half of the seed should be spread in parallel lines and the other half in a perpendicular direction for even distribution. It is a good idea to separate the seed mix into larger and smaller seeds and apply these separately to avoid uneven distribution.

Some tips for broadcasting seeds include:

- Due to the very fine nature of many seeds, it is recommended that the native seed be mixed with a bulking agent at a ratio of 5:1 (bulking agent to seed) for more even distribution. The bulking agent could be sand, vermiculite, or a nurse crop of annual oats.
- A power broadcaster will need to have a modified agitator to pull the fluffy seed down to the feed hole, and calibration can be difficult.
- Do not broadcast seed on windy days, as the light seed will blow in irregular directions and create an uneven distribution.
- Seeding over a thin layer of snow can be helpful to see where seed has fallen; but unless the sun melts the seed through the snow or more snow is put down right after, the seed will be exposed to the elements and easily visible to foraging animals.

4.3.3 Potted Plants

Potted or plug plantings are an effective way to increase establishment and cover quickly. Potted plants have an established root system and stand a better chance of establishing and tolerating weather changes. However, potted plants are expensive and it can be difficult to locate large quantities of certain species, so this approach is better suited for smaller, garden-style projects. Potted plants may also require frequent watering to promote establishment, which may not be feasible on large sites. If planting this type of stock in the spring, plan for watering to be included into the budget. Often, potted stock will do better being planted in the fall, as the weather conditions will prevent them from drying out or requiring additional watering. During the fall season, plants are entering a state of dormancy and do not put energy into growth or reproduction, making transplanting less stressful on the plant.

Potted plants and plugs can provide a great opportunity for organized planting events with the public or private sector to foster community involvement, corporate sponsorship, and environmental education.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4.4 TIMING OF NATIVE SEED APPLICATION

Native seeding should occur during late fall through to late spring, as these seasons experience higher precipitation and cooler temperatures. Seeding over the winter months is possible if snow depths are minimal. No seed or potted stock should be planted in the heat of the summer months, as plant survival is low due to high temperatures and drought conditions.

Timing of seeding is affected by site goals, species selection, project budget and weather. Different species have different seed germination requirements; ensure the seeding timing selected will benefit the greatest number of species in the mix. Some species have built-in dormancy mechanisms that prevent them from germinating at the incorrect time and require certain conditions to occur to break this dormancy. For example, some herbaceous species require exposure to prolonged cold moist periods (such as the winter season) to break apart the outer layer of the seed and allow it to germinate. If this is the case for most of the species in the mix, seeding in the fall or winter will allow for that natural stratification period and should result in higher germination rates.

Project budget/funding requirements will dictate if the seed must be planted in the first year, or whether it can be held over until the following spring. Weather can impact seeding as it can limit when equipment can be run and what equipment can be used, as well as restrict the number of days with ideal conditions for seeding (considering things like soil moisture, snow cover, frozen soil, etc.).

4.4.1 Spring Seeding

Planting in the spring is beneficial as growth rates improve with increasing exposure to sunlight and warmth, particularly for grass species. Spring planting is advantageous for mixes that do not require seed stratification. With spring planting, the winter freeze/thaw will have firmed up the soil surface making it ready for a seed drill, eliminating the need to pack the site.

One challenge to spring planting is that some species require a cold moist stratification period that will not be achieved until the following spring, so there is potential for these seeds to remain dormant until the following year. Depending on your seed supplier, asking for seed to be cold stratified could help speed this process up.

Spring planting brings challenges around wet soil conditions and not being able to get equipment on site until later in May/early June. Careful planning around weather conditions should be taken as increased temperatures could create harsh drought-like conditions for newly germinated seeds, making them more susceptible to drought stress and low germination rates.

Seeding in the spring may allow non-native cool season weeds to establish before the planted native seeds, causing them to shade out the native seedlings. It is recommended to apply a blanket herbicide treatment mid-May before the native seed goes down in late May or early June (see this article for details).

4.4.2 Fall and Winter Seeding

When seeding in the fall, it is important to ensure it occurs after the growing season, when seeds are dormant. A warm spell may cause the seeds that do not need to be cold stratified to germinate early, causing the seedlings to die off over the winter. The advantage to fall seeding is that species that require cold moist stratification to germinate will overwinter in the ground and be ready to emerge in spring.

Timing of a fall seeding must be done carefully, as fall rains may cause the soil, and the seed within it, to stick to the seeding equipment. Seed drilling directly into a light frost will help with this process.

Winter seeding is also viable provided there is minimal snow cover and ground conditions are sufficient for the seed drill. This can be a useful strategy on sites with loose soft soils, as the freezing temperatures will firm up the ground and prevent the seed from being planted too deeply. If broadcasting the seed onto frozen ground, it is best done before a snowfall or light rainfall to help protect the seeds from predation and erosion and ensure good seed to soil contact.

4.5 NURSE CROPS

Nurse crops are cover crop species (such as annual oats or millet) that are planted at the same time as the native seeding and once established, help shade the emerging native seeds, so they do not dry out as fast. As a guideline, the rate of nurse crop seed application should be around 35-40 kg/ha (31.2-35.7 lb/acre) if broadcast seeded and 20-25 kg/ha (17.8-22.3 lb/acre) if drill seeded (drill seeding has higher germination rates as the nurse crops are incorporated into the soil).

A native crop of Canada wild rye can also be used as a nurse crop, but it is not as fast-growing compared to a traditional non-native cover crop species. Nurse crops should only be seeded if there is no existing vegetation on the site. Otherwise, excessive vegetation pressure can prevent the native seeds from growing.

Things to consider for nurse crop sowing:

- The seed sowing method (i.e., seed drill vs. hand or machine broadcast): Germination rates will be much higher when using the seed drill compared to broadcast seeding.
- The hydrology/topography of the site: Slopes may have the potential to cause erosion of the soil and seed, especially if the seed is broadcasted. Wet soils will cause the seed to stick to the tires, causing uneven distribution. Extremely dry sites may have reduced germination if the nurse crop is only broadcast seeded.
- The nurse crop should not be a perennial species that could, if left unchecked, take over the site in future years. Use annual species to provide benefits the first year after native seeding, while also allowing them to fade out as the native species establish.

4.6 NATIVE SEED COLLECTION, CLEANING AND STORAGE

Over time, it may be possible to use seed collected from well-established sections of the meadow to seed newly prepared areas. Use of this local seed would ensure that it was produced within the targeted seed zone, and it is adapted to local environmental conditions. The ability of these established species to successfully grow and reproduce in the area is both a measurement of success for those specific species and clear indication of a self-sustaining ecosystem. Seed collection should be undertaken ethically, limiting the amount that is collected and avoiding collection of the same species or within the same area year after year.

4.6.1 Ethical Seed Collection

- **Do not collect seed from vulnerable, threatened or endangered species** without the guidance of a qualified ecologist or biologist. Under Ontario's Endangered Species Act, it is illegal to pick the seeds of endangered plant species. Always obtain permission from the landowner before collecting. Remember that seed-collecting is normally prohibited in national and provincial parks, national wildlife areas, nature reserves and nature sanctuaries.
- Do not collect all the seed from one stand of plants. Guidelines on the amount to collect recommend a maximum of 35% of the seed from perennial plants and 10% of the seed from annual plants. The general rule of thumb is that 20% is the maximum collected.
- Store and handle this valuable, perishable resource wisely.
- Make sure you are collecting from large, established populations that are high enough density of the target species to warrant harvesting. This ensures you are not depleting a fragile population and helps avoid diminishing food resources for wildlife.

4.6.2 Ensure Genetic Diversity

Weather in Southern Ontario is extremely variable, and plants need to be able to adapt to these changes. Genetic diversity allows plants the ability to do so. Maintain genetic diversity by:

- Collecting seed from a large population. Take small quantities of seed from many individual plants rather than large quantities from a few specimens. Avoid choosing only the most handsome plants. Valuable genetic traits for long-term survival may be missed if you are too selective.
- Collect seed of each species from several different locations with varying soil and moisture conditions.
- The seed of some species ripens over time. In these cases, collect early, mid and late-ripening seed.
- Collect in different years and add to your planting site.

4.6.3 Seed-Collecting Tips

- Seed for most prairie and meadow species begins to ripen by mid-late summer.
- Most seeds are ready for collection six to eight weeks from time of blooming.
- Let seed ripen thoroughly on the plant, as not all seed will continue to mature once picked.
- Seed is ripe when:
  - » *It is dry and falls away readily when seed heads are handled*
  - » *Individual seeds are brown, tan or grey, and hard (pinch with fingernails to test)*
  - » *Seed pods are brown or tan and beginning to split open, and seed is easily dislodged or readily falls from pod when it is shaken.*
- Plants in seed often bear little resemblance to the same plants in full bloom. Make sure you can identify a species throughout the seasons to ensure you know what you are collecting.
- Use a hand lens and pen knife to check the quality of seed in the field before spending time collecting it. Look for full seeds with no insect damage.
- Use paper or burlap bags to hold seed, and store in a cool, dark place. Do not use plastic because it heats up and retains moisture, which will damage the seed.
- Immediately after collecting, label each bag with the species name, the date when and the location where the seed was collected.
- You may have to collect some species before most of the plants are ready (anything with light fluffy seed), otherwise the mature seed will blow away before harvesting. This may also be the case with high value seeds for birds (such as cup plant, *Silphium perfoliatum*). Collect before the seed ripens, and then let it mature on the drying rack.
- Use secateurs or scissors to remove the seed head from the plant. Wear gloves to avoid irritation from seed heads.

4.6.4 Seed Drying and Cleaning

- Seed should be thoroughly dry before it is stored; for most seed, this will take four or five days in good conditions.
- Place it in shallow pans or on screens in an area free of rodents or place it in a paper bag and hang it from a rafter of an unheated garage or barn. Do not use a conventional oven, microwave oven or food-drying machine. Low humidity and warm temperatures will speed the drying process, but higher temperatures will reduce seed viability.
- *During seed cleaning, pods and hulls need to be shattered, and seed heads broken up. Consider wearing a face mask while cleaning seed as it can release a lot of dust and fibres into the air, which some may find irritating to airways.*
- Separate the dried seed from the waste plant material (chaff) using one of the following techniques:
  - » *Sift seed through a variety of sieves, screens or light blender to help remove casing.*
  - » *Separate seed from its casing (fluff) by rubbing it gently through a screen. Use a hand lens to check periodically for seed damage.*
  - » *Pour the seed from one container into another outside in a light breeze or indoors in front of a fan. The heavier seed will land in the container or in front of the fan, and the lighter chaff will blow away.*
  - » *On a smaller scale, a hair dryer can be useful for blowing chaff from a pan of seed.*

4.6.5 Seed Storage

- To remain viable for as long as possible, dry seed should be stored at low temperatures (4° C) and low humidity (no more than 10 percent). Keep newly collected seed in paper bags or envelopes until they are completely cleaned and dried, then store dry seed in airtight containers (jars or plastic pails with tightfitting lids) in a refrigerator or in an unheated building over the winter, and in a space that can be kept as cool as possible during summer months. Seed stored above 28° C will lose viability quickly.
- Insect eggs that are present at the time of collection can hatch, and the larvae can damage seed. Just because insects are not visible, do not assume that there are no eggs. Eggs are often present inside the seed. Check stored seed periodically for the presence of insects. At the first sign of insect activity, place seed along with small pieces of No-Pest® strips in sealed bags or containers. Squirrels and mice can also damage the seed; however, cats can be a good deterrent for mice in indoor storage areas.
- Keep seeds dry.

4.7 WOODY SPECIES SELECTION AND PLANTING

Although The Meadoway project is primarily focused on restoring meadow habitat, shrub species have been planted throughout the corridor in small, designated nodes creating a variation in habitats. In The Meadoway, shrub nodes are typically included: at the edge of wetlands, ravines, and in other areas that already feature native shrub cover, as well as in nodes along the edge of the meadow to add habitat diversity.

Shrub nodes are kept away from the actual meadow using mown turfgrass buffers that serve to separate the shrubs from the meadow. This helps minimize the potential spread of the shrubs into the meadow footprint, reducing the threat of succession and decreasing management work. This also helps prevent any invasive species that might be growing within the shrubs from spreading into the meadow. All shrub node species must be approved by utility corridor managers and must fit within the allotted height restrictions outlined. In The Meadoway, TRCA works closely with HONI and City staff to plan and design the shrub nodes, and the city implements and maintains them.

Shrub species were chosen based on the following criteria:

- Species should be native to the region and approved for height of growth by the utility company.
- Species should provide habitat and/or food source for wildlife. Many species selected
- Have large showy flowers (e.g., purple-flowering raspberry, *Rubus odoratus*, ninebark, *Physocarpus opulifolius*, and elderberry, *Sambucus canadensis)* that add aesthetic value and, more importantly, provide a food source for pollinators, birds and other wildlife.
- Mid-sized shrubs provide perching spots for songbirds and raptors, as well as places to build their nests. The shaded ground beneath these shrubs is home to a variety of small mammals, and the shrubs provide camouflage for burrows, dens and deer beds.
- When planning locations of shrub nodes, keep in mind trail placement and sight lines for maintaining public safety. Keep vegetation short within 3.25 metres of the trail edge on both sides to allow sight lines to be clear for users. Shrubs should only be planted beyond the 3.25 m grass buffer.
- If possible, plant shrubs with thorns on the inside of the node instead of along the edges, to help maintain staff safety while working alongside the node. Also keep in mind which species tend to send out shoots/runners or nodding branches that flop into the adjacent turfgrass buffers (e.g., raspberry, etc.).
- Avoid planting very aggressive shrubs that spread easily (such as staghorn sumac), as they could potentially spread into the adjacent meadows and create challenges with management.

5 Adaptive Management

Meadows and other natural systems are dynamic in nature and, if unchecked, will experience subsequent stages of natural succession to scrublands or shrub thickets. To help ensure the original restoration objectives continue to be met following restoration, and that the site remains suitable for the operation of the utility, it will be necessary to prepare and implement an ongoing management plan. Management direction should conform to the goals and objectives of the site plan and will be informed by monitoring activities.

5.1 BIOMASS REMOVAL

To ensure native seed establishment and promote biodiversity, meadow restoration projects require a maintenance regime that is appropriate to the site and project objectives. In the absence of natural disturbance, meadows will typically evolve into shrub and forest communities. Under natural conditions, this succession may be prevented either by periodic fires, animal grazing or by a very dry or very wet climate that discourages the growth of woody-stemmed trees and shrubs.

Depending on the size of the project, maintenance should be planned on a rotating schedule that leaves a portion of meadow untouched each year. These areas will remain as refuge for many species that use the standing vegetation for food and shelter.

5.1.1 Maintenance/Cultural Mowing

The meristems (i.e., growing parts) of most meadow plants are situated close to or underneath the ground surface, so mowing does not affect the re-growth of the plant. Infrequent mowing can work to stimulate the growth of these well-adapted plants.

Burning is not an option in The Meadoway currently, so mowing and discing are used to break up the thatch in the spring. Mowing the meadow can be beneficial in the first year of establishment, followed by every three to five years afterward to prevent succession. These activities are generally carried out in the very early spring or fall when the plants are not growing. Early spring mowing allows the standing cover to remain as habitat and food sources over the winter, but spring maintenance can be hampered by wet/ sloppy soil conditions if using larger tractors for mowing.

Mowing is generally done using a rotary mower or flail bar mower attached to a tractor. The height of the cut can differ, but generally a low mow is used to help break up plant material. A rotary mower can tolerate thicker stemmed herbaceous and woody vegetation and denser vegetation but chops vegetation into medium sized pieces ranging from 6 inches to 3 feet long. A flail mower can cut the vegetation into a finer thatch which helps biodegrade the thatch layer faster, but it cannot tolerate thick stemmed vegetation.

If mowing in the spring, care must be taken to ensure that this is done before bird nesting season to avoid the impact on nests and conform with the regulations under the federal Migratory Birds Convention Act, 1994. More information regarding the scheduling of mowing operations can be found using the Nesting Calendar Query Tool, an app available on the Birds Canada website.

Thatch may begin to build up after successive mowing, which is not ideal for meadow health, as it shades out the establishment of new plants and prevents the sun from reaching the seeds on the soil. If your site will allow, rake and pile the thatch into compost piles; otherwise, baling and off-site disposal may be needed to keep the thatch layer to a minimum.

5.1.2 Prescribed Burning

Historically, fire was a natural agent that maintained meadows and prairies. Prescribed burning can be a very effective method of removing thatch buildup, as well as shrubs and trees that start to grow in the meadow. It will also help encourage the growth of native species, stimulating fire-adapted meadow species to spread and fill out. Burning may not be practical or even allowed depending on jurisdiction and, in any event, will require special burn permits and experienced staff. If allowed by the owner of the infrastructure corridor, a prescribed burn can be a highly effective way of reducing thatch buildup and simultaneously decreasing risks of uncontrolled/unplanned fires by minimizing fuel loads. Prescribed burns are typically conducted in spring or fall when vegetation is dry and minimizes impacts on native plants and wildlife.

5.1.3 Herbivores

Rotational grazing with animals (such as cows, sheep or goats) can be another method to limit succession. Grazing should be done in rotations at low to moderate intensities. Grazers typically do not eat below the meristematic tissue of native plants at these intensities, allowing the plants to regrow following grazing.

High-intensity grazing can negatively affect native grasses, as grazers typically eat the plants right down to the ground (below the meristematic tissue), preventing the plant from growing back. Some grazers can also be trained to prefer certain invasive species (for example, goats favour the bark and twigs from European buckthorn). In The Meadoway, grazers have not been used, but it is a technique that TRCA is interested in exploring, pending approvals from landowners.

5.2 INVASIVE PLANT MANAGEMENT

Even when the best efforts to reduce undesirable or invasive species occurred during site preparation, management strategies will be required to deal with the re-establishment of invasive plants within the meadow site and prevent them from outcompeting and replacing native species. This can be an ongoing challenge in urban meadows, given the number of invasive species and avenues of spread.

Invasive plants spread rapidly, create monocultures, and negatively impact the local ecosystem. Invasive plant management in urban areas works to reduce the impacts of these species and prevent monocultures to help improve biodiversity.

Special focus should be given to site borders and trail edges, as these areas have greater potential exposure to seeds of invasives. Utility corridors are vulnerable to re-introduction of seeds carried by wildlife and from adjacent properties that are colonized by invasive species. It is important to communicate and collaborate effectively on this problem with neighbouring stakeholders. Additionally, disturbance to the site from infrastructure maintenance activities, illegal trespassing or dumping can create ideal conditions for the spread of invasive plants.

The Meadoway team uses Integrated Pest Management practices to guide decision-making concerning invasive plant management activities. Individual species are managed in accordance with the applicable Invasive Species Best Management Practices (BMPs), as published and regularly updated by the Ontario Invasive Plant Council (OIPC). Management is typically achieved through a combination of mechanical, biological and chemical controls. Each control method has advantages and disadvantages that should be weighed against the resources available.

Considerations for determining which method to use include:

- species characteristics and life cycle
- patch size and extent
- density of the target plant
- number of patches
- management techniques available
- the budget and time available

The lifecycle of the target species should be understood and used to inform the planning of the control program. This will affect what type of management technique is most effective, and the timing of when it should occur for maximum benefit. The projected timeline for the complete removal of invasive plants is a minimum of three to five years and should initially focus on high-density areas and species that present the greatest threats.
Note that complete eradication is generally implausible, and the goal for management should be focused on reducing target species populations to a point where they are not outcompeting native species and creating monocultures with low diversity.

It is very important to ensure that everyone who works on invasive plant management understands how to identify the target plant throughout its entire life cycle to prevent misidentification and damage to non-target species.

Priority species that are currently being removed or otherwise managed within The Meadoway include: garlic mustard (*Alliaria petiolata*), dog-strangling vine (*Vincetoxicum rossicum*), Canada thistle (*Cirsium arvense*), spotted knapweed (*Centaurea stoebe*), field bindweed (*Convolvus arvensis*), European or common buckthorn (*Rhamnus cathartica*), phragmites (*Phragmites australis*) and common tansy (*Tanacetum vulgare*).

5.2.1 Mapping and Assessment

Mapping target species is important to help understand the extent of the species across the space, identify new populations, and plan the most effective management strategy. Frequent, accurate monitoring and mapping of high-density spots or new populations can help determine priority areas to be managed. Both baseline and follow-up data are needed to refine future control practices. When choosing the best way to record invasive species locations, budget, access to technology and scale of project should be considered.

The Meadoway team uses Arc FieldMaps to collect and record geospatial data. When mapping invasive plant populations, polygons are generally more useful than individual points, as polygons can better depict population size and spread. While mapping, the goal is not to mark down each individual plant stem, but to locate large patches that management strategies should target. When assessing an area for potential mapping, the patch size should be a minimum of five m^2 and have distinct edges. Along with the size, shape and location of the patch, it is beneficial to also record species type, density/coverage, the date the information was collected, and what type of further management is recommended. Management activities should also be mapped and recorded to ensure accurate record keeping and help assess the effectiveness of the treatment. This will help with long-term management and monitoring of the meadow.

5.2.2 Mechanical Removal

Manual Removal Methods
This method involves identifying the plant species and removing the roots from the soil, either by pulling or digging it. It is important to ensure that the entire root system is collected to prevent regrowth from root fragments. This method works well in loose soils, and on species that have taproots/root systems that are easier to remove. Avoid ripping just the above ground vegetation out and leaving the root.

Manual plant removal is very slow and labour-intensive, so it is best done on small, localized patches of plants. This method is also best done before a plant produces flowers or seeds, to prevent the spread of seeds during handling. If targeting species with spines or thorns, ensure workers have the necessary PPE. Removal of biomass from site should be considered, especially if the plant is in flower or seed (to prevent the spread of seeds). This method is excellent for volunteers; however, identification of target species could be challenging depending on the species and the volunteers' experience level. When working with volunteers, consider choosing a small patch where completion is achievable to ensure morale remains high.

Mowing or Trimming

Another mechanical method of invasive species management is mowing or trimming the above-ground plant material. This method is used to prevent flowering, thereby controlling the spread of seeds and limiting population growth. This method should be repeated multiple times throughout the growing season to manage stem regrowth (the number of times depends on the species). However, this method does not reduce the current population, so other activities will need to be used. Timing is important for this method to be effective, and the greatest success occurs before the plant is in flower. Research has shown that cut flowers can still produce some viable seeds (though seed dispersal is much more limited), and the more mature the flower, the higher the seed viability.

Mowing equipment can include tow-behind mowers for large spaces, or handheld line trimmers for a more targeted application. With both methods, non-targeted native species may also be cut, so managers must weigh the costs and benefits of this method.

5.2.3 Biocontrol

Biological controls (biocontrol) are an established method of invasive species management both in restoration and agricultural industries. This involves the use of biological agents to manage a targeted species via predation. The use of biocontrol agents is tightly regulated in Canada, and extensive research is done to ensure that the agent controls only the targeted species and has no negative effects on native ecosystems. Generally, biocontrol agents are insects or fungal species that are found with the targeted species in its natural range and serve as natural means of population control through predation.

Biocontrol species can be used in meadow restorations to control invasive species such as purple loosestrife (*Lythrum salicaria*), phragmites (*Phragmites australis*) and other invasive herbaceous and woody plants. It is important to check regulations, commercial availability, control agent restrictions and life cycles of species. Although biocontrol methods are less labor-intensive compared to other methods, they take several years to establish a viable population, their populations can be very cyclical in nature, and they will never fully eradicate the targeted species. It is important to plan for monitoring both the control agent and the host invasive species in upcoming years. Biocontrol should be looked at as another tool to help manage invasive species long-term and used to complement other management techniques for the best results.

5.2.4 Targeted Herbicide Application

The approach to an herbicide application should be informed by IPM strategies, local regulations, the pesticide label, BMPs, and spray equipment manuals. It is not recommended to spray herbicides during the flowering stage of a plant, as this can negatively impact pollinator species that may be using the floral resources. Land managers should consider timing windows to ensure such treatment causes the least harm.

Personal protective equipment (PPE) decisions should be informed by the pesticide label, provincial legislation and exterminator licensing manuals. Challenges with PPE include proper fit, extreme heat/cold environmental conditions, visibility and communication. When wearing protective suits, ensure the size is large enough to accommodate all types of movements and bending to prevent movement restrictions and tearing. High heat conditions can cause sweating and fogging, preventing respirators from fitting correctly and limiting visibility through goggles, glasses and shields. Cold can cause plastic on PPE to become brittle and break. Communication may be limited due to limited dexterity, restricted vision from PPE, and head coverings muffling sounds, so use of consistent hand signals is beneficial.

Training is extremely important for members of a spray application team.

Review identification regularly to ensure that the team knows what the target species looks like throughout its life cycle. Be aware of lookalike native and invasive species. One example of a challenge we faced is distinguishing grey headed coneflower from spotted knapweed which can look very similar in the basal rosette stage. Crews should also recognize that invasive plants may occur in different growth forms in a different area.

Spot spray herbicide applications in restored meadows are done to target undesirable species and preserve/protect desirable native planted species. These spot applications are precise and can target single stems and patches of targeted species. Backpack sprayers are best suited for this method due to the precise nature of the application.

Although backpack spot spraying is highly useful for its targeted nature, it is also very labour-intensive and time-consuming (and thus requires sufficient budget to accomplish). Challenges for backpack spot spraying include visibility, hazardous vegetation, slips, trips and falls. Visibility may be extremely poor as vegetation can grow above shoulder height, making it difficult to see where you are going, where the rest of the team is, and where the next target species is. Uneven terrain, vines and other vegetation are difficult to see and can trip operators and tangle equipment. Move slowly and carefully through these areas and consider half filling packs (or less) to keep the operator's center of gravity low. Plants with thorns can also rip protective clothing, so consider this when choosing PPE materials. Many of these issues can be reduced by mowing an area the season before an herbicide application occurs.

Non-targeted effects of herbicide can occur when herbicide is accidentally applied to non-target surfaces. This can happen through factors such as drift, secondary contact, and leakage or spills. Herbicide drift occurs when the spray application hits non-target surfaces (desirable plants, the applicator, other areas). This can be caused by factors like wind speed and direction, distance from the nozzle to the target surface, nozzle type, and applicator error. To mitigate herbicide drift, ensure that the nozzle tip of the wand remains as close to the target species as possible, keep the overall pressure on the backpack sprayer low, and choose days when winds fall to 10 km/hr (6.2 mph) or below to perform the herbicide application.

Secondary contact occurs when herbicide is transferred from one object to a different, non-targeted one. An example of this would be if herbicide is on an applicator's boots/clothing and the applicator walks through an area of desirable plants and the herbicide is transferred from their clothing to the plants they touch. This can be prevented by being aware of leaks and contamination, planning an entry and exit route while applying to prevent cross-contamination, and cleaning and maintaining equipment. Leakage or spills can be the result of equipment failure or operator error during mixing or operating.

Regular equipment maintenance is required to ensure the integrity of the sprayers, and operators must be vigilant to ensure leaks are reported and fixed. Chemical mixing and loading present the greatest risk of spills, so applicators should mix products over a catch tray to avoid this. Leaks that occur while operating can include drips from the nozzle, leaks at hose connections, or leaks from the tank or pump.

There are a variety of methods of application for each pesticide. Choose the one that works best for controlling the targeted species, the timing of application, and the required exterminator effort. Be aware of the advantages and disadvantages of each method.

Equipment Selection

Backpacks with a manual pump work best for very precise spot spray applications as it is easier to vary the pressure coming out of the nozzle. The Meadoway team prefers backpacks with an internal pump, as they generally require less maintenance. Electric backpacks work well for larger, less targeted areas where the goal is a non-selective blanket application; but are not preferred for small, highly targeted spot sprays. Note that most electric packs come with pressure washer fittings and nozzles and additional hardware will be required to adjust nozzles.

Packs with a robust strap system and waist belt are preferable for operator comfort. A flat fan nozzle with a coarse droplet size works best for a targeted application where the goal is to avoid spraying native species. Nozzles with an 80° to 110° output angle allow adequate coverage while minimizing overspray. Ensure your nozzle sets are compatible with spray equipment and the herbicide label.

Transect Method

One way to apply herbicide post-restoration is by using a transect application method. This involves applicators moving in parallel lines to sweep through the entire area. The transect method should be used when you want to thoroughly hit as many of the target species as possible in an area. This method takes more time but achieves a high percentage coverage of a defined area and can be very effective at total eradication or high reduction amounts.

However, this method is most effective when the plants are shorter in height and are either in their rosette form or have just begun bolting. The best time to perform this method is during the spring and early summer months, as it increases overall visibility and accuracy while spraying targeted invasive species. As the plants start to grow taller and obscure visibility, you can add an additional flagging system to the transect method to mark lanes.

This method generally works best with a team of four applicators; however, any number of people from two to six will work. Use of large, visible flags can help applicators space themselves evenly and ensure adequate coverage of the entire meadow footprint. In the context of a meadow in a long, thin, utility corridor broken up by major roads, running transects widthwise is ideal for both improved visibility and reduced operator fatigue. Slopes, trees and shrubs may create visibility issues, and should be considered when setting up transects.

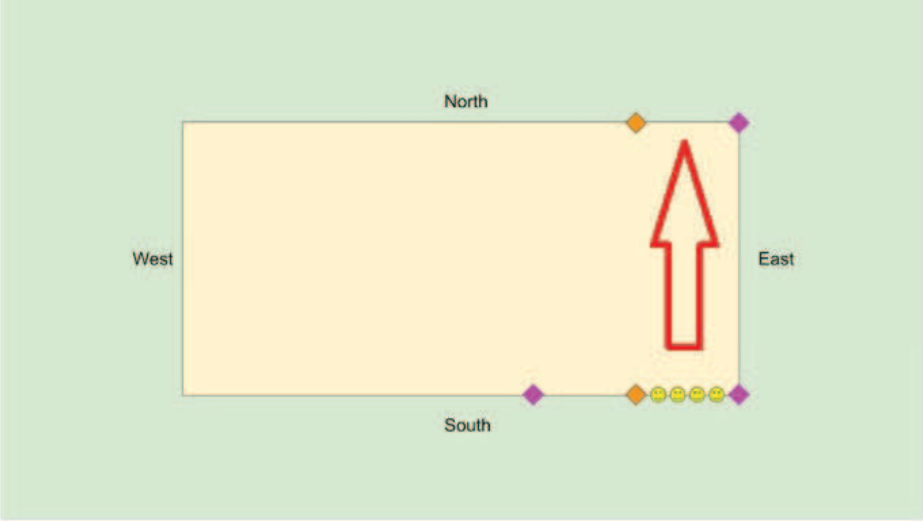

Figure 3: The transect method: The different colour diamond shapes depict different coloured marking flags used to outline the edges of each transect. The herbicide applicators (depicted by smiley faces) then move from one side to the other within the confines of the flagged area and move the flags westward as they complete the transects.

Patch Method

This method should be used when targeting dense, well-defined areas or clusters of invasive target species, instead of spraying every single individual plant within a given section of the meadow. This method targets the bulk of the invasive population but may miss some individuals plants. While the main goal of the transect method is to completely eradicate the target species from the entire meadow footprint, the goal of the patch method is to simply reduce or control dense populations of the target species. The patch method is used to reduce the main seed sources and remove dense colonies to prevent continued colonization and spread.

The patch method is most suitable when you don't have the time or budget to complete a full transect method, or when the transect method is not suitable, such as scenarios where the meadow plants become too large, greatly reducing both visibility and mobility within the meadow area. This method unfortunately does not allow for complete ground coverage throughout the affected area but will effectively treat and eradicate areas with high target species population density. This method can also be effective when applicators work alone or in pairs (each person maps and treats all the patches within a defined area). When applying, ensure that you are not walking through previously treated areas.

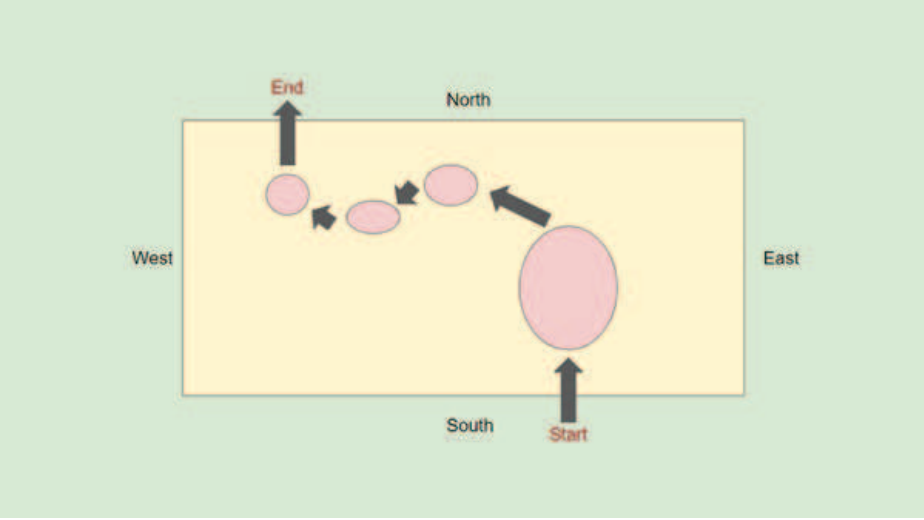

Figure 4: Patch method involves travelling to just the previously specified distinctive areas where the invasive species is present. The applicator would design their route to travel to all patches without doubling back to previously sprayed areas.

5.2.5 Managing Woody Species

Woody species need to be managed in meadows to prevent ecosystem succession from an open area to a shrub thicket. Because of this, both native and non-native trees and shrubs pose an ongoing threat to the long-term success of a meadow and require ongoing management. There are a variety of methods used to manage woody species, often with a combination of mechanical and chemical methods.

Invasive woody species may be managed using a foliar application, a basal bark application, or an application to the cambium after stump cutting. The chemical most often used to manage woody invasives is Garlon™ RTU, an oil-based, premixed, systemic herbicide. A basal bark application has generally found to be preferable over a cut and spray application, as it is less labour intensive, quicker to apply and has had better success controlling some species.

Challenges to managing woody invasives within a meadow footprint include visibility, timing, weather and access. It is difficult to locate and identify woody species within a meadow when the herbaceous plants are at full height, so treatment success can be greatly affected. Weather is a limiting factor, as treatment should not occur when the stem is wet, and snow height can impact the applicator's ability to access the base of the stem. Finally, it may be difficult to access the base of the shrub, especially with multi-stemmed species and thatch build up. Effective control requires application to every stem, so pruning the tree/shrub prior to management will improve access and safety for operators and equipment. Management timing is species-specific, and some species will require multiple applications for effective control.

The size, shape, form and species of the target stem will influence the application method that will be used. The applicator(s) must treat every individual stem within a clump/cluster of plant species to achieve 100% control and effectiveness of the product. Often, thick stands of invasive woody plants (like buckthorn or honeysuckle) prevent easy access into the center of the stand. To combat this, take the time before spraying to cut lateral branches (using loppers or brush saws) to create access pathways into the stand to ensure that the applicator and their backpack do not get caught up in the brush. Ensure that workers are not wearing their spray equipment backpacks during cutting operations to prevent accidental spills or entanglement/equipment breakage.

If performing a cut and spray application, the best approach is to designate roles to team members as either shrub cutters or stump sprayers. The cutters will locate shrubs, cut the stems to the base, leaving a small stump, and then will identify the location of the stump for the herbicide applicator. The applicator will then move in and spray the cambium of the shrub stumps (the inner layer just inside of the bark) and the root collar of the stump. When cutting stumps, it is important to cut them flush to the ground to avoid causing tripping hazards and machinery damage.

For all application methods:

- Ensure full coverage of the stem(s) to effectively control target plant species.
- Do not treat very wet bark as the herbicide will not penetrate the saturated stem.

5.2.6 Post Management Monitoring

Removal of invasive plants species often creates a soil disturbance or loss of vegetation, leaving a bare spot. Plan to over-seed the exposed area with a cover crop and/or native seed to help combat secondary invasions. Additionally, post-treatment monitoring should occur to ensure that the management activity was successful or to determine what additional strategies are required.

5.3 MAINTENANCE TURFGRASS BUFFER AREAS

Mowed turfgrass buffers around the edges of the meadows were included in the initial plans and are recommended in urban areas where public use occurs (e.g., trails). These turfgrass buffers surround the meadows and any shrub nodes, and serve multiple purposes:

- Ensuring access and maintenance. These spaces are used by the public as informal trails for recreational and transportation purposes. For restoration practitioners, these spaces can serve as access roads around the meadows, permitting maintenance activities.
- Preventing the spread of invasive species from adjacent areas into the meadow.
- Creating a defined space between trail-users, neighbouring properties and the meadow footprint and separating the trail from the meadow. This helps ensure that trail sightlines are maintained to aid in trail user safety.
- Serving as natural firebreaks should there be a fire in either the meadow or surrounding communities. If suitably mown and maintained, the turfgrass buffers will stop the spread of the fire between the meadow and surrounding properties, ensuring safety for neighbouring residents.

In The Meadoway, a larger buffer width (of at least five metres, 16.4 ft) between the meadow and the fence lines of properties was chosen to provide a fire prevention gap between property lines and the meadow. When setting the width of this buffer zone, ensure it comfortably fits your largest piece of maintenance equipment, so that crews can navigate around the meadow easily. Smaller widths were assigned to trail edges (3.25 m, 11.5 ft) and shrub node borders (a single mower width of 2 m, 6.6 ft) to accommodate the mowing equipment used to maintain these turfgrass areas.

Regular maintenance of turfgrass buffers helps delineate the boundaries of the meadow, maintains a manicured environment for the public, and reduces the spread/growth of invasive species. To aid in this activity, regular placement of signage can depict where the meadow footprint begins and help delineate the exact route for turfgrass buffer mowers, preventing accidental mowing of the meadow area. This signage is especially important when multiple agencies and/or contractors may be responsible for mowing.

Turfgrass buffer areas should be mowed around six to eight times per year. Allowing the grass to grow too long in buffer areas can blur its distinction from the meadow footprint and can also hide hazards, posing dangers to equipment and workers. Hazards (such as garbage) should be removed, and larger hazards should be marked with paint or flagging tape to avoid damaging mowing equipment.

Zero turn mowers are ideal for mowing long, narrow buffers and navigating obstacles like hydro poles. In the previous edition of this manual, we recommended using tractors to mow buffers; however, tractors face many more limitations when maneuvering around obstacles and, in most cases, zero turns are preferred.

5.4 PUBLIC USE

Monitoring of public use within the restoration site is ongoing during the restoration process. This can increase awareness of potential emerging issues and/or damage occurring to the meadows. In addition, an array of tools is being developed and used to help educate the public and encourage stewardship of The Meadoway. These include:

- Signage (both informational/interpretive signage)
- Educational tools (brochures and social media)
- Informational events (walks, seminars, online live chats, etc.)

Interpretive signage along trails and meadow borders provides a description of the work and goals for the site. The contents and messaging of these signs are updated according to which phase of the restoration process a particular worksite has reached. Together, this information provides the public with a deeper understanding and appreciation of the project goals and objectives.

Conspicuous "No Mow" signs help both the public and mowing contractors recognize the meadow footprint and modify their mowing activities. Pairing these "No Mow" signs with informational signage can provide a reasonable explanation for the limitation on mowing, as well as serving as an educational and regulatory tool.

Informational signs are placed and updated over a three-year timeframe:

- Year 1 signs indicate site preparation is occurring.
- Year 2 signs indicate that native meadow seeding has occurred and encourages patience to allow the new meadow to germinate and become established.
- Year 3 signs demonstrate what an established meadow will look like and explains ongoing management activities.

These signs are critical in the explanation of the environmental changes that residents and trail- users will be witnessing as The Meadoway project proceeds. (Note, examples of the "No Mow" and informational signs are displayed in Appendix 1.)


The Meadoway
COMMUNITY POWERED GREEN SPACES
MEADOW RESTORATION
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ATTENTION
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NO MOW
AREA
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6 Monitoring

6.1 KEY PERFORMANCE INDICATORS

Understanding key performance indicators (KPIs) can aid in adaptive management, inform reporting deliverables within the organization, and support funding applications. KPIs are measurable results that indicate whether goals are being met and aid tracking the progress of the project. KPIs help to create qualitative and quantitative measurable matrices.

Species Inventories and Biodiversity Conservation Measurements
Having a baseline inventory of the species present on the site pre-restoration is essential to understand changes in species assemblages and the assessment of biodiversity targets. Species richness and abundance are expected to increase with time, and these changes need to be monitored (and be reported to funders and the public). Monitoring activities will be covered in more detail later in this manual.

Typical conditions to be monitored and/or documented include:

- Number of native trees and shrubs planted
- Kilograms of native seed used
- Quantity of invasive plants removed
- Changes in habitat connectivity
- Changes in the diversity of native species
- Changes in the abundance and distribution of selected species (especially species-at-risk)
- Amount of carbon sequestered in plants and soils

Ongoing monitoring is used to continually track and reassess the establishment of the meadow community, measure the subsequent growth in wildlife diversity, and ensure minimal succession is occurring. Pre-implementation data collected before the site preparation phase serves as a baseline to monitoring changes occurring during and after the restoration. Monitoring is done every year in Years 1 through 4, followed by every three years. This will ensure continuity in data and allow TRCA to accurately measure its success in meeting restoration goals. Monitoring data typically includes:

- Vegetation plots or transect monitoring protocols
- Butterfly transects
- Bird transects or point spots

The establishment of permanent photo monitoring points is also highly recommended to help track long-term changes.

6.2 VEGETATION MONITORING

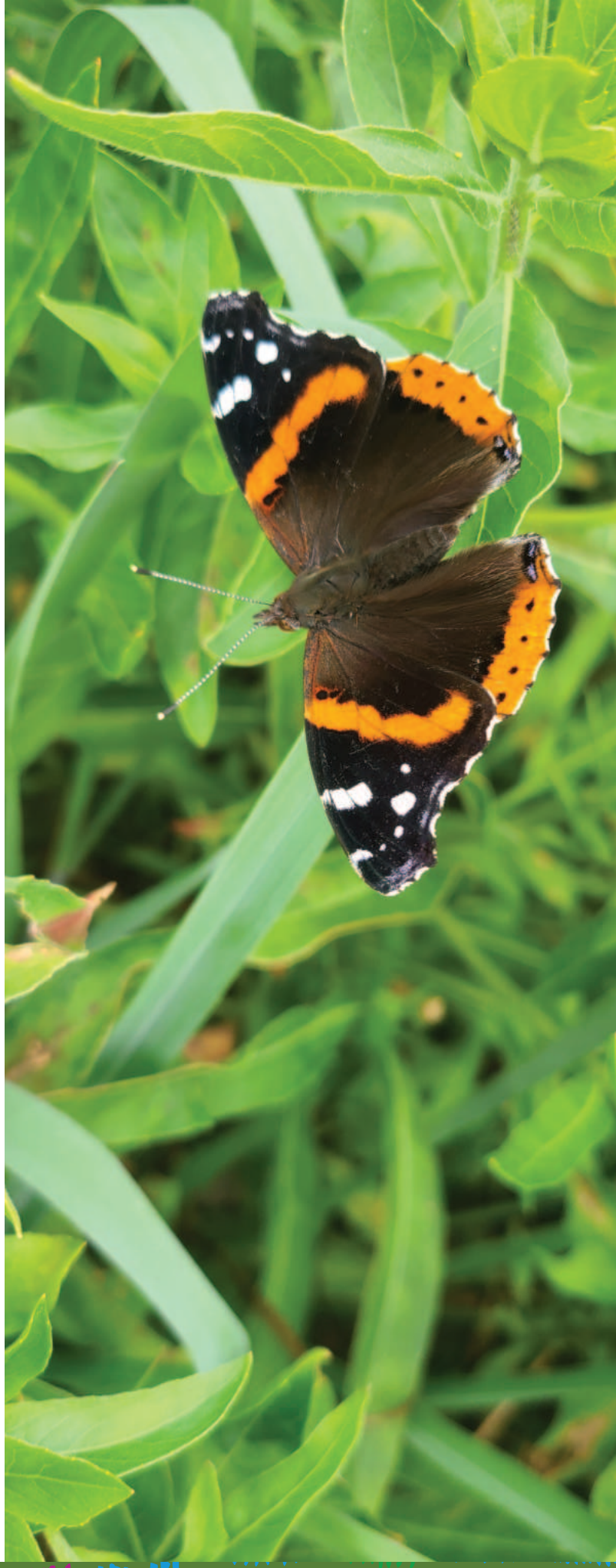
The establishment of a vegetation monitoring protocol will allow staff to monitor the species diversity (richness and evenness) of the site and quantify and ensure that the overall restoration goals are met. The data collected can help monitor both natural and artificial (i.e., human-caused) changes at the population and community level. To effectively create and carry out a vegetation monitoring plan, workers should be proficient in plant identification and understand both the Ecological Land Classification (ELC) system and the restoration objectives of the site. The vegetation community should be evaluated based on composition, diversity, density, frequency, structure, percent cover, and dispersion parameters.

This information will be crucial for evaluating the completion of the restoration goals, compliance with the ELC classification, and the control of invasive species, as well as informing future management decisions. Special attention should be paid to any invasive plants found, particularly non-native invasive plants. The population of invasive plants could explode rapidly if left unchecked as they outcompete native species. If found, these unwanted individuals or populations should be geo-tagged with information, such as the life stage of plant, its relative abundance, and the size of the invaded area. Long-term patterns will be tracked to document the ratio and composition of native to non-native or unwanted species within the sampling quadrants. This will aid in the development and re-evaluation of a management plan to control these species.

The methodology for monitoring meadow ecosystems used by 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 specific to The Meadoway's ecosystem. Monitoring reports from previous years can be found on The Meadoway website.

6.3 BUTTERFLY MONITORING

Butterfly surveying in The Meadoway consists of walking a specified path (transect) through the meadow and identifying and counting all stages of butterfly species observed. Start and end times should be recorded and kept generally consistent over the long-term. Butterflies should be identified to species level (where possible) or to genus (if species-level identification is not possible). In The Meadoway, 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 (i.e., greater than 20oC, no rain, light winds).



6.4 BIRD MONITORING

Meadow bird monitoring in The Meadoway has followed an adapted Ontario Forest Bird Monitoring Protocol. This protocol is also used for meadow bird surveys conducted through TRCA's Terrestrial Long-term Monitoring Program Bird Monitoring Protocol.

Meadow birds are monitored twice during the field season with the first visit occurring between May 15 and May 30, and the second visit between May 30 and June 15, with at least 10 days between visits. Counts are conducted between 05:00 and 10:00 and at approximately the same time of day on subsequent visits from year to year. Counts are only conducted in good weather conditions (i.e., no rain, light winds). All birds seen or heard within a 100-metre radius and during a 10-minute period are recorded.

Bird data were interpreted using TRCA's Local Ranking and Scoring System (L-rank) for fauna. Fauna L-ranks are based on scores for six criteria: local occurrence, population trends, habitat dependence, area sensitivity, patch isolation sensitivity, and sensitivity to development. Ranks from L1 – L3 represent those species most at risk within the jurisdiction (being highly sensitive to habitat loss and disturbances), while L4 are species found more widespread regionally, and L5 species are presently not of conservation concern.

6.5 MONITORING UNSANCTIONED ACTIVITIES

Ongoing monitoring by restoration workers can help identify and document instances of vandalism, encroachment and other potentially harmful activities, including:

- Illegal dumping of trash
- Dumping of yard clippings and other organic wastes
- Unauthorized mowing within the meadow footprint
- Creation of new trails (such as mountain bike trails) through the meadow footprint
- Intentional introduction of exotics and invasives
- Use of off-road vehicles, motorbikes and other motorized vehicles

Use of the ArcGIS Field Maps app allows staff to record and geo-reference these issues, as well as append a photo to further illustrate the problem and direct appropriate action to address the issue(s). Field reporting and mapping can also highlight the need for additional communication and educational opportunities. Garbage dumping has become a large issue, with staff having to spend more time cleaning up after these events. Dumping yard waste, including grass clippings, leaves, and branches, in natural areas like meadows can introduce invasive plants and displace native species.

6.6 LONG-TERM PHOTO MONITORING

Permanent photo monitoring points are specific, geo-referenced locations that offer a defined and permanent view of the restoration site. Taking numerous site photos over time from the same vantage point(s) can help:

- Track long-term changes wrought by restoration processes
- Inform on progress toward restoration goals
- Track succession of the vegetation community
- Show evidence of invasive plant growth/ removal

Defined monitoring locations will allow the compilation of sequential and comparable photos and data points that can be used in reports to the public or stakeholders.

Footage captured by a drone or from a helicopter is another valuable way to document the meadow restoration project. Again, it is important to maintain the same vantage points and routes so changes over time can be visualized and documented. Within The Meadoway, all drone flights have to be pre-approved by HONI before TRCA can move forward with flights. Once approved, HONI or your electrical company will outline specific height restrictions for how low the drone can fly above the towers.

6.7 RESEARCH OPPORTUNITIES

Ecological restoration projects offer many research opportunities for collaboration with universities/ colleges, institutions, non-governmental organizations and the private sector. Research can involve investigations of invasive species BMPs, biodiversity enhancement techniques, seed research, root density sampling and literature reviews.

Additionally, unique urban naturalization projects such as The Meadoway afford an opportunity to study the social and biocultural aspects of restoration and increased exposure to healthy natural areas. These efforts expand our collective ecosystem management knowledge, while raising and broadening awareness of and attention to The Meadoway project. A list of the research that has taken place at The Meadoway is presented in Appendix 3.

7 Community Engagement

The Meadoway provides opportunities for community groups, school groups and the public to engage with and learn about the project. From the start, outreach and informative events were and remain important to educate and capture the imagination of residents and the general public. They also offer an opportunity to voice questions and recruit long-term stewards of these restored lands. Outreach at The Meadoway is ongoing and uses a variety of platforms to connect with the widest audience, including newsletters, blogs, X (formerly Twitter), Facebook and Instagram.

Documenting outreach efforts will also help with funding and with tracking the societal and community impacts of the project.

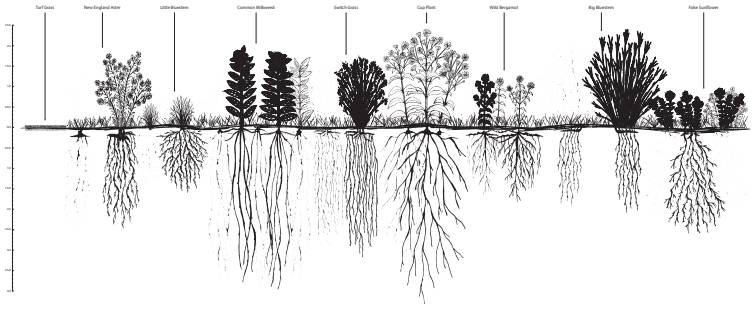
8 Appendices

8.1 MEADOWAY SIGNAGE

The Meadoway
COMMUNITY POWERED GREEN SPACES

MEADOW RESTORATION

This area has been planted with native wildflowers and grasses. Patience is critical for the success of any meadow. You can expect to see beautiful wildflowers in the summer and fall each year. Meadows are a vital component of our natural landscape as they provide food and shelter particularly for birds and butterflies. Maintenance mowing will occur every 3-4 years.



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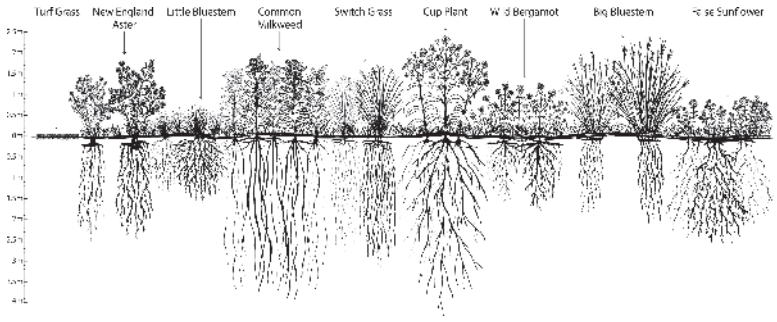
The Meadoway
COMMUNITY POWERED GREEN SPACES

MEADOW RESTORATION

This site has been seeded with native wildflowers and grasses, enhancing flora biodiversity. You can expect to see beautiful wildflowers the second year after seeding, as native wildflowers and grasses spend the first years of their growth cycle putting most of their energy into root development. With time this meadow will provide food and shelter particularly for birds and pollinators.



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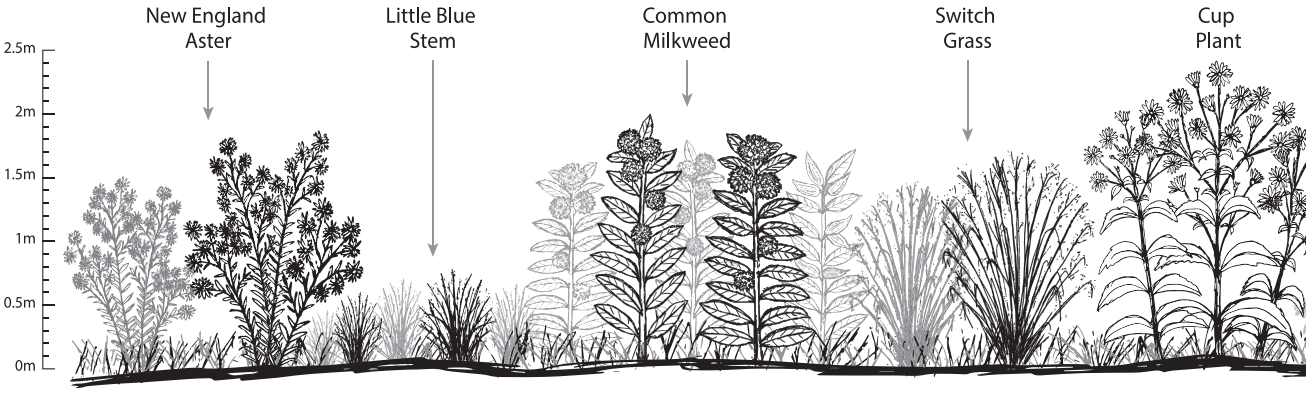
The Meadoway

COMMUNITY POWERED GREEN SPACES

MEA
RESTO

Meadows are an endangered ecosystem and provide ha
This area is being prepared to establish native wildflowe
and patience are critical for the success of the meadow.
and meadow plants will be seeded in the second year.



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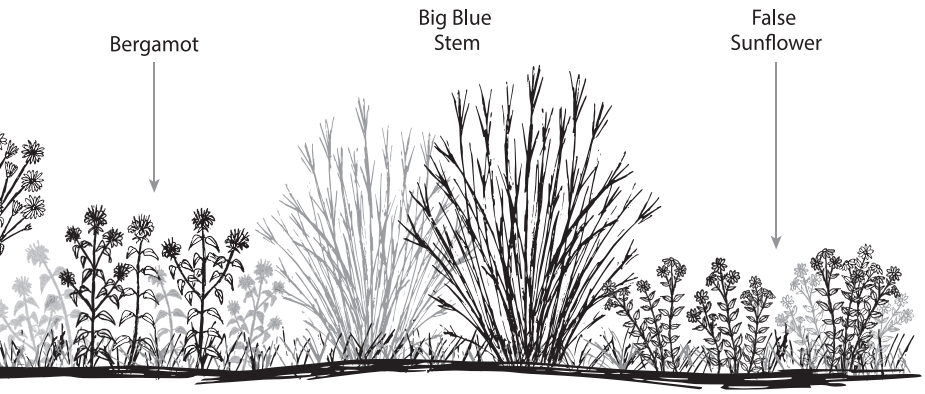
ORATION

abitat for pollinators, birds and wildlife.
ers and grasses. Proper site preparation
A nurse crop is planted in the first year



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8.2 MEADOWAY SEED MIXES

Butterfly Mix (high amounts of flowers, good for pollinators, aesthetics)

Scientific Name	Common Name	%
Andropogon gerardii	big bluestem	7%
Elymus canadensis	Canada wild rye	6%
Panicum virgatum	switch grass	7%
Schizachyrium scoparium	little bluestem	3%
Sorghastrum nutans	savanna grass	7%
Asclepias syriaca	common milkweed	3%
Asclepias tuberosa	butterfly milkweed	3%
Coreopsis lanceolata	lance-leaved coreopsis	1%
Desmodium canadense	showy tick-trefoil	3%
Drymocallis arguta	tall cinquefoil	2%
Euthamia graminifolia	grass-leaved goldenrod	1%
Heliopsis helianthoides	oxeye	5%
Lespedeza capitata	round-headed bush-clover	2%
Monarda fistulosa	wild bergamot	6%
Oenothera biennis	common evening primrose	3%
Penstemon digitalis	foxglove beardtongue	4%
Penstemon hirsutus	hairy beardtongue	3%
Pycnanthemum virginianum	Virginia mountain mint	5%
Ratibida pinnata	grey-headed coneflower	2%
Rudbeckia hirta	black-eyed Susan	6%
Silphium perfoliatum	cup-plant	2%
Sisyrinchium montanum	blue-eyed grass	1%
Solidago nemoralis	grey goldenrod	2%
Solidago rigida ssp. rigida	stiff goldenrod	1%
Symphyotrichum ericoides	heath aster	3%
Symphyotrichum laeve var. laeve	smooth aster	2%
Symphyotrichum novae-angliae	New England aster	3%
Verbena hastata	blue vervain	3%
Verbena stricta	hoary vervain	2%
Vernonia gigantea	tall ironweed	2%

Total % **100%**
Grass% **30%**

Grass Dominant Mix

Andropogon gerardii	**big bluestem**	**15%**
Elymus canadensis	Canada wild rye	5%
Panicum virgatum	switch grass	13%
Schizachyrium scoparium	little bluestem	15%
Sorghastrum nutans	savanna grass	20%
Sporobolus cryptandrus	sand drop seed	2%
Asclepias syriaca	common milkweed	2%
Asclepias tuberosa	butterfly milkweed	1%
Desmodium canadense	showy tick-trefoil	1%
Helenium autumnale	sneezeweed	1%
Heliopsis helianthoides	oxeye	2%
Lespedeza capitata	round-headed bush-clover	2%
Monarda fistulosa	wild bergamot	4%
Oenothera biennis	evening primrose	3%
Pycnanthemum virginianum	Virginia mountain mint	2%
Rudbeckia hirta	black-eyed Susan	5%
Solidago nemoralis	grey goldenrod	4%
Symphyotrichum ericoides	heath aster	1%
Symphyotrichum novae-angliae	New England aster	1%
Symphyotrichum oolentangiense	sky blue aster	1%

Total % **100%**
Grass% **70%**

Invasive Resilient Mix

Scientific Name	Common Name	%
Andropogon gerardii	big bluestem	16%
Elymus canadensis	Canada wild rye	7%
Elymus virginiana	Virginia rye	6%
Panicum virigatum	switchgrass	15%
Sorghastrum nutans	savanna grass	16%
Asclepias syriaca	common milkweed	3%
Desmodium canadense	showy tick-trefoil	3%
Heliopsis helianthoides	false sunflower	6%
Monarda fistulosa	wild bergamot	5%
Oenothera biennis	evening primrose	5%
Rudbeckia hirta	black-eyed Susan	5%
Silphium perfoliatum	cup-plant	3%
Solidago juncea	early goldenrod	2%
Symphyotrichum lanceolatum	panicled aster	2%
Symphyotrichum novae-angliae	New England aster	3%
Verbena hastata	blue vervain	3%

Total % **100%**
Grass% **60%**

Poor Soil Mix (designed for sandy, rocky soil)

Andropogon gerardii	**big bluestem**	**15%**
Andropogon gerardii	big bluestem	10%
Bouteloua curtipendula	side-oats grama	2%
Carex granularis	meadow sedge	4%
Danthonia spicata	poverty oat grass	2%
Elymus canadensis	Canada wild rye	10%
Elymus trachycaulus	slender wheat grass	2%
Panicum virgatum	switchgrass	8%
Schizachyrium scoparium	little bluestem	7%
Sorghastrum nutans	savanna grass	10%
Anaphalis margaritacea	pearly everlasting	3%
Anemone cylindrica	thimbleweed	1%
Apocynum androsaemifolium	spreading dogbane	1%
Asclepias syriaca	common milkweed	2%
Asclepias tuberosa	butterfly milkweed	1%
Coreopsis lanceolata	lance-leaved coreopsis	3%
Desmodium canadensis	showy tick-trefoil	3%
Heliopsis helianthoides	false sunflower	2%
Lespedeza capitata	round-headed bush-clover	1%
Liatris cylindracea	cylindrical blazing-star	1%
Monarda fistulosa	wild bergamot	3%
Oenothera biennis	common evening primrose	4%
Penstemon hirsutus	hairy beardtongue	2%
Ratibida pinnata	grey-headed coneflower	2%
Rudbeckia hirta	black-eyed Susan	4%
Solidago nemoralis	grey goldenrod	2%
Solidago ptarmicoides	upland white aster	2%
Solidago rigida	stiff goldenrod	2%
Echinacea pallida	pale purple coneflower	1%
Symphyotrichum ericoides var. ericoides	heath aster	2%
Verbena stricta	hoary vervain	3%

Total % **100%**
Grass% **55%**

8.3 RESEARCH

Current Research Articles include:

Qin, K. (2022). Enhanced Hydrological Regulating Services by Meadow Restoration Supported by Rainfall Simulation Tests.

Qin, K. (2022). Regulating and Supporting Ecosystem Services Provided by Urban Greenspace and Restored Meadows along a Hydro Corridor in Toronto.

Irwin, S. (2022). Effect of Ecological Restoration on Plant-Pollinator Networks in Urban Meadows.

Hall, T.C.K. (2025). Assessing the Effects of Mowing Intensity on the Over-wintering Stem-dwelling Insect Community of Solidago altissima L.

Hall, T.C.K. (2024). Investigating the Effect of Mowing in Urban Meadow Restoration on the Stem-dwelling Insect Community of Solidago altissima.

Lacoste Bider, P. (2024). Effects of Invasive Plant Removal on an Urban Plant-Bee Community.

Snyder, E.H.U. (2024). Excising the Ghosts of Invasions Past: Restoring Native Vegetation to Soil Infested with Invasive Swallowworts.

Kotsopoulos, S., Turnbull, K., Cormack, C., Cartwright, L., Hayes, S., Ford, B., Shachak, R. & Watkinson, A. (2024). The Meadoway: Native Meadow Creation in Underutilized Transmission Line Corridors.


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