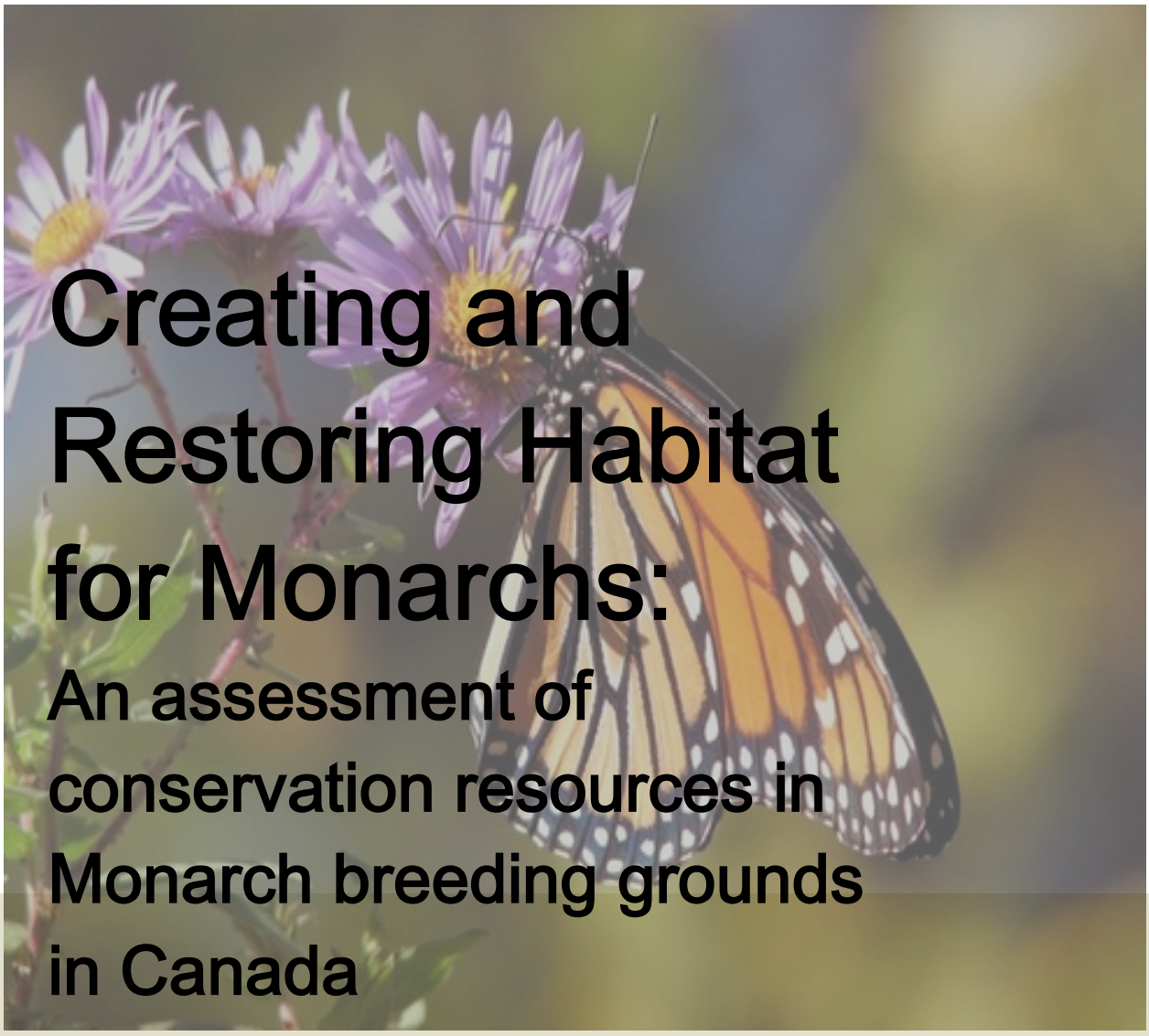

Creating and Restoring Habitat for Monarchs:

An assessment of conservation resources in Monarch breeding grounds in Canada

Final Report

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EXECUTIVE SUMMARY

The Monarch butterfly is listed as a species of Special Concern (Schedule 1) under both Canada's and Ontario's Species at Risk Acts. To address significant declines in Monarch butterfly populations, Canada, Mexico and the United States have committed to a tri-national conservation effort to ensure the long-term viability of this species' unique continental migration. In the short-term, all three countries will work towards a target of six hectares (15 acres) of occupied overwintering habitat in Mexico by 2020. In support of this commitment, Canada released the *Management Plan for the Monarch (Danaus plexippus) in Canada* (2016), which calls for the conservation, creation and management of habitat on which Monarchs rely. This document reports on the native plant industry's capacity to supply vegetation materials in support of the habitat conservation measures outlined in the Plan, and also provides a summary of spatial considerations and current research efforts pertaining to Monarch butterfly support. Also included are a list of native plants used by Monarchs for nectaring, and a list of their larval host, milkweeds (*Asclepias spp.*). Plant lists have been aggregated from various resources and vetted with primary and secondary literature.

Currently, there is little data pertaining to the quality and quantity of monarch habitat in the main Canadian breeding grounds in Southern Ontario and southern Quebec. While milkweed has been identified as a limiting factor in the U.S. Midwest, it is unknown whether there have been any significant changes in milkweed densities in Canada, and whether there have been losses of other floral resources Monarchs rely on. Canadian researchers and their American counterparts are currently developing tools to provide the spatial analysis needed to answer these questions. In the meantime, research on Monarch population dynamics suggests that the best conservation strategy is to protect and restore habitat across their breeding range, as this is most likely to ensure long-term population viability. It is also more feasible to implement small conservation gains at multiple locations rather than focus on large gains in a few regions. To that end, developing conservation measures specific to land use types and stakeholders is an effective way of distributing such gains across the Monarch's

range. The general consensus is that continuing with an “all hands on deck” approach that makes use of “low hanging fruit” is the most effective strategy for making the most of limited conservation resources.

In practice, this means adopting an ecosystem and landscape-scale approach and integrating Monarch conservation into existing programs and landscape management regimes. Three broad land use categories, among others, can help prioritize conservation actions: Parks and protected areas; rights-of-way (ROW); and agricultural lands. Though initiatives in each of these categories are already underway, increasing coordination between stakeholders – particularly native plant nurseries, industry organizations, and conservation groups – will ensure that opportunities are seized.

Two primary areas of focus in this regard are the development of landscape management practices and the expansion of the supply of native plant materials for habitat creation. First, the adoption of lower impact management practices, in ROW or agricultural lands for example, that reduce the extent and amount of interventions can save costs and have significant advantages for Monarchs and other pollinators. Second, while there exists a significant capacity within the native plant industry in the main Monarch breeding grounds to supply conservation measures, demand often exceeds supply, particularly for large-scale projects such as those that might be undertaken along ROWs. Because increasing the supply of native plants and seeds requires a few years of preparation, greater coordination in the form of multi-year contracts between nurseries and other stakeholders would allow meeting long-term needs and making the most of current conservation opportunities. Such coordination to increase supply would also help lower the costs of materials, which would help increase habitat creation more broadly, particularly in agricultural areas where the costs of native plants can be an impediment to effective interventions.

Despite some limitations in the supply of native plant materials and knowledge of where best to focus habitat restoration, stakeholder interest and technical requirements in support of Monarch conservation measures are present. Greater coordination between stakeholders such as government agencies, nurseries,

ROW managers, and agricultural organizations and industry, will allow the most effective use of these resources to meet the objectives of the Management Plan.

SUMMARY OF RECOMMENDATIONS

- Integrate Monarch conservation into existing habitat restoration and conservation initiatives to make use of limited resources and encourage ecosystem and landscape-scale conservation.

- Support current spatial analysis research by Canadian researchers and collaboration with the USGS to prioritize Monarch habitat creation on a spatial and land use basis.

- Support initiatives by conservation groups such as Pollinator Partnership, Conservation Authorities and others to tailor BMPs to Canadian stakeholders, including ROW managers and agricultural groups such as Ontario Soil and Crop Improvement Association, Union des producteurs agricole, and others.

- Support initiatives by Pollinator Partnership Canada, the Ontario Plant Restoration Alliance, and other groups to convene native plant producers, industry stakeholders, conservationists and researchers together to identify needs and gaps in native plant production to support conservation projects.

- Identify funding and support multi-year contracts to nurseries to develop the supply of native plant materials for large-scale restoration projects on public and private lands.

1. MONARCH CONSERVATION CONTEXT

1.1 Introduction

The Monarch butterfly is listed as a species of Special Concern (Schedule 1) under both Canada's and Ontario's Species at Risk Acts. To address significant declines in Monarch butterfly populations, Canada, Mexico, and the United States have committed to a tri-national conservation effort to ensure the long-term viability of this species' unique continental migration. In the short-term, all three countries will work towards a target of six hectares (15 acres) of occupied overwintering habitat in Mexico by 2020. To achieve this goal, each country has developed strategies to mitigate threats and increase habitat. In 2016, Environment and Climate Change Canada released the *Management Plan for the Monarch (Danaus plexippus) in Canada*. In support of the habitat conservation measures outlined in the management plan, this report provides an assessment of the native plant industry's capacity in the main Monarch breeding grounds within Canada to supply plant materials for habitat creation with milkweed and other native forbs.

The Monarch butterfly, *Danaus plexippus*, depends exclusively on milkweed plants for egg laying sites and larval development. Once caterpillars are developed into adults, Monarchs rely on specific floral nectar resources. Nectar resources become increasingly important in providing fuel and nutrition before the fall migration period. Abundant milkweed and floral habitat that provides nectar throughout the full residency period is critical for the Monarch butterfly to thrive. An abundant Monarch population in Canada helps to maintain the migration across North America and ensure its long-term viability through continental changes in habitat and climate. For this reason, one of the primary strategies in support of Monarch butterflies includes the planting of complete habitats that include a mix of milkweeds and nectar plants.

Deficits in both seed availability (milkweed and native nectar plants) and plant preference data can impact successful Monarch conservation efforts. Native

seed and plant producers are critical partners in Monarch conservation; to be successful they require information to anticipate and meet demand for habitat restoration materials. Gaps in information and available resources can also result in waning interest in conservation efforts. Citizens and community groups will be key players in Monarch conservation and must be engaged with programs that provide viable options to support Monarchs. Similarly, industry and commercial stakeholders are eager to engage in conservation support for Monarchs, but will rely on plant availability to carry out conservation projects.

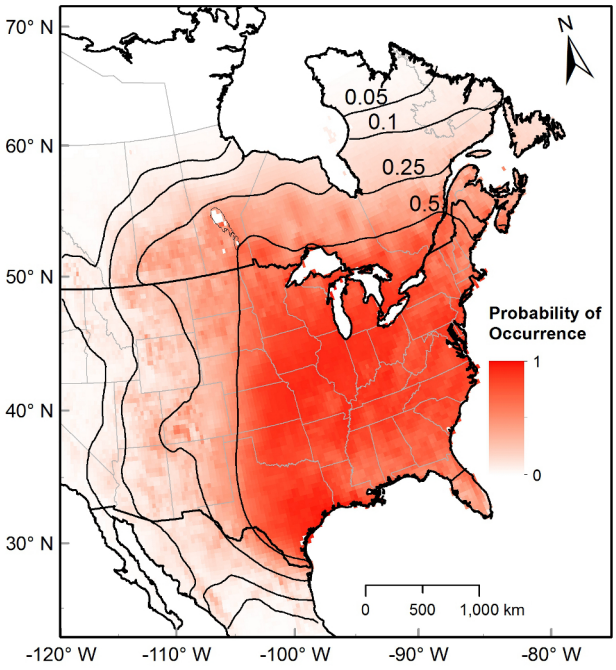
By assessing the current capacity of the native plant industry, gaps between goals and the resources needed to meet them can be identified and bridged. To that end, section 1 will provide general context for Monarch habitat conservation and creation in the Canadian portion of the main breading grounds of the Eastern North American population, including recommendations on the use of spatial tools and for select land uses. Section 2 presents the results of our assessment of the native plant industry's capacity to supply Monarch conservation efforts. Section 3 provides an overview of general technical recommendations for the use of milkweed and native nectar plants in Monarch conservation. Section 4 is the aggregated plant list for Monarchs based on the best available scientific knowledge.

1.2 Canadian Context

Between 10% and 15% of the North American breeding population of the Monarch butterfly is found in Canada, with density varying from year to year (ECCC 2016). There are two distinct populations occurring in Canada, the Western North American and the Eastern North American. The portion of the Western North American population occurring in Canada is generally restricted to the Southern Interior of British Columbia, coinciding with the distribution of showy milkweed (*A. speciosa*) (ECCC 2016). It is the Eastern North American population, however, that accounts for over 90% of Monarchs occurring in Canada, and while their range extends from Alberta to the Maritimes, the breeding population is concentrated in southern Ontario and southern Quebec,

where common milkweed (*A. syriaca*) is widespread (ECCC 2016). This assessment therefore focuses on conservation resources in the main breeding range of the Eastern North American population.

Monarch probability of occurrence in eastern North America
from Flockhart et al. 2013



"The probability of occurrence of Monarch butterflies in eastern North America throughout the breeding season. This predictive map takes the maximum probability of occurrence of each cell in the landscape from all monthly distribution maps. The 0.5, 0.25, 0.1 and 0.05 isoclines are indicated." (Flockhart et al. 2013, p.4)

Declines in Monarchs have been attributed largely to habitat loss, and to declines in the presence of milkweed specifically (Pleasants and Oberhauser 2013). In the U.S. Midwest, in particular, where an average of 38% of Monarchs overwintering in Mexico originate (Flockhart et al. 2017), there has been an estimated loss of 58% of milkweed stems as a result of the widespread use of glyphosate and glyphosate-resistant crops (Pleasants and Oberhauser 2013). Consequently, American Monarch recovery efforts have focused on planting milkweed and creating habitat in the Midwestern Corn Belt (primarily Iowa, Illinois, Indiana, Ohio, Nebraska, Minnesota, and parts of Wisconsin).

Currently, there are no estimates of changes, if any, in milkweed numbers in Canada. Anecdotally, milkweed in the main breeding grounds in Quebec and Ontario are still widespread (Maxim Larrivée, *pers. comm*). The exception might be in Southwestern Ontario, where corn and soybean production are concentrated and where glyphosate and glyphosate-resistant crops dominate. While there is currently no data available on changes in milkweed occurrence in these crop growing areas, the transformation of pastures into crop fields (for example, see Huron County, 2013) and anecdotal accounts from farmers (author, *unpublished data*) suggest that there might be some loss of milkweed, and loss of pollinator habitat more generally. In addition to changes in agricultural practices, the loss of farmland to development has also contributed to habitat loss for Monarchs and pollinators. Between 2001-2011, more than 27% of agricultural land was lost in the Mixedwood Plains ecozone, the region bounded by Lakes Huron, Erie and Ontario and that extends along the St-Lawrence River to Quebec (Statistics Canada 2014). This area largely coincides with Monarch breeding grounds. Nevertheless, in the absence of data, it is difficult to determine whether milkweed is a limiting factor in Canadian Monarch recovery efforts.

Fortunately, Monarch conservation efforts can be part of a more extensive strategy to address pollinator declines and habitat restoration broadly. In other words, despite gaps in our knowledge of Monarch-specific habitat requirements in Canada, integrating what we do know into existing wilderness conservation programs, vegetation management and biodiversity initiatives will provide broad benefits to ecosystems and make more effective use of limited resources. For example, conservation initiatives aimed at savannahs, prairies, alvars, and other early successional, seral, and open habitats can include Monarchs within their broader goals by including locally appropriate species of milkweed and nectar plants, such as asters and goldenrods. As a ‘flagship’ species, Monarchs therefore represent the conservation and restoration of habitats for hundreds of other species of pollinators, wildflowers, and grasses.

Recommendations:

- Integrate Monarch conservation into existing habitat restoration and conservation initiatives to make use of limited resources and encourage ecosystem and landscape-scale conservation.

1.3 Spatial Considerations

The question of where best to focus limited resources is essential to any conservation management plan. Given the Monarch's continental range and multigenerational annual life cycle, the challenge is especially considerable. In the U.S., many efforts have concentrated in the Midwest breeding grounds, where the largest proportion of Monarchs overwintering in Mexico originate, as that is where the largest gains are to be made compared to other areas (Flockhart et al. 2017). However, two recent studies, using different methodologies, have concluded that the most effective approach is to invest in conservation across the Monarch's range. Karen Oberhauser et al. (2016) developed a spatially explicit demographic model to simulate the North Eastern Monarch's population dynamics under various conservation scenarios. Their results "suggest that large-scale habitat restoration and management efforts across the breeding and migratory range is the best strategy for long-term population recovery, assuming that modest gains in vital rates everywhere will be more easily attained than dramatic grains in any single region." (Oberhauser et al., 2016: p.7). Similarly, Tyler Flockhart et al.'s (2017) study combining isotope analysis and geospatial modeling to identify the natal origins of Monarchs overwintering in Mexico found that over 50% of the Eastern North American population comes from outside the US Midwest (Flockhart et al. 2017). While efforts in the Midwest, where the largest portion of Monarchs overwintering in Mexico originate, are likely to benefit a greater overall number compared to interventions in other single regions, conservation investments across their range is nevertheless most likely to ensure population viability in the long-term, especially given uncertainty as to changes in land use across North America, annual weather variation, and changes in climate (Flockhart et al. 2017). In

essence, the optimal conservation investment strategy is to distribute small gains across the entire breeding range.

Spatial Tools

In the U.S., the United States Geological Survey (UGSG) Monarch Conservation Science Partnership has developed two GIS conservation planning tools to help prioritize counties based on positive attributes and potential threats. The Monarch Conservation Science Partnership Desktop and Online Spatial Tools consolidate geospatial data layers pertaining to land use and cover, climate and stewardship information to help guide decision making and conservation resources where they can have the highest impact. This spatial tool helps direct limited conservation resources where they have the potential to be most effective. Informal discussions between USGS scientists (Wayne Thogmartin) and Canadian researchers (Gregory Mitchell, ECCC and Maxim Larrivée, Insectarium de Montréal) on the possibility of using these tools to determine whether milkweed is a limiting factor in Monarch recovery in Canada are currently underway.

In Canada, Jeremy Kerr (University of Ottawa), Paul Galpern (University of Calgary), and Maxim Larrivée (Insectarium de Montréal) are currently using land cover data to estimate changes in milkweed density to assess the need for habitat restoration in the Monarch's Canadian breeding range. Initial results are expected mid-May 2017.

Recommendations:

- Support current spatial analysis research by Canadian researchers and collaboration with the USGS to prioritize Monarch habitat creation on a spatial and land use basis.

1.4 Land Use and Stakeholders

Practically, the strategy to distribute small gains across the Monarch breeding and migratory range also entails further refining and prioritizing interventions

based on land use. There already exists considerable knowledge pertaining to management of ROW and agricultural stewardship for Monarchs. The gap, it would seem, is in tailoring these resources to Canadian stakeholders and promoting them through collaborative partnerships so that they are more readily available and accessible.

Recommendations:

- Support initiatives by conservation groups such as Pollinator Partnership, Conservation Authorities and others to tailor BMPs to Canadian stakeholders, including ROW managers and agricultural groups such as Ontario Soil and Crop Improvement Association, Union des producteurs agricole, and others.

Below are recommendations for three land use types where ongoing Monarch conservation will benefit from increased coordination in the supply of native plant materials and vegetation management.

Parks and Protected Areas

Parks and protected areas provide critical Monarch habitat. Protected sites along the Great Lakes have long been recognized for their importance in fall staging, when Monarchs congregate in trees while awaiting favourable winds to cross the Great Lakes on their southbound migration. These sites include Presqu'ile Provincial Park, Prince Edward Point National Wildlife Area, Long Point Provincial Park, Long Point National Wildlife Area, Rondeau Provincial Park, and Point Pelee National Park (COSEWIC, 2010). The *Management Plan for the Monarch (Danaus plexippus)* (ECCC 2016) lists three of these protected areas within the Tri-national "Sister Protected Areas" (SPA) Network. Notably, these five sites are all in the most densely populated region of Canada (the Greater Golden Horseshoe) and serve a critical function by protecting the little remaining habitat in an otherwise heavily developed and cultivated landscape. Continued support of these protected sites is therefore paramount.

In addition to nationally and provincially protected sites, other sites at the municipal level, or under private or non-profit management also play a critical function in sustaining Monarch and pollinator habitat. For example, the Ojibway Nature Centre in Windsor protects one of the last remnant patches of tallgrass prairie in Carolinian Canada, and is home to the highest concentration of rare species in Ontario, with over 160 species of provincially rare plants and animals, including four types of milkweed rare to Ontario: Purple milkweed (*A. purpurascens*), Prairie milkweed (*A. sullivantii*), Whorled milkweed (*A. verticillata*), and Green milkwed (*A. viridiflora*). Recognizing the role of these privately and/or municipally managed sites is important for determining the amount and quality of Monarch habitat, coordinating conservation efforts and sharing information.

Additionally, initiatives around certain ecosystem types can also be recruited to Monarch conservation. For example, many organizations are active on tallgrass prairie conservation and restoration, from Alberta to Ontario. Where appropriate, local milkweed species can be added to planting mixes to support Monarchs. Such inclusion can help support broader conservation goals beyond Monarchs, especially if additional resources earmarked for Monarchs can dovetail with ecosystem conservation and other species-at-risk efforts. At the landscape and ecosystem level, Carolinian Canada leads a project called “The Big Picture”, which maps out 38 critical sites within the Carolinian ecoregion and possible habitat corridors linking these together. Directing Monarch conservation resources to such a project would make use of existing knowledge and governance infrastructure, and would support multiple species through an ecosystem and landscape-scale lens.

At the management level, simply reducing or eliminating roadside mowing in parks could benefit Monarchs and other pollinators. Similarly, parks with landscaped areas and flowerbeds could gradually include native perennial forbs.

Secondary recommendations:

- Continued support and protection of known Monarch habitat in parks and protected areas.

- Identification of parks and protected areas at the private and municipal level that already sustain Monarch habitat or could be habitat restoration sites, such as Nature Conservancy lands in Manitoba and Ontario and the "Big Picture" project of Carolinian Canada.

- Identification and support of possible corridors linking parks and protected areas where habitat can be protected or restored, such as the "Big Picture" project of Carolinian Canada.

Rights-of-way

Rights-of-way (roadsides, utility corridors, pipelines, etc.) have been suggested as an important component of landscape-level Monarch conservation strategy (Wojcik and Buchmann 2012). As large tracts of land under single management regimes, they present the opportunity to make significant gains at the landscape level through relatively simple changes in management practices. Because of this, ROW have been described as a 'low hanging fruit' in terms of habitat restoration priorities. In the U.S. Midwest, the I-35 highway that runs from Texas to the Great Lakes, through the Corn Belt and along the central Monarch flyway, has been designated as a "Monarch Highway". Various federal and state agencies (including transportation authorities), private landowners and conservation groups are currently working together to identify appropriate sites for roadside plantings and to train personnel on Integrated Vegetation Management (IVM) along the I-35.

In Canada, interest in pollinator conservation from ROW managers and provincial transportation ministries is growing. Roadside plantings in Ontario have included a 6 ha (15 ac) pollinator habitat along the 401 Highway extension in Essex County (the Herb Gray Parkway in Windsor). More broadly, the Ministry of Transportation of Ontario is currently reviewing seed mixes to include more native species of both grasses and forbs. Current limitations reported both in Canada and in the U.S. by ROW managers are the limited supply of vegetation materials (both seeds and transplants) and the high cost of native species.

Coordination between government agencies, nurseries, seed suppliers, and conservation specialists would help increase the supply and, through economy of scale, reduce the costs of native plant materials for roadside re-vegetation.

In addition to increasing native species in roadside vegetation mixes, changing management practices to reduce mowing and herbicide treatments are beneficial to Monarchs and other pollinators. The adoption of lower impact strategies that reduce the extent and amount of interventions (mowing and pesticide use) save costs and have significant advantages for Monarchs and other pollinators. Reducing mowing to one or two times a year, and restricting mowing activities to areas only where it is essential to maintain visually clear zones, preserves more wildflower habitat. Similarly, limiting and targeting herbicide use along corridors is a strategy that eliminates unwanted weeds, preserves remaining floral resources, and saves on costs. Public and private corridor managers in power and gas transmission as well as roadsides and railway management have been keen to adopt cost-saving measures that result in biodiversity benefits. Estimates of the extent of networks in Ontario alone suggest that 270 000 km of managed roadways and 36 000 ha (89 000 ac) of other managed ROW of potential Monarch and pollinator habitat can be enhanced through management.

Secondary recommendations:

- Promote the adoption of Integrated Vegetation Management (IVM) regimes by ROW and support the training of staff in IVM and Monarch conservation and monitoring.

- Support initiatives by Pollinator Partnership Canada, the Plant Restoration Alliance, other groups, and industry stakeholders to develop seed mixes and guidelines for Monarch conservation specific to ROW.

Agricultural lands

Much of the focus of agri-environmental stewardship programs has been on improving water quality through the planting of riparian buffers with grasses.

Including native flowering forbs (as well as native flowering trees and shrubs where appropriate) in riparian buffers and similar on-farm re-vegetation projects is an effective way of integrating several ecological functions in a single intervention. Significant barriers to the adoption of more biodiverse, pollinator-supporting farm plantings include the high cost of materials (compared to grass seed and non-native cover crops) and a lack of Canadian experience and knowledge pertaining to managing biodiverse plantings in and near crop fields and pastures. To address these barriers, collaboration between government agencies (federal and provincial), farm organizations, and the agriculture industry is needed to develop seed mixes and management practices specific to Canadian farmers' needs.

Given the diversity of farming types and practices in Canada, prioritizing the development of management practices and seed mixes for specific farming types would be helpful. For example, focusing on pollinator-dependent crop systems would help engage producers who would benefit financially from increasing pollinator services to their crops through the provision of on-farm habitat.

Secondary recommendations:

- Support collaboration between farm organizations like ALUS Canada, Farms at Work, Ontario Soil and Crop Improvement Association, Conservation Districts (Manitoba), Conservation Authorities (ON), Union des producteurs agricoles (QC), Pollinator Partnership Canada, and other farm and conservation groups to promote stewardship programs and BMPs related to Monarch conservation.

- Support initiatives by Pollinator Partnership, Ontario Plant Restoration Alliance, farm organizations, researchers, native plant producers and the agriculture industry to develop native seed mixes for farm use and decrease their costs.

2. NATIVE PLANT SUPPLY AND INDUSTRY

2.1 Capacity of native plant industry in the main Monarch breeding regions

This assessment of the native plant industry focused on the primary Monarch breeding regions, southern Ontario and southern Quebec, and to a lesser extent, Southeastern Manitoba. Nurseries were identified through online searches that included lists prepared by native plant societies, naturalists clubs and industry listings. All nurseries specializing in native forbs were included; nurseries specializing in trees and shrubs to the exclusion of forbs were omitted from the survey. Once the list was completed, nurseries were contacted by email with questions on their milkweed and nectar plant stocks (seed, plug and container); production and contract capacity; and local ecotype practices (original source location of plant materials). The initial email was followed up with phone calls, either to clarify information received or to garner a response. Thirty nurseries were contacted, from Alberta to Quebec, but only those from Manitoba to Quebec were retained for analysis (27); of these, two were discarded (out of business and non native-specialised), for a total of twenty-five (25) respondents.

The picture that emerged is of an industry in expansion, characterized by a wide range of company sizes and capacities; concentrated in Southwestern and Central Ontario; and marked by growing demand that often exceeds supply.

Ontario

Nineteen native plant nurseries that include or specialize in native forbs were identified in Ontario. This group is characterized by a diversity of business sizes and models that fit into three general categories based on size: large, medium, and small. Six large companies produce seeds in the hundreds of kilograms and/or plants in the tens and hundreds of thousands: Native Plant Source, Ontario NativeScape, Sassafras Farms, St Williams Nursery and Ecology Centre, Tin Roof Rusted Farm and Plant Nursery, and Wildflower Farm. Most of these provide landscape restoration, contract growing, and seed collection services. Even within this category, there is a significant size differential between the largest and most established, and their relatively smaller competitors. In the mid-

size category, there are seven nurseries, producing anywhere from 5000-40,000 plant units: Grand Moraine Growers, Green Side Up Environmental Services and Landscaping, Grow Wild, Kayanase, Native Plant Nurseries, Native Plants in Claremont, and Verbinnen's Nursery. Of these, only two produce seed commercially and in small amounts (single kg of each species). Mid-size companies also often provide restoration services, contract growing and seed collection for large projects. Finally, six small companies are found at the other end of the spectrum: Fuller Native and Rare Plants, Natural Themes Farms, Nith River Plants, Not So Hollow Farm, Ontario Flora, and Ottawa Valley Native Plants. The nurseries in this category have the capacity to produce <5000 plants a year, and in one case as little as 200; and with low (under 5kg) or no seed production. The more established of these small operations tend to work on contract for local, private landowners, while the newer ones are looking to expand their capacity in the future.

The general impression communicated by native plant producers was that demand for native plants from the general public is increasing, and that their businesses at times struggle to meet demand. Paul Heydon, from Grow Wild, stated: "If you had told me twenty years ago when I first started in this business, that I would be planting common milkweed for sale, I would have laughed. But last year it was one of the species I had the most demand for." For nurseries looking to expand production, the lag time between investing in new capital (land, greenhouses, equipment, etc.) and seed stock development on the one end, and the production of commercially viable products on the other end, was frequently cited as a barrier to meeting increased demand.

Restoration specialists, from both the large and mid-size nursery categories, described barriers around Species at Risk regulations. For example, dense blazing star (*Liatris spicata* – a noted Monarch-favoured species) is listed as Threatened in Ontario. Nurseries who have Ontario-sourced ecotypes cannot sell it, though commercial cultivar varieties and wild ecotypes from the U.S. are commercially available.

Quebec

The native plant industry in Quebec is significantly smaller than Ontario. Up until recently, there were four nurseries that offered native forbs. Pépinière Aiglon and Pépinière Indigo merged in late 2016 to form Aiglon Indigo, the largest of the now three nurseries but operating at a similar capacity as the mid-sized operations in Ontario. The two other nurseries are Pépinière Rustique, also a mid-sized operation, and Pépinière Rhizome, a small-sized nursery in its second year that plans to expand its capacity in the future. In Quebec nursery operators also noted an increase in demand for native plants from the general public.

Manitoba

The native plant nursery industry in Manitoba is comparable to Quebec, with two specialized native plant nurseries, Prairie Originals (mid-sized capacity) and Prairie Flora, (small-sized capacity). A third company, Prairie Habitats, was the first native plant company in Manitoba, but sold its nursery operations to Prairie Originals in the 1990s and has since specialized in restoration consultation and equipment, including the development of the Prairie Habitats Seed Harvester, a hand held device to collect seed from the wild.

Both nurseries and conservation professionals in Manitoba have cited small production capacity as a serious limiting factor to habitat restoration initiatives. Commercial projects requiring native grass seed for large, several hundred acre projects have not been able to source local Manitoba ecotypes and have resorted to importing seed from the United States. Conservation organizations, such as the Nature Conservancy of Canada that does extensive tallgrass prairie restorations in Manitoba, struggle to source local ecotypes of both grasses and forbs for their projects.

ONTARIO NATIVE PLANT INDUSTRY CAPACITY 2017

CAPACITY	NAME	LOCATION	PHONE NUMBER	EMAIL	PLANT MATERIALS				CONTRACT CAPACITY			ECOTYPE PRACTICES
					Asclepias spp. seed	*Asclepias spp.* plants	Nectar-producing forbs seed	Nectar-producing forb plants	Restoration	Plant production	Seed production/ collection	
Large	Native Plant Source	318 Misty Cr, Kitchener, ON N2B 3V5	519-748-2298	info@nativeplantsource.com	x	x	x	x	250 acres/yr	x	x	Stock from Grand River Valley; seed zone records, population and habitat specifics for all stock.
	Ontario NativeScape	6890 Base Line E, Wallaceburg, ON N8A 2K6	519-809-5767	lbuchanan.rlsn@gmail.com	x	x	x	x	200-500 aresc/yr		x	Stock originally sourced from provincial parks in the Lambton-Kent region.
	Sassafras Farms	270 Humberstone Rd, Welland, ON L3B 6H1	905-658-8907	cdiraddo@sassafrasfarms.ca	x	x	x	x	x	700,000/yr		Locally sourced with exception of Species at Risk contracts
	St Williams Nursery and Ecology Centre	885 Hwy 24 W, P.O. Box 150, St. Williams, ON N0E 1P0	519-586-9116	kristen.sandvall@stwilliamsnursery.com	x	x	x	x	1000-2500 acres/yr	x	x	Focus on maintaining genetic diversity. Stock identified to seed zones; most from z37 and z34 with exception of Species at Risk contracts.
	Tin Roof Rusted Farm and Plant Nursery	9567 Concession 4 N, RR1, Mount Forest, ON N0G2L0	519-261-0330	tinroofrustedfarm@gmail.com		x		x		x	x	Locally sourced in the Saugeen weatershed following Sustainable seed harvesting protocol.
	Wildflower Farm	10195 Hwy 12 West, RR2, Coldwater, ON L0K 1E0	1-866-476-9453	paul@wildflowerfarm.com	x		x				x	Stock from southern Ontario with exception of a few species sourced in Alberta and Maitoba in the 1990s.
Medium	Grand Moraine Growers	7369 12th Line, RR2 Alma, Ontario, Canada, N0B 1A0	519-638-1101	info@grandmoraineegrowers.ca	x	x		x		x		Stock sourced locally and neighbouring watersheds and identified to seed zone.
	Green Side Up Environmental Services and Landscaping	121 Grassy Rd, Omemee, ON K0L 2W0	705-799-2610	doug@greenservices.ca		x		x	x	x		Locally sourced when possible.
	Grow Wild	3784 ON-7, Omemee, ON K0L 2W0	705-799-2619	paul@nativeplantnursery.ca		x		x	x	x	x	High quality ecotype protocol, seed zone identification

Medium (cont.)	Kayanase	993 Highway #54, P.O. Box 820, Ohsweken, ON	519-770-0013	dan@kayanase.ca	x	x	x	x	x	x	x	Stock sourced from local seed zone z37; source from project locations when doing restoration work.
	Native Plant Nurseries	Tottenham, ON and Pefferlaw, ON	416-768-1959	nativeplantnurseries@hotmail.com	x	x	x	x		x	x	Stock locally sourced.
	Native Plants in Claremont	4965 Westney Rd, Pickering (Claremont) Ontario L1Y 1A2	905-649-8176	info@nativeplants.ca		x		x				Stock sourced locally from see zones z34 and z36; adhere to SER seed collection protocol.
	Verbinnen's Nursery	1504 Brock Rd, RR4, Dundas, ON L9H 5E4	905-659-7072	bernard@verbinnens.com		x		x		x		Stock locally sourced; employ certified local seed collectors and supply from Wildflower Farms as well.
Small	Fuller Native and Rare Plants	175 Airport Pkwy, Belleville, ON K8N 4Z6	613-968-4643	info@fullerplants.com				x				Locally sourced.
	Natural Themes Farms	219 Maybee Rd, RR1 Frankford, Ontario K0K 2C0	613-398-7971	bea@naturalthemes.com		x		x				Asclepias locally sourced; sources from Ontario and American native plant seed suppliers.
	Nith River Plants	4265 Wilmot-Easthope Rd, New Hamburg, ON N3A 3S7	office 519-662-	nithriverplants@hotmail.com				x	x			Stock sourced locally (within 100km of nursery); will source from the U.S. when no local options.
	Not So Hollow Farm	838369 4th Line East, Mulmur, Ontario, L9V 0J7	705-466-6290-705-627-8004	idpayne@notsohollwfarm.ca		x		x				?
	Ontario Flora	Toronto, ON	416-964-0201	info@ontarioflora.ca		x		x				?
	Ottawa Valley Native Plants	1671 Micksburg Rd, RR5, Cobden, ON K0J 1K0	613-646-2386	dorothy@connaughtnursery.com						x		Stock sourced locally (within 100km)

QUEBEC NATIVE PLANT INDUSTRY CAPACITY

CAPACITY	NAME	LOCATION	PHONE NUMBER	EMAIL	PLANT MATERIALS				CONTRACT CAPACITY			ECOTYPE PRACTICES
					Asclepias spp. seed	*Asclepias spp.* plants	Nectar-producing forbs seed	Nectar-producing forb plants	Restoration	Plant production	Seed production/ collection	
Medium	Aiglon Indigo	320, rang Saint-Joseph, Lourdes, QC G0S 1T0	819-385-4509	info@aiglonindigo.com	x	x	x	x		x	x	?
Medium	La pépinière rustique	1614 Chemin du Village, Saint-Adolphe-d'Howard, QC J0T 2B0	819-327-2225	info@pepiniererustique.com	x	x	x	x		x	x	Seed stock sourced locally; when not available, sources from similar climates.
Small	Pépinière Rhizome	1610 rue St-Charles, Portneuf, QC G0A 2Y0	581-981-3861	pepiniererhizome@gmail.com	x	x	x	x		x		?

MANITOBA NATIVE PLANT INDUSTRY CAPACITY 2017

CAPACITY	NAME	LOCATION	PHONE NUMBER	EMAIL	PLANT MATERIALS				CONTRACT CAPACITY			ECOTYPE PRACTICES
					Asclepias spp. seed	*Asclepias spp.* plants	Nectar-producing forbs seed	Nectar-producing forb plants	Restoration	Plant production	Seed production/ collection	
Medium	Prairie Habitats	0043E – 82nd Road N, Argyle, MB, R0C 0B0	204-467-9371	john01@xplornet.com					x		x	Seed stock locally sourced
Medium	Prairie Originals	27 Bunns Rd, Box 25, Grp. 310, RR 3, Selkirk, MB R1A 2A8	204-785-9799	kelly@prairieoriginals.com	x	x	x	x				Seed stock locally sourced
Small	Prairie Flora	P.O. Box 621, Teulon, MB R0C 3B0	204-866-2420	aimee@prairieflora.com	x	x	x	x			x	Sourced from within 300km of Winnipeg

2.2 Milkweed and nectar plant supply

Nurseries were asked to provide estimates of their stock and production capacities, either for the current year or their average annual production for: *Asclepias spp.* (milkweed species), in seed and plants (plugs, pots, containers, etc.); and nectar-producing forbs, in seed and plants (plugs, pots, containers, etc.). While not all nectar-producing forbs are visited by Monarchs, a broader category facilitated responses from nurseries and reflects the fact that ecologically functional Monarch habitat is early successional habitat that supports a broad range of species.

Below are the minimum and maximum ranges (rounded) of seed and plant units produced by native plant nurseries in Manitoba, Ontario and Quebec. These numbers reflect both current stock and total capacity at the time of survey, January-February 2017.

NATIVE PLANT STOCK IN MAIN CANADIAN MONARCH BREEDING GROUNDS
2017 ESTIMATE
(Manitoba, Ontario and Quebec native plant nurseries)

Milkweed seed (kg)	Milkweed plants (units)	Nectar-producing forb see (kg)	Nectar-producing forb plants (units)
115 - 145	81,000 - 97,000	1100 - 1300	840,000 - 1,230,000

How much habitat can these quantities support?

Establishment from seed

Seeding habitat, as opposed to transplanting, is the most cost-effective method and is most appropriate for large-scale projects 1 ha (>2 acres). Based on the following guidelines (from Nabhan et al. 2014) for habitat restoration seeding requirements:

- 10-20 milkweed plants per half hectare (per one acre),
- 50:50 ratio of forbs to grasses,
- seed mix of 30-40 native species of forbs,
- 500 sown seeds of milkweed per 0.5 ha (1 ac),
- 1kg of milkweed seed sufficient for 113 ha (280 ac);

There is currently enough milkweed seed to sow a minimum of **13,000 ha** (32,200 ac) of Monarch habitat, and up to **16,000 ha** (40,000 ac). Because of the variety of seed mass, germination rates and biodiversity requirements for seed mixes, it was not possible to determine the amount of habitat the current supply of nectar-producing forb seed could provide with precision. However, St. Williams Nursery Tallgrass Prairie mix, which is composed of a 50:50 grass to forb ratio, is seeded at 8-12kg/ha. Extrapolating from these numbers, 1100 kg of forb seed would be enough to restore **275 ha** (760 ac) of tallgrass prairie habitat at a seeding rate of 8kg/ha (lower seeding rates are used when drill-seeding, higher rates are used when broadcasting and when site is slopped).

Establishment from transplants

For smaller sites (<1 ha; <2 ac), transplanting from plugs and containers may be more appropriate than seeding. This may be the case when the restoration site also serves a public education function, such as in a park or demonstration garden where more mature plants will be more attractive than seeds in their first year of establishment. Transplants require more labour and resources than seeding and the cost is usually substantially higher; however, the higher survival rate of plugs compared to seeds can help offset costs (Pollinator Partnership and USDA Forest Service 2016).

In general, plugs are planted at a rate of 3-5 per square meter. With the current supply, **28-40 ha** (70-100 ac) could be planted at 3 units/m^2; or **17-25 ha** (40-60 ac) at 5 units/m^2. These estimates are purely theoretical, in that they don't reflect whether this supply of plugs would be adequate to restore habitat with appropriate species composition. They are therefore provided not as a practicable goal, but to convey the current capacity for habitat restoration.

Estimating costs

Estimating costs related to monarch habitat creation is not without challenge. The considerable variety between sites, nurseries and restoration specialists means that costs can vary substantially from one project to another. The price of common milkweed seed alone can vary greatly between sources, from a low of $300/kg up $1,400 (In comparison, common milkweed seed prices range $100-300 [US dollars] in the US). The prices of seed mixes also vary substantially, depending on the species composition and on the nurseries. For example, one of the least expensive, a roadside edge mix containing 0.5% common milkweed and 20% forbs, sells for $110/kg. With recommended rates of 7-10 kg/ha (3-4kg/ac), the cost of seed would be between $770-1100/ha ($330-440/ac), excluding labour, machinery and maintenance. In contrast, a ready mix designed for a loam soil prairie, containing 1.79% butterfly milkweed and 60% forbs, sells for $600/kg. With seeding rates recommended at 21kg/ha (8.36kg/ac), the cost of seed is $5,312 ha ($2125/ac), with a potential discount of 10-15% for large orders. It is, however, the conditions at a given site, including size, soil, land use, slope, historic vegetation, etc., that will determine which species are appropriate for restoration purposes and that will ultimately determine the price.

Nevertheless, seed costs can be reduced by designing mixes with a higher proportion of grasses, which are less expensive than forbs. The Tallgrass Prairie Centre in Iowa recommends a 50:50 ratio of grasses to forbs to maximize forb presence and diversity while retaining the functional benefits of grasses. However, in Southwestern Ontario, St Williams Nursery and Ecology Centre has found ratios of 80:20 and 90:10 of grasses to forbs to provide well-rounded ecological benefits at more affordable costs. The proportion of grasses in mixes can therefore be determined both by the ecological

requirements of a given site and with budgetary constraints in mind. It is important to note that whether the best option to meet a site's conservation goals is to lower or increase the proportion of grasses, price efficiencies should not be sought by decreasing the diversity of flowering species but by reducing their proportions within the mix. In other words, rather than having high proportions of a few inexpensive forbs, it is better to have lower proportions of more forb species. It is noteworthy that many seed mix producers and restoration specialists omit common milkweed from plantings because of its ability to colonize by rhizome and overtake sites. Because it is widespread in many areas of Ontario and Quebec, it is often expected to make its own ways into restored sites and created habitats.

Price of Milkweed

	Common Milkweed		
	Low	High	Median
Seed ($/kg)	$300	$1,040	$650
Plug	$0.75	$2.25	$1.00
	Swamp Milkweed		
	Low	High	Median
Seed ($/kg)	$600	$1,538	$1,200
Plug	$0.75	$2.25	$1.15
	Butterfly Milkweed		
	Low	High	Median
Seed ($/kg)	$600	$1,200	$1,157
Plug	$0.75	$2.25	$1.15

There are online tools available to help individuals and organizations estimate the costs of seed mixes. These online seed mix calculators allow inputting the prices of seed, seeding rates, site size, etc. to determine the cost of seed for a project:

- The Xerces Seed Mix Calculator (http://xerces.org/xerces-seed-mix-calculator/)

- Iowa Prairie Seed Calculator (http://www.jamess.com/IowaPrairieSeedCalculator-D2/)

Estimating the cost of restoration per hectare, which includes labour and machinery, is also challenging given the diversity of possible scenarios. Small sites (<1ha; <2ac) are often less expensive because they can be hand seeded and so there are no costs associated with bringing in specialized machinery and labour. Larger sites (>1ha; >2ac) that cannot be hand seeded are therefore more expensive and costs will vary not only in terms of acres, but also in days of labour and machinery required. Estimates gathered during this survey ranged from $2500/ha ($1000/ac) to $6000/ha ($2400/ac) for a small site.

Community engagement in monarch conservation projects can help reduce some costs associated with monarch habitat creation. Volunteers for planting and hand weeding can help not only decrease costs but also increase community engagement with monarch conservation projects. However, at a larger scale, integrating native vegetation into existing re-vegetation programs will be an effective way of reducing conservation costs. For example, supporting the development of native seed mixes for roadside re-vegetation makes use of an existing need for plant material and does not require retiring land from other uses.

2.3 Native plant industry supply development

Monarch conservation efforts in the U.S. have relied on an established network of over 300 government agencies, non-profits and native plant producers to support habitat creation efforts (see Nabhan et al., 2015). A concerted effort by the name of Seeds of Success has been in place since 2001 to develop a large supply of appropriate ecotypes for the whole of the continental U.S. Though it can take 10-20 years to develop a commercial crop from wild collected seed (Nabhan et al., 2015), collaboration between these multiple stakeholders has helped decrease that time frame in many instances. It is the multi-stakeholder collaboration that has underpinned the

development of native plant materials for conservation that has been a critical component of successful Monarch and pollinator conservation efforts. While the governance framework and the scale of habitat loss and restoration efforts are different in Canada, lessons from this collaboration are nevertheless applicable.

The single largest barrier currently is the limited supply of seed materials for large-scale restoration projects. This is especially true in Manitoba, where projects by organizations such as the Nature Conservancy of Canada are limited by a lack of seed from local ecotypes, and where large corporate clients re-vegetating roadways or infrastructure projects cannot find an adequate supply of materials. In Quebec, new legislation on riparian buffers on agricultural lands represents an opportunity to increase biodiversity and ecological functions in agro-ecosystems, but this opportunity will be impeded by a lack of affordable native plant materials.

Timeframe for development

To address the relatively limited supply and high costs of native plant materials, concerted efforts by stakeholders to identify needs to ecoregion and land use are needed. Because the development of a crop and the expansion of supply take several years, such concerted efforts would allow nurseries to plan their investments over years, diminishing risks and ensuring production meets demand. Nabhan et al. (2015) suggest 10-20 years as a window of time from the collection of wild seed to the production of a commercial crop, though nursery owners surveyed for this report suggested shorter timeframes. Most reported three years as the minimum amount of time needed for seed production of most native perennial forbs. However, only a relatively small amount of seed is likely to be produced within that time. To scale production up for large-scale restoration work or for commercially viable sized crops is likely to take over five years. Nursery owners consulted for this report were hesitant to suggest specific timeframes, given the uncertainty surrounding demand and ecotype requirements (i.e., where an ecotype is already in production, timeframes will be smaller than for those that need to be wild collected).

At this time, there is insufficient coordination between supply and demand to know what the needs and gaps might be. For example, it could be that a spatial prioritization of

habitat creation recommends a region for which there already exists a substantial source of ecotype-appropriate seeds, in which case there might be little lag time between the identification of potential habitat sites and their subsequent creation. Conversely, a spatial prioritization exercise could reveal a gap where habitat is needed but there are no or little available ecotype-appropriate seeds. In such a case, the lag time between the identification of potential sites and the development of seeds sourced from the wild would add a few years to the project.

Given the potential to integrate Monarch conservation into other habitat restoration projects, collaboration between nurseries and stakeholders with specific needs (agricultural land and ROW managers, for example) would facilitate the development of seed mixes and management practices that meet particular requirements. Drawing on lessons from the success of the development of the native plant industry in the U.S., it is clear that government agencies can play a crucial role in convening stakeholders, identifying needs and providing resources (financial and technical).

Recommendations:

- Support initiatives by Pollinator Partnership Canada, the Ontario Plant Restoration Alliance and other groups to convene native plant producers, industry stakeholders, conservationist and researchers together to identify needs and gaps in native plant production to support conservation projects.

- Identify funding and support multi-year contracts to nurseries to develop the supply of native plant materials for large-scale restoration projects on public and private lands.

3. ASSESSMENT OF CURRENT TECHNICAL RECOMMENDATIONS FOR THE USE OF MILKWEED AND NECTAR PLANTS FOR MONARCH CONSERVATION

Milkweed and nectar plant use in restoration projects

The size, location, general characteristics and land use type of a site will determine which methods are most appropriate for establishing milkweed and nectar plants for Monarch conservation. For example, a demonstration garden within a public park would usually include aesthetics into its design considerations, and in such a case denser concentrations of fewer species might be more appealing. Such a site would presumably have access to irrigation and regular maintenance. For these reasons, the use of plugs, though more expensive than seeds, would likely be more successful. In contrast, seeding is more cost-effective for large-scale naturalization projects (>2 acres), and the seeding methods will depend on the site conditions. Drill-seeding is usually the preferred option, though broadcasting is an option for smaller naturalization sites (>1 acre). On sloped or difficult to access sites, hydroseeding is recommended. In any restoration project, identifying historic vegetation, sourcing local ecotypes and making use of local expertise will help ensure success.

Recommendations for the management of Monarch and pollinator habitat will also vary with geographic location, size and land use type. There are general recommendations for a variety of scenarios, though there are gaps, in particular as regards the Canadian context. For example, a study examining the effects of mowing common milkweed on Monarch reproduction in upstate New York found that milkweed mowed in late July sustained up to ten times more eggs than controls or than those mowed in early July (plots mowed in mid-August proved too late for milkweed recovery) (Fischer et al. 2015); these results are in line with previous studies that have found that Monarchs prefer to lay their eggs on younger leaves. Determining the optimum time to mow milkweed to stimulate Monarch reproduction would require studies in a variety of locations and would have to consider annual climate and weather variations. In the absence of this knowledge, mowing recommendations are simply to limit mowing to once a year, depending on the management goals. Earlier spring mowing can help limit

weed growth; mid-summer mowing (presumably mid- to late-July) can help stimulate new milkweed growth but also poses a mortality risk to eggs and larvae.

General recommendations for establishment and maintenance are as follows:

- 50:50 grass to forb ratio.
- Use of native perennial species.
- Inclusion of local milkweed species.
- At least three flowering species in each season; spring, summer, and fall.
- Increased plant species diversity with larger site size.
- Reduction or elimination of herbicide and insecticide treatments.
- Mowing limited to once a year;
    - Early spring for weed management
    - Mid- to late-July (in most areas) to stimulate new milkweed growth for Monarch oviposition.
- One un-mowed patch at all times (rotate patch over time).

Milkweed production for seed

At this point, whether milkweed is a limiting factor in Canadian Monarch recovery efforts is unknown. Researchers and conservation biologists generally suggest the Canadian portions of the breeding range have not experienced a loss of milkweed of the same order as has occurred in the main breeding grounds in the U.S. Midwest. Concurrently, there is probably not the same need to dramatically increase the supply of milkweed for restoration. However, should it be needed, the knowledge and expertise to support such an endeavour exists in Canada. First, native plant producers already produce milkweed and given sufficient time, could increase seed production to meet that need. Secondly, there is an opportunity to engage agricultural producers if and where appropriate. In Quebec, Coopéative Monark is a farmer cooperative with over 100 hundred members

who produce milkweed for fibre through an exclusive contract for a textile manufacturer. This group has developed the methods and governance structure to produce milkweed on a large scale (over 3500 acres collectively), and they have collaborated with botanists to develop a model by which each farmer establishes their crop from local ecotypes, ensuring genetic diversity. This model could potentially be recreated in other areas and add an economic development dimension to Monarch conservation.

Detailed information of the development of milkweed crops for seed production is available in *Milkweeds - A Conservation Practitioner's Guide: Plant Ecology, Seed Production Methods and Habitat Restoration Opportunities* (2014), by Brianna Borders and Eric Lee-Mader (Xerces Society for Invertebrate Conservation).

4. AGGREGATED PLANT LIST FOR MONARCHS

Evidence supporting planting recommendations for the purpose of Monarch butterfly habitat is patchy. The source of planting recommendations is also unclear in many instances. The purpose of developing the plant list presented here was to create a vetted set of recommendations based, as much as possible, on published evidence of Monarch use. Our research and review of existing resources has indicated that there is limited promotion of planting lists for monarchs, even when the pollinator support and conservation programs of local NGOs are reviewed.

The following lists are an aggregation of available resources listing milkweed species (*Asclepias spp.*) by region and other native plants used by the Monarch butterfly (*Danaus plexippus*). The nectar plant list is meant to inform conservation efforts by providing vetted plant species based on the most current knowledge of Monarchs in Canada. These plant lists also exist as more detailed spreadsheets.

As a generalist species that migrates across large portions of continental North America, the Monarch makes use of a wide variety of habitats and plant species. Conservation efforts should therefore seek to increase habitat throughout its range. Nevertheless, despite being generalists, the Monarch has specific plant species preferences in addition to its association with its larval host, milkweeds (*Asclepias spp*). These lists should therefore be used in conjunction with local species lists so that any site includes a portion of locally appropriate species listed here, in addition to the ecologically relevant species in a given area. Indeed, this list is not a ‘recipe’ for a restoration mix but rather a resource to consult to ensure that monarch-specific species are included in the creation of functional habitat sites. To that end, the Monarch serves as a flagship species in conservation efforts that benefit multiple species and ecosystems.

Methods

The sources aggregated here were selected on the basis of geographic relevance and scientific credibility (quality of source). An extensive literature search and consultation

with Monarch experts identified no peer-reviewed publications addressing Monarch dietary preferences explicitly. Instead, references to plant species used by Monarchs are often incidental in published papers dealing with other research questions. The evidence for plant use therefore comes from a variety of sources, including unpublished data from scientific studies, field observations by both experts and citizen scientists, and pollinator syndromes (colour, structure, scent, and phenology). High quality 'grey literature', in particular the co-publication by The Xerces Society, Monarch Joint Venture, and National Wildlife Federation (US), is considered scientifically based, though the basis on which the recommendations are made is unknown. To account for the variety of methods used in identifying Monarch nectar sources, evidence was categorized in the following categories:

Pollinator syndromes: Predictors of plant-pollinator interactions based on floral anatomy, fragrance, and phenology.

Field Observations: Includes evidence from peer-reviewed journals, unpublished data from researchers and citizen science records.

Recommended for monarchs in grey literature: Though not peer-reviewed, recommendations come from trusted conservation practitioners and are likely based on field observations.

Recommended for pollinators generally: Though not monarch specific, these plant species are found on lists for the general public that include easy to grow and accessible/available native plant species.

Sources

List of milkweeds

White, D. J. (1996). Milkweeds of Canada: Status, Distribution, and Potential Impact from Noxious Weed Legislation. Canadian Wildlife Service

List of nectar and other plants

1. Pollinator Partnership, & USDA Forest Service. (2016). Conservation and Management of Monarch Butterflies: A Land Manager's Restoration Guide for the Eastern U.S. San Francisco; and other Pollinator Partnership pollinators guides for Canadian ecoregions (for grass species)

2. Monarch Joint Venture, National Wildlife Federation, & Xerces Society for Invertebrate Conservation. (2016). Monarch Nectar Plants: Great Lakes. Portland, OR.

3. MacPhail, V., & David Suzuki Foundation. (n.d.). Toronto Plant Guide for Attracting Pollinators.

4. Robson, Diana B. unpublished data from:

Robson, D. B. (2008a). Appendix. Plant-flower visitor matrix at Living Prairie Museum and Tall Grass Prairie Preserve, southern Manitoba. Botany, 86(11), electronic appendix.

Robson, D. B. (2008b). The structure of the flower–insect visitor system in tall-grass prairie. Botany, 86(11), 1266–1278. http://doi.org/10.1139/B08-083

5. Gibbs, D. (n.d.) Maryland native nectar plants for monarch butterflies. Monarch Joint Venture, personal communication.

6. Toronto Region Conservation Authority. (2009). Butterfly Gardens. Toronto.

7. Urquhart, F. A., & Urquhart, N. R. (1979). Breeding areas and overnight roosting locations in the northern range of the Monarch butterfly (*Danaus plexippus plexippus*) with a summary of associated migratory routes. The Canadian Field-Naturalist, 93(1), 41–47.

8. Hilty, J. Editor. 2017. Insect Visitors of Illinois Wildflowers. World Wide Web electronic publication. illinoiswildflowers.info, version (02/2017) http://www.illinoiswildflowers.info/flower_insects/insects//moths/danaus_plexippus.htm

Milkweeds of Canada
(*Asclepias spp*.)

LATIN NAME	COMMON NAME	BC	AB	SK	MB	ON	QC	NB	NS	PE	STATUS
A. syriaca	Common milkweed			Rare	Unc.	Com.	Unc.	Unc.	Unc.	Unc.	Primary host plant in Eastern Canada; most widespread and locally abundant, from southeast SK to PEI.
A. incarnata	Swamp milkweed				Unc.	Com.	Com.	Unc.	Unc.	Unc.	Fairly common, Southeast MB to PEI.
A. tuberosa	Butterfly milkweed					Unc.	Rare				Southern ON to southwest QC.
A. ovalifolia	Oval-leafed milkweed	Rare	Unc.	Unc.	Unc.	Rare					Western species, extreme northwestern ON to southern BC.
A. exaltata	Poke milkweed					Unc.	Rare				Rare, only southern ON.
A. hirtella	TallGreen milkweed					Rare					Rare, only southern ON.
A. lanuginosa	Woolly or side-cluster Milkweed				Rare						Rare, only southern MB.
A. purpurascens	Purple milkweed					Rare					Rare, only southern ON.
A. quadriflora	four-leafed milkweed					Rare					Rare, only southern ON.
A. speciosa	Showy milkweed	Unc.	Unc.	Unc.	Unc.						Primary monarch host plant in Western Canada; western species, from southern MB to southern BC.
A. sullivantii	Sullivant's Milkweed					Rare					Rare, only southern ON.
A. variegata	Variegated milkweed					Ex.					Rare, only southern ON.
A. verticillata	Whorled milkweed			Rare	Unc.	Rare					From southern ON to southern SK.
A. viridiflora	Green milkweed	Unc.	Rare	Unc.	Unc.	Rare					Primarily western species, southern ON to southern BC.
	total:	3	3	5	7	12	4	2	2	2	

key: Com. = common, Ex = extirpated, Unc. = uncommon. If a cell is empty, it indicates that species does not occur in that province. The status assessments are based on the most current floras and rare plant publication.

Adapted from White, D. J. (1996). *Milkweeds of Canada: Status, Distribution, and Potential Impact from Noxious Weed Legislation*. Canadian Wildlife Service

PLANT LIST FOR THE MONARCH BUTTERFLY

LATIN NAME	COMMON NAME	PROVINCE	BLOOM TIME	POLLINATOR SYNDROMES	FIELD OBSERVATIONS	RECOMMENDED FOR MONARCHS IN GREY LITERATURE	RECOMMENDED FOR BUTTERFLIES/ POLLINATORS GENERALLY	FOUND ON THESE LISTS
Forbs								
Northbound migration (late May-July)								
Allium canadense	wild garlic, meadow onion, meadow garlic	ON; QC; NB	May-Jul	1				1
Apocynum androsaemifolium	Spreading dogbane	BC; AB; SK: MB; ON; QC; NB; NS; PEI; NF; YK; NWT	Jun-Aug	1	5			1, 5
Apocynum cannabinum	Indianhemp	BC; AB; SK; MB; ON; QC; NB; NS; NF	Jun-Aug	1	5			1, 5
Caltha palustris	marsh marigold	BC; AB; SK; MB; ON; QC; NB; NS; PEI; NWT; Nunavut	Apr-Jun		5			5
Cirsium discolor	Field thistle	MB; ON; QC; NB	Jun-Sep	1	5, 8	2		1, 2, 8
Coreopsis lanceolata	Sand coreopsis, lance leaved coreopsis, lanceleaf coreopsis, lanceleaf tickseed	BC; ON	May-Jul	1				1
Coreopsis tripteris	tall coreopsis	ON; QC	Jul-Sep		8			
Echinacea pallida	pale purple coneflower	ON	Jun-Jul	1	8		6	1, 6, 8
Echinacea purpurea	eastern purple coneflower	ON; QC	Jun-Aug	1	5, 8	2		1, 2, 5, 8
Erigeron annuus	Daisy fleabane	AB; ON; QC; NB; NS; PEI	May-Oct				3	3
Erigeron philadelphicus	Philadelphia fleabane	BC; AB; SK; MB; ON; QC; NB; NS; PEI; NF; YK; NWT	Apr-Aug	1				1
Erigeron pulchellus	Poor robin's fleabane; robin's plantain	ON; QC	May-Jul				3	3
Erigeron strigosus	lesser daisy fleabane, rough fleabane, prairie fleabane	BC; AB; SK; MB; ON; QC; NB; NS; PEI	Apr-Aug				3	3
Heliopsis helianthoides	smooth oxeye	SK; MB: ON; QC	Jun-Sep			2		2
Lilium philadelphicum	wood lily, western red lily	BC; AB; SK; MB; ON; QC; NWT	Jun-Aug		8			8
Lobelia cardinalis	Cardinal flower	MB; ON; QC; NB	Jul-Sep	1				1
Mertensia virginica	Virginia bluebells	ON; QC	Apr-Jun		8			8
Packera aurea	Golden ragwort	MB; ON; QC; NB; NS; PEI; NF	May-Aug	1	5			1, 5
Penstemon digitalis	white beardtongue, foxglove beardtongue	ON; found but not native in QC; NB; NS	May-Jul	1				1
Phlox Divaritica	Wild blue phlox	ON; QC	Apr-Jun		5, 8			5, 8
Pycnanthemum virginianum	common mountain mint, Virginia mountain mint	ON; QC; NB	Jul-Sep	1				1
Rhums aromatic	Fragrant sumac, lemon sumac	MB; ON; QC	Apr-Jun	1			3	1, 3
Rhus copallina	Shining sumac	ON	Jul-Aug				3	3
Rhus glabra	Smooth sumac	BC; AB; SK; MB; ON; QC; NB; NS; PEI	Jun-Jul				3	3

Rhus typhina	Staghorn sumac, velvet sumac	ON; QC; NB; NS; PEI	Jun-Jul				3	3
Rudbeckia hirta	blackeyed Susan, hairy coneflower	BC; AB; SK; MB; ON; QC; NB; NS; PEI; NF	Jun-Oct	1		2		1, 2
Vaccinium corymbosum	highbush blueberry	ON; QC; NB; NS	May-Jun	1				1
Viola sororira	common blue violet	SK; ON; QC	May-Jun		8			8
Viburnum acerifolium	mapleleaved viburnum	ON; QC; NB	May-Jul	1				1
Zizia aurea	golden alexander, golden zizia, common alexanders	MB; ON; QC; NB; NS	Apr-Jun	1				1

Southbound migration (August-October)								
Agastache nepetoides	yellow giant hyssop	ON; QC	Jul-Sep	1	8			1, 8
Anaphalis margaritacea	pearly everlasting	BC; AB; SK; MB;ON; QC; NB; NS; PEI; NF; YK; NWT	Jul-Sep				6	6
Bidens cernua	nodding beggartick	BC; AB; MB; ON; QC; NB; NS; PEI; YK; NWT	Aug-Oct		8			8
Chelone glabra	turtlehead	MB; ON; QC; NB; NS; PEI; NF	Jul-Sep				6	6
Cirsium discolor	Field thistle	MB; ON; QC; NB	Jun-Sep	1	5, 8			1, 5, 8
Eupatorium fistulosum	hollow Joe Pye weed	ON; QC	Jul-Sep		5		6	5, 6
Eupatorium maculatum	Spotted joe pye weed	BC; AB; SK; MB;ON; QC; NB; NS; PEI; NF	Jul-Sep			2	6	2, 6
Eupatorium perfoliatum	boneset, common boneset	MB; ON; QC; NB; NS; PEI	Jul-Oct	1	5, 8	2		1, 2, 5, 8
Eupatorium purpureum	sweet Joe Pye weed, purple boneset, sweet scented Joe Pye weed	ON	Jul-Sep	1	8		6	1, 6,8
Eurybia macrophylla	bigleaved aster, largeleaf wood aster	MB; ON; QC; NB; NS; PEI	Aug-Nov	1				1
Euthamia graminifolia	flat top fragrant goldenrod	BC; AB; SK; MB;ON; QC; NB; NS; PEI; NF; NWT	Jul-Oct		8			8
Helenium autumnale	common sneezeweed	BC; AB; SK; MB; ON; QC; NWT	Aug-Oct	1	5			1, 5
Helianthus annuus	common sunflower	AB; SK; MB; NWT	Jul-Oct	1	8			1
Helianthus divariticus	woodland sunflower	ON; QC	Jul-Sep		5			5
Helianthus tuberosus	Jerusalem artichoke	SK; ON	Aug-Sep		5			5
Liatris aspera	Rough blazing star, Tall greyfeather, tall blazing star,	ON	Aug-Oct	1	8	2	6	1, 2, 6, 8
Liatris cylindracea	Ontario greyfeather, cylindric blazing star	ON	Aug			2	6	2, 6
Liatris ligulistyls	Meadow blazingstar	AB; SK; MB	Jul-Aug		4		6	4, 6
Liatris punctata	dotted blazing star	AB; SK; MB	Aug-Oct			2	6	2, 6
Liatris spicata	dense blazing star	ON; QC (non-native to QC)	Jul-Nov	1	5, 8	2	6	1, 2, 5, 6, 8
Lobelia cardinalis	Cardinal flower	MB; ON; QC; NB	Jul-Sep	1				1

Lobelia siphilitica	great blue lobelia	MB; ON	Aug-Sep		8			8
Monarda fistulosa	wild bergamot, monarda, bee balm	BC; AB; SK; MB; ON; QC; NB; NWT	Jun-Aug	1	5, 8		6	1, 5, 6, 8
Monarda punctata	horsemint, spotted bee balm	ON	Jul-Oct		5			5
Physostegia virginiana	obedient plan, false dragonhead	SK; ON; QC; NB	Jun-Sep		8			8
Pycnanthemum virginianum	common mountain mint, Virginia mountain mint	ON; QC; NB	Jul-Sep	1				1
Oligoneuron rigidum (formerly Solidago rigida)	stiff goldenrod	SK; MB; ON	Aug-Oct		5, 8		6	5, 6, 8
Rudbeckia hirta	blackeyed Susan, hairy coneflower	BC; AB; SK; MB; ON; QC; NB; NS; PEI; NF	Jun-Oct	1			6	1, 6
Silphium laciniatum	compass plant	ON	Jul-Sep		8			8
Silphium terebinthinaceum	prairie dock	ON	Jul-Aug		8			8
Solidago caesia	bluestem goldenrod	ON; QC; NB	Aug-Oct		5		6	5, 6
Solidago canadensis	Canada goldenrod	BC; AB; SK; MB; ON; QC; NB; NS; PEI; NF; NWT	Jul-Oct	1	5, 7, 8		6	1, 5, 6, 7, 8
Solidago nemoralis	grey goldenrod	BC; AB; SK; MB; ON; QC; NB; NS; PEI	Aug-Oct	1	8		6	1, 6, 8
Symphyotrichum ericoides	heath aster	BC; AB; SK; MB; ON; QC; NWT	Aug-Oct		5		6	5, 6
Symphyotrichum cordifolium	heartleaf aster	MB; ON; QC; NB; NS; PEI	Aug-Oct		5		6	5, 6
Symphyotrichum laeve	smooth blue aster, smooth aster	BC; AB; SK; MB; ON; QC; NB; NS; NF; YK	Aug-Nov	1	5, 8		6	1, 5, 6, 8
Symphyotrichum laterifoloium	white woodland aster, calico aster	MB; ON; QC; NB; NS; PEI; NF	Aug-Oct		5		6	5, 6
Symphyotrichum novae angliae	New England Aster	SK; MB; ON; QC; NB; NS	Aug-Oct	1	5, 7, 8	2	6	1, 2, 5, 6, 7, 8
Symphyotrichum puniceum	swamp aster	BC; AB; SK; MB; ON; QC; NB; NS; PEI; NF; NWT	Aug-Sep		5, 8		6	5, 6
Verbana hastata	blue vervain	BC; AB; SK; MB; ON; QC; NB; NS	Jun-Sep	1	5		6	1, 5, 6
Vernonia fasciculata	prairie ironweed	SK; MB; ON	Jul-Sep		8			8
Vernonia noveboracensis	New York ironweed	ON	Aug-Oct		5			5
Veronicastrum virginicum	Culver's root	MB; ON	Jul-Sep	1		2		1, 2

Trees/Shrubs								
Acer spp. (rubrum, saccharum, negundo)*	maples				7			7
Betula spp	birches						6	6
Ceanothus americanus	New Jersey tea	ON; QC	May-Jun				6	6
Cephalanthus occidentalis	buttonbush	ON; QC; NB; NS	Jul-Sep		5, 8			5, 8
Cornus spp	dogwood						6	6

Crataegus crus galli	cockspur hawthorn	ON; QC; NS	May-Jun		8			8
Lindera benzoin	northern spicebush	ON	Mar-Apr				6	6
*Picea spp.**	spruces				7			7
*Pinus spp.**	pines				7			7
Populus tremuloides	trembling aspen	BC; AB; SK; MB; ON; QC; NB; NS; PEI; NF; YK; NWT; NU	Mar-Apr				6	6
Prunus americana	American plum	SK; MB; ON; QC	Apr-Jun		8			8
Prunus serotina	wild black cherry, chokecherry	ON; QC; NB; NS	May-Jun		8			8
Salix spp.	willows				7			7
Symphoricarpos albus	common snowberry	BC; AB; SK; MB ;ON; QC; NB; NS; PEI; NF; NWT	May-Jul		8			8
Symphoricarpos occidentalis	wolfberry, western snowberry, buckbrush	BC; AB; SK; MB; ON; QC; NWT	Jul-Jul		8			8

** denotes species recorded for roosting/staging use (either exclusively, or in addition to nectar source, such as Salix spp.).*

Vines								
Clematis virginiana	virgin's bower	MB; ON; QC; NB; NS; PEI	Jul-Oct		5			5

Grasses								
Andropogon gerardii	big bluestem	SK; MB; ON; QC	Jul-Sep				6	6
Bouteloua gracilis	blue grama grass	BC; AB; SK; MB; ON	Jul-Sep				6	6
Sorghastrum nutans	indiangrass	SK; MB; ON; QC	Aug-Sep				1	1
Bromus kalmii	arctic brome	MB; ON; QC	Jun-Aug				1	1
Schizachyrium scoparium	little bluestem	BC; AB; SK; MB; ON; NB; NS	Aug-Oct				1	1
Panicum virgatum	switchgrass	SK; MB; ON; QC; NS	Jul-Sep				1	1
Carex stricta	upright sedge	MB; ON; QC; NB; NS; PEI	May-Jun				1	1
Scirpus cyperinus	woolgrass	BC; AB; SK; MB; ON; QC; NB; NS; PEI; NF	Jul-Sep				1	1

Sources

1. Pollinator Partnership, & USDA Forest Service. (2016). Conservation and Management of Monarch Butterflies: A Land Manager's Restoration Guide for the Eastern U.S. San Francisco; and other Pollinator Partnership pollinators guides for Canadian ecoregions (for grass species)

2. Monarch Joint Venture, National Wildlife Federation, & Xerces Society for Invertebrate Conservation. (2016). Monarch Nectar Plants: Great Lakes. Portland, OR.

3. MacPhail, V., & David Suzuki Foundation. (n.d.). Toronto Plant Guide for Attracting Pollinators.
4. Robson, Diana B. unpublished data from:
Robson, D. B. (2008a). Appendix. Plant-flower visitor matrix at Living Prairie Museum and Tall Grass Prairie Preserve, southern Manitoba. Botany, 86(11), electronic appendix.
Robson, D. B. (2008b). The structure of the flower–insect visitor system in tall-grass prairie. Botany, 86(11), 1266–1278. http://doi.org/10.1139/B08-083

5. Gibbs, D. (n.d.) Maryland native nectar plants for monarch butterflies. Monarch Joint Venture, personal communication.

6. Toronto Region Conservation Authority. (2009). Butterfly Gardens. Toronto

7. Urquhart, F. A., & Urquhart, N. R. (1979). Breeding areas and overnight roosting locations in the northern range of the Monarch butterfly (Danaus plexippus plexippus) with a summary of associated migratory routes. The Canadian Field-Naturalist, 93(1), 41–47.

8. Hilty, J. Editor. 2017. Insect Visitors of Illinois Wildflowers. World Wide Web electronic publication. illinoiswildflowers.info, version (02/2017)
http://www.illinoiswildflowers.info/flower_insects/insects//moths/danaus_plexippus.htm

5. BIBLIOGRAPHY

Borders, B., and E. Lee-Mader. 2014. Milkweeds - A Conservation Practitioner's Guide: Plant Ecology, Seed Production Methods and Habitat Restoration Opportunities. Xerces Society for Invertebrate Conservation, Portland, OR.

COSEWIC. 2010. COSEWIC Assessment and Status Report on the Monarch (Danaus plexippus) in Canada. Page Assessment. Committe on the Status of Endangered Wildlife in Canada, Ottawa.

Crolla, J. P., and J. P. Lafontaine. 1996. Status Report on the Monarch Butterfly (Danaus plexippus) in Canada. Ottawa.

Environment and Climate Change Canada. 2016. Management Plan for the Monarch (Danaus plexippus) in Canada Monarch. Environment and Climate Change Canada, Ottawa.

Fischer, S. J., E. H. Williams, L. P. Brower, and P. A. Palmiotto. 2015. Enhancing Monarch Butterfly Reproduction by Mowing Fields of Common Milkweed. The American Midland Naturalist 173:229–240.

Flockhart, D. T. T., J.-B. Pichancourt, D. R. Norris, and T. G. Martin. 2014. Unravelling the annual cycle in a migratory animal□: breeding-season habitat loss drives population declines of monarch butterflies.

Flockhart, T., L. P. Brower, I. Ramirez, K. A. Hobson, L. Wassenaar, S. Altizer, and R. Norris. 2017. Regional climate on the breeding grounds predicts variation in the natal origin of monarch butterflies overwintering in Mexico over 38 years. Global Change Biology:1–12.

Hilty, J. Editor. 2017. Insect Visitors of Illinois Wildflowers. World Wide Web electronic publication. illinoiswildflowers.info, version (02/2017) http://www.illinoiswildflowers.info/flower_insects/insects//moths/danaus_plexippus.htm

Huron County. 2013. Huron County Agriculture Fact Sheet 2013.

MacPhail, V., & David Suzuki Foundation. (n.d.). Toronto Plant Guide for Attracting Pollinators.

Monarch Joint Venture, National Wildlife Federation, & Xerces Society for Invertebrate Conservation. (2016). Monarch Nectar Plants: Great Lakes. Portland, OR.

Nabhan, G., C. Taylor, B. Harper-Lore, L. L. Jackson, E. Mader, M. Fishbein, S. Jepson, L. Lopez HOffman, and J. Anderson. 2014. State of Milkweed Seedstock Availability for Monarch Habitat Restoration State of Milkweed Seedstock Availability for Monarch Habitat Restoration. http://makewayformonarchs.org/i/archives/1106.

Nabhan, P., I. Warren, and C. Taylor. 2015. Monarch Recovery from a Milkweed' s Point of View: Milkweed Seed Supply Chains for Monarch Habitat Restoration.

Oberhauser, K., R. Wiederholt, J. E. Diffendorfer, D. Semmens, L. Ries, W. E. Thogmartin, L. Lopez-Hoffman, and B. Semmens. 2016. A trans-national monarch butterfly population model and implications for regional conservation priorities. Ecological Entomology:1–10.

Pleasants, J. M., and K. S. Oberhauser. 2013. Milkweed loss in agricultural fields because of herbicide use: effect on the monarch butterfly population. Insect Conservation and Diversity 6.

Pollinator Partnership, and USDA Forest Service. 2016. Conservation and Management of Monarch Butterflies: A Land Manager's Restoration Guide for the Eastern U.S. San Francisco.

Robson, D. B. (2008a). Appendix. Plant-flower visitor matrix at Living Prairie Museum and Tall Grass Prairie Preserve, southern Manitoba. Botany, 86(11), electronic appendix.

Robson, D. B. (2008b). The structure of the flower–insect visitor system in tall-grass prairie. Botany, 86(11), 1266–1278. http://doi.org/10.1139/B08-083

Statistics Canada. 2014. Agriculture in Canada. Page The Daily. Ottawa.

Toronto Region Conservation Authority. (2009). Butterfly Gardens. Toronto.

Urquhart, F. A., & Urquhart, N. R. (1979). Breeding areas and overnight roosting locations in the northern range of the Monarch butterfly (Danaus plexippus

plexippus) with a summary of associated migratory routes. The Canadian Field-Naturalist, 93(1), 41–47.

White, D. J. 1996. Milkweeds of Canada: Status, Distribution, and Potential Impact from Noxious Weed Legislation.

Wojcik, V. a, and S. Buchmann. 2012. Pollinator Conservation And Management On Electrical Transmission And Roadside Rights - Of - Way: A Review. Journal of Polination Ecology 7:16–26.

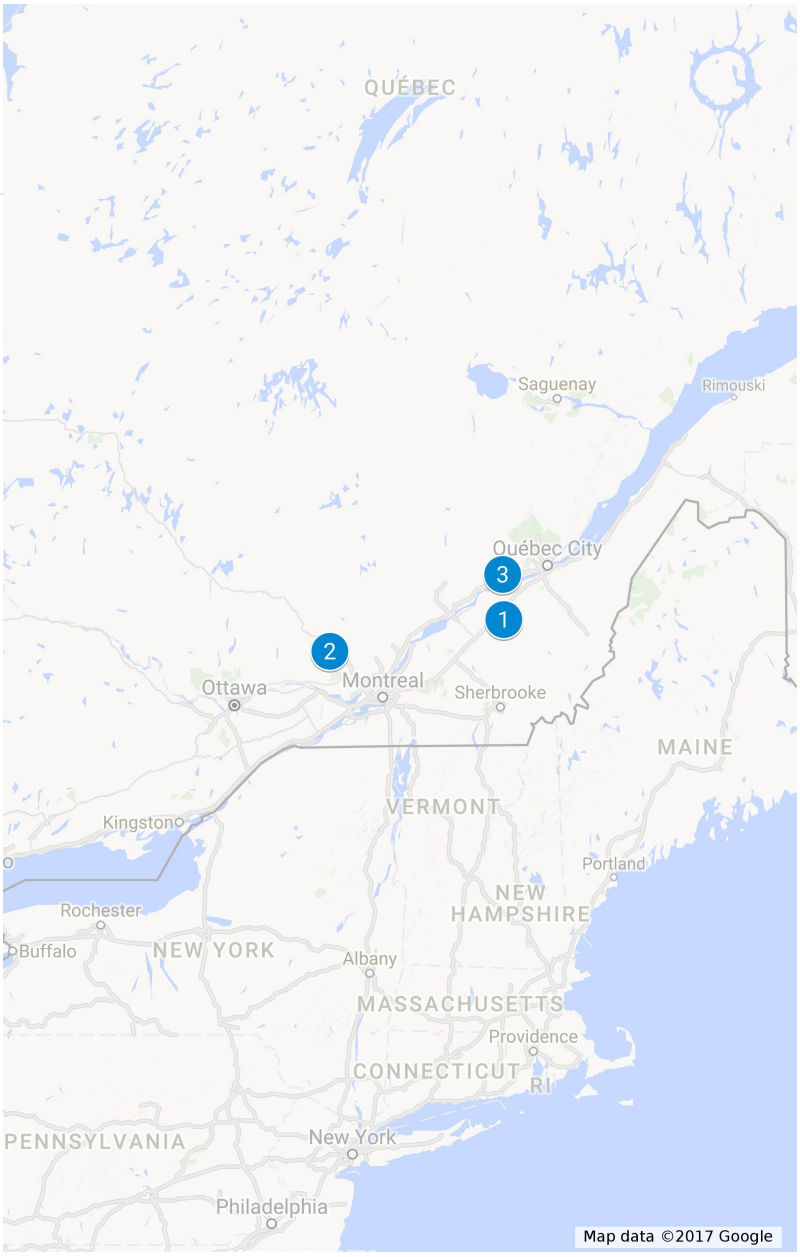
Ontario Native Plant Nurseries

Native plant nurseries in Ontario that produce forbs (seeds or plant)

Quebec Native Plant Nurseries

Quebec Native Plant Nurseries

1. Aiglon Indigo
2. Pépinière Rustique
3. Pépinière Rhizome



Manitoba Native Plant Nurseries

Manitoba Native Plant Nurseries

1. Prairie Habitats Inc.
2. Prairie Originals
3. Prairie Flora