Saskatchewan
Prairie Conservation
Action Plan

Guide to Managing for Optimal Habitat Attributes:

Monarch Butterfly (*Danaus plexippus*)

May, 2020

ACKNOWLEDGEMENTS

This guide was developed by Sue Michalsky, Ashley Cole-Wick and Heather Peat Hamm with technical and editorial input from Rodrigo Solis Sosa, Marian MacNair, Andre-Philippe Drapeau-Picard and Alessandro Dieni.

The project was financially supported by the Department of the Environment of the Government of Canada (Environment and Climate Change Canada), through the Canada Nature Fund granted to the Saskatchewan Prairie Conservation Action Plan (PCAP). Ce projet a été réalisé avec l'appui financier du gouvernement du Canada agissant par l'entremise du ministère fédéral de l'Environnement (Environnement et Changement climatique Canada).

Thank you to all the PCAP Partners and other organizations who provided support into this project: Environment and Climate Change Canada, Mission Monarch, Native Plant Society of Saskatchewan, Paskwa Consultants Inc., Parks Canada – Grasslands National Park, Ranchers Stewardship Alliance Inc., and University of Regina.

Many sources of information were used in compiling this document including expert opinions and both published and unpublished literature. Literature used in compiling this review is provided in the References section.

May, 2020

This project was undertaken with the financial support of the Government of Canada.
Ce projet a été réalisé avec l'appui financier du gouvernement du Canada

ABOUT THIS GUIDE

A NEW APPROACH TO MANAGING FOR SPECIES AT RISK

The intent of this guide is to determine site and landscape-scale habitat features that are optimal for species at risk at different life stages, as well as important non-habitat related beneficial management practices. As habitat for species at risk declines and threats to populations increase in jurisdictions outside Canada, it becomes critical to provide optimal conditions on what remains in Canada if we are to conserve or recover a species.

This First Approximation of the guide for Monarch Butterfly should be considered a living or dynamic document that will continually evolve. As our knowledge of prairie species at risk improves with research and monitoring, this guide will need to be periodically revisited and updated.

WHO SHOULD USE THIS GUIDE?

Most species at risk in Saskatchewan exist on working agricultural lands that often support grazing livestock and sometimes support annual or perennial crops. Some occur in forested areas that are managed for industrial forest products or local use of trees for poles, posts or firewood. This guide provides habitat targets and non-habitat related beneficial management practices (BMPs) for land managers who may have the opportunity to aid in the conservation of species at risk on the land under their control. Additionally, the habitat targets and BMPs may be used by conservation organizations in designing results-based agreements with land managers.

The Environmental Benefit Index is designed to be used by any stakeholder to prioritize sites and/or projects for conservation and recovery programs, or by land managers to evaluate the value of their property for a particular species.

HOW TO USE THIS GUIDE

This guide is presented in two parts. The first part summarizes the important spatial and temporal needs of the species and presents habitat targets and non-habitat related BMPs. Habitat targets for this species are presented at the site scale and categorized by the type of habitat required at different life stages. Site scale targets are those attributes that individuals prefer at a certain time (e.g., breeding, foraging, staging or migrating) or in a certain portion of their home range. Site habitat targets are most commonly physical vegetation, water, soil and/or topography parameters, but may also include such attributes as configuration of land cover or habitats, presence/absence of human infrastructure, among others. The rationale for each target or BMP is also provided so land managers can readily understand the relationship between the target and use of habitat by the species.

Guides have been prepared for individual species. Habitat targets for individual species give the land manager the choice of species they wish to benefit. Managing for a single species may result in habitat that is undesirable for another species. Conflicts between species are addressed in the

Environmental Benefit Index.

The second part of the guide presents an index (Environmental Benefit Index) that places values on the habitat targets and BMPs in combination with other considerations. An Environmental Benefit Index (EBI) is a compound index that considers multiple environmental factors when determining an ecological outcome. EBIs can be used to evaluate and prioritize opportunities for conservation programs. An EBI is of considerable importance in determining priority sites to invest in, particularly when funds are limited.

The overall goal of the EBIs for species at risk habitat is to ensure maximum environmental value for an investment in results-based conservation programming. The EBI has several potential uses including:

- Geographically targeting the most important locations;
- Evaluating and ranking candidate properties or projects for their environmental benefit;
- Ranking the environmental benefit of candidate properties or projects by cost (or bid); and
- Evaluating projects, or the efficiency of the investment, over time to determine if environmental values are being improved or maintained.

EBIs were identified as a method to target programming and prioritize participation in the design of the Prairie Beef & Biodiversity program (Commission for Environmental Cooperation, 2013). EBIs were subsequently developed for the Greater Sage-Grouse (Ranchers Stewardship Alliance Inc., 2014), Piping Plover (PCAP SK, 2017), Burrowing Owl (PCAP SK, unpublished), Northern Leopard Frog (PCAP SK, 2018a), Loggerhead Shrike (PCAP SK, 2018b), Baird's Sparrow (PCAP SK, 2019a) and Chestnut-collared Longspur (PCAP SK, 2019b).

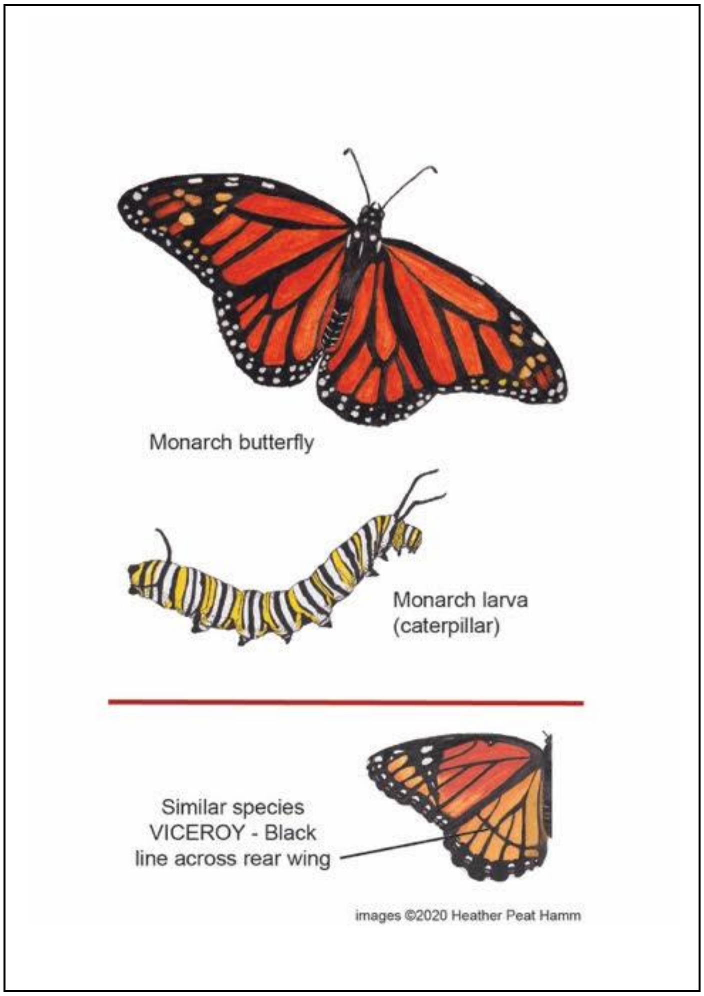
MONARCH IDENTIFICATION AND LIFE CYCLE

COSEWIC status: Endangered

S-Rank for Saskatchewan: S2B (Imperiled/Very Rare)

Adult

The Monarch (*Danaus plexippus*) adult is a large, showy butterfly with a wingspan of 7-11 cm. The wings are deep orange with black borders and veins, and white spots along the edges. The orange fades to a sandy yellow as the adult ages. The underside of the wings is paler orange, so that the butterfly is more cryptic when the wings are folded. Male and female Monarchs can be differentiated by a black spot at the center of the hindwing, which is only present in males. The body is black with white markings.



Similar species

The Viceroy butterfly is often mistaken for a Monarch. The main visual difference between the two species is the black line that crosses perpendicularly through the black bands on the Viceroy's hindwings. The black lines in a Monarch's hindwing have no perpendicular crossing line.

Egg

Female Monarchs nearly always lay their eggs directly on milkweed (*Asclepias sp.*) host plants. Wild Monarchs lay approximately 300 - 500 eggs over a 2 to 5 week period (Fischer *et al*. 2015). They seldom deposit more than 2 eggs on an individual plant (NRCS 2018). The eggs are most often laid on the underside of leaves, but can also be laid on the top of leaves, on flowers and on stems. Eggs are attached to the host plant with a small amount of glue-like substance that the female secretes as she is laying. The eggs are pale yellow-to-clear in color and are approximately 1mm in width, characterized by longitudinal ridges that run from the tip to the base, with a bluntly pointed apex. Just before hatching, the caterpillar's head can be seen as a black dot visible through the skin of the egg. Eggs take approximately four to ten days to hatch depending on weather.

Larvae

Caterpillars are the larval stages of moths and butterflies, both members of the order Lepidoptera. A newly hatched Monarch caterpillar is 2-6mm in length and will feed on its nutrient-rich egg casing before beginning to forage on its milkweed host plant. The caterpillars have a head, thorax, and abdomen, with six pairs of simple eyes (ocelli). Fleshy tentacles on the head and tail end of the caterpillar are not true antennae, but these sense organs function similarly by helping guide the caterpillar as it moves, since its vision is poor. The larval stage of the Monarch's life lasts 9 - 14 days, and encompasses 5 instars, also known as molts. By the time the caterpillar reaches its fifth instar, it may be as long as 5cm. Monarch caterpillars have white, yellow, and black bands; making it easily distinguishable from other caterpillars in Saskatchewan.

Pupa

Once a Monarch caterpillar has finished eating in its fifth instar, it pupates, forming a chrysalis in which it transforms into an adult butterfly. Monarch caterpillars usually will not pupate on their host plant, but instead move up to 10 metres to an adjacent plant or other structure. The pupa is green and gold, about 2.5cm long and 10-12mm wide, and weighs about 1.2 grams. The adult wing pattern becomes visible through the covering when the butterfly is nearing the end of pupation, which lasts 8-15 days, depending on ambient temperatures.

Lifespan

Several generations of Monarchs occur through spring, summer and fall. Summer generation adults may live up to 30 days, however many only live a few days due to myriad of natural and anthropogenic risks. Development from egg to adult averages 30 days but can vary from 20-45 days. Fall migratory butterflies, which begin their journey in reproductive diapause, may live 6-9 months. Their metabolism slows down allowing them to overwinter and reproduce the following spring.

Monarchs are believed to have two populations in North America. Monarchs in Saskatchewan are part of the Eastern Population (Figure 1). Note that individuals may occur outside the primary breeding range.

The Monarch's Canadian range of occurrence includes portions of all ten provinces as well as the Northwest Territories. The North American migratory Monarch population is divided by the Rocky Mountains into an Eastern and Western Population (Figure 1). Monarchs that migrate to Saskatchewan in the summer are considered part of the Eastern Population. The breeding range in Saskatchewan, Alberta and Manitoba, extends to approximately 50 degrees north latitude. Monarchs documented north of 50^{o} are often considered vagrant.

Figure 2 shows predicted habitat suitability for the Monarch within Saskatchewan.

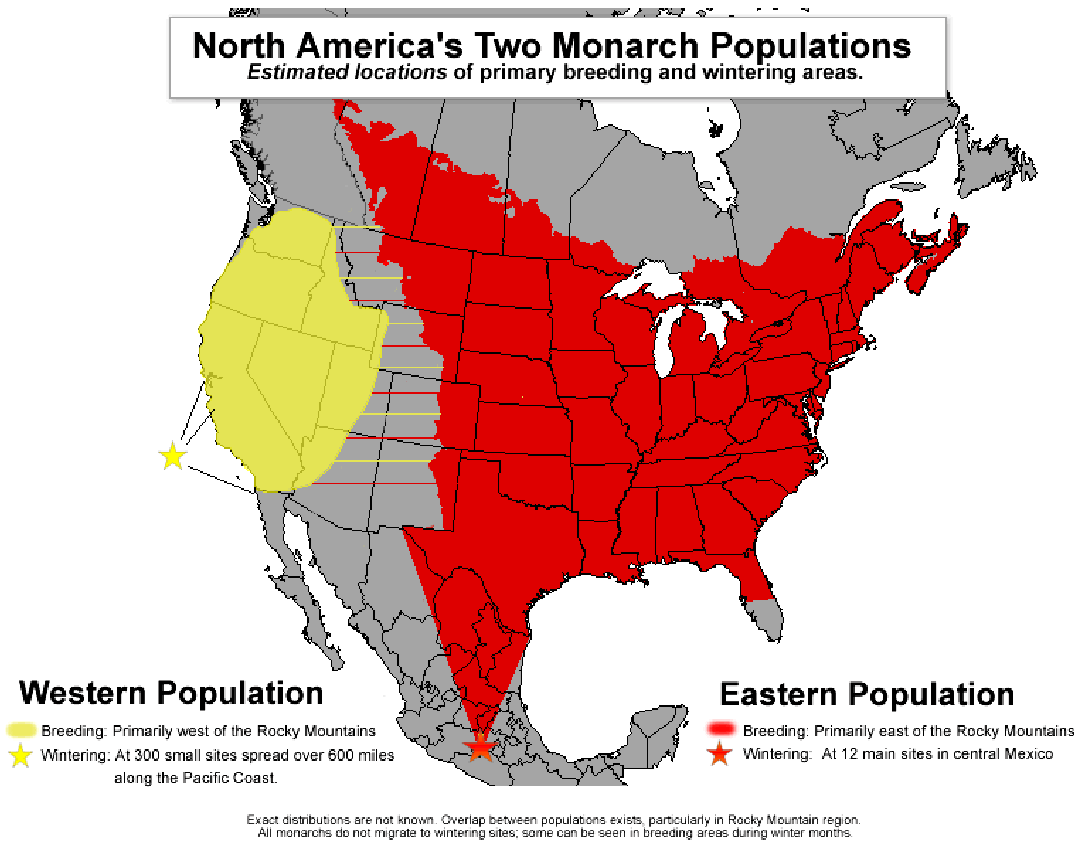


Figure 1. Breeding and Wintering Range of the Monarch Butterfly in North America (from www.journeynorth.org).

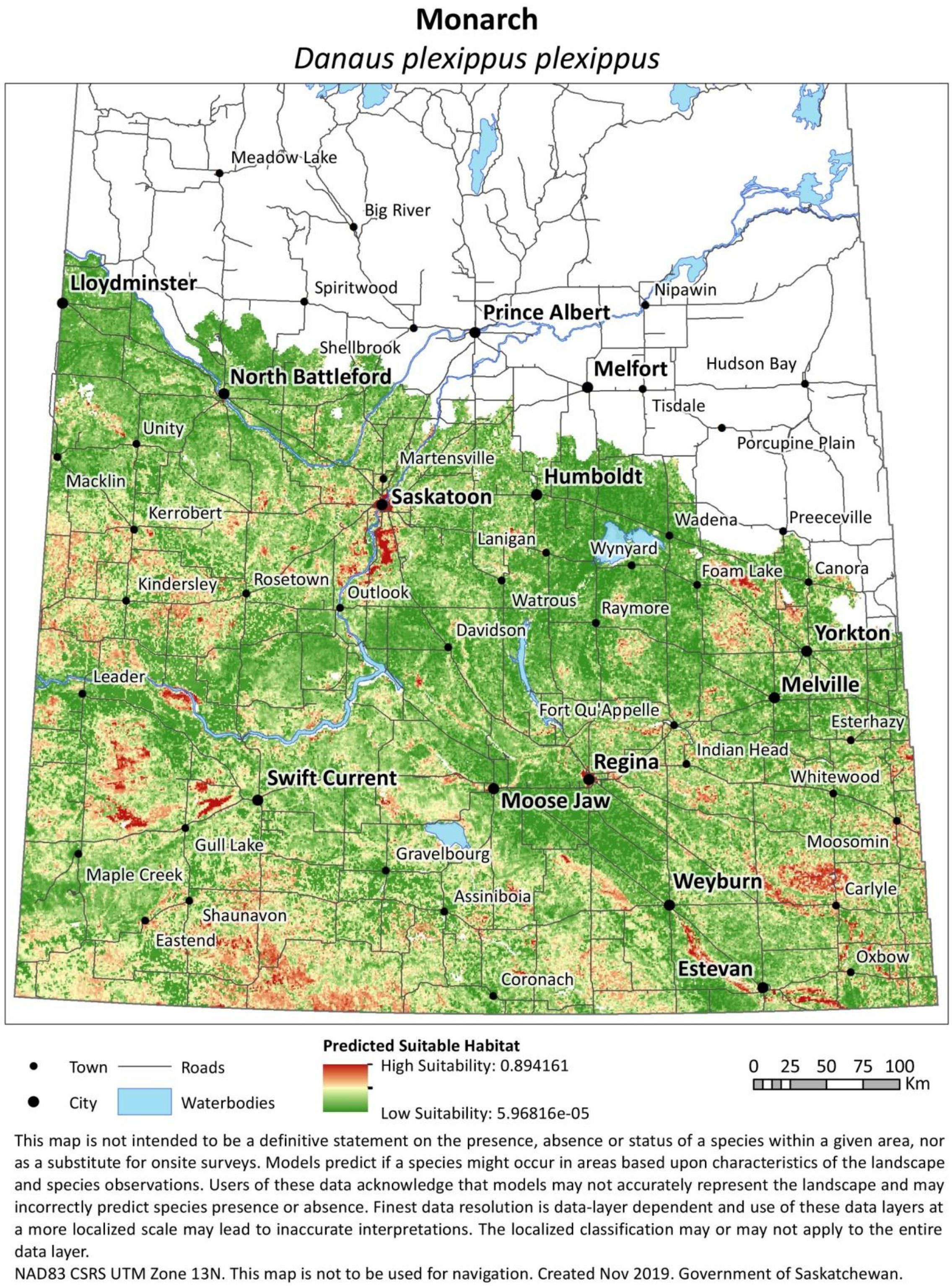


Figure 2. Habitat suitability map of Monarch Butterfly in Saskatchewan (Saskatchewan Conservation Data Centre, 2019).

THREATS

Historically, the loss of mature Oyamel fir forests in the overwintering habitat in Mexico was thought to be the most significant factor influencing Monarch populations. While this is still a threat to Monarchs, hazards along the migration route between breeding and overwintering sites, and habitat loss in nectaring and breeding areas are now also thought to be significant.

HABITAT LOSS

In North America, Monarchs lay most of their eggs on common or showy milkweed; the former is considered an agricultural weed in much of North America. Across their range, the Eastern Monarch population is threatened by loss of milkweed resulting from conversion of natural vegetation to agricultural lands, as well as extensive herbicide use on croplands. With the introduction of herbicide-resistant corn and soybeans in 1996, many agricultural lands have now become uninhabitable areas for Monarchs, as milkweed plants cannot survive broad-spectrum herbicide application. One study estimated that from 1999-2014, 850 million milkweed stems were lost in the United States' Midwest due to herbicide use in corn and soybean fields.

Monarchs may have historically used primarily the Great Plains of North America for summering and wintering habitat and subsequently changed their habitat and migration route to correspond with increased milkweed availability on cropland in the Midwest US (COSEWIC 2016; Brower 1995). Native prairie is still an important part of both breeding and migrating habitat for Monarchs, and may become more important if they re-establish their historic migration routes.

Herbicide-resistant crop use in Canada has increased substantially in recent decades. Herbicide-resistant canola was first used in 1997, followed by soybeans, corn, and wheat. By 2005, about 95% of canola, and 60% of soybean crop area in Canada were glyphosate-resistant plants. This increased herbicide use not only negatively impacts milkweed populations, but also other wildflower species used by Monarchs for nectaring.

An increasingly larger proportion of Monarchs are relying on host and nectar producing plants found in fragmented grassland habitat present in ditches, pastures, transportation rights-of-way, and urban parks.

Cutting and Tallamy (2015) found that Monarchs laid eggs at a higher density in gardens with high milkweed density than in natural sites, with 2.0 and 6.2 times more eggs per plant per observation in 2009 and 2010, respectively. However, higher density of eggs per stem has also been noted to increase instances of predation (NRCS 2018, see Breeding Habitat Characteristics for more discussion).

Dog-strangling vine (*Vincetoxicum rossicum*), an introduced invasive plant, has not been recorded in Saskatchewan, but is infesting milkweed habitat in Ontario. Female monarchs will oviposit on dog-strangling vine, but prefer to oviposit on milkweed (Matilla and Otis 2003). Larvae on dog-strangling vine do not appear to develop beyond the first instar, indicating that this species is a poor host plant and possibly a sink.

MOWING AND BURNING

Mowing and burning can result in high rates of direct mortality for Monarch eggs and larvae. Across Canada, large areas of perennial grasslands are mowed for agricultural, safety, and aesthetic reasons. Understanding when Monarch eggs and caterpillars are using milkweed plants is critical to the timing of mowing.

Some research has shown that well-timed mowing of milkweed may benefit Monarchs. Often, uncut milkweed leaves will already be yellowing and dying back in late July, before the final generation of Monarchs begin feeding as caterpillars. In upstate New York, areas mowed in early July reached the same height as the non-mowed areas by mid-September. Milkweeds cut in late July also regrew, but their growth was delayed, and they only reached half their pre-mown height by late September. Other studies have found that plants cut in midsummer had more eggs laid at the top of the plant than did uncut plants. Milkweeds in mowed strips provided younger, non-senescent leaves and therefore August egg-laying density was higher on mowed milkweed. Several studies have noted a preference of Monarch females for younger leaves. Loss of larval Monarchs due to early-season mowing was compensated by increased oviposition, densities of eggs, and caterpillar abundance after mowing. Predators were strongly suppressed by mowing treatments, with adult Monarchs recolonizing milkweeds 2-4 weeks after disturbance, followed by increased abundance of caterpillars on flowering stems.

There may be a short window in Saskatchewan in late June or early July (Oberhauser 2017*b*) when mowing or burning of grasslands can occur while leaving enough time for milkweed re-growth at a biomass required to support Monarch reproduction. However, without further research the risk associated with this window is high.

PREDATION & NATURAL DISEASE

Predation is a natural occurrence for Monarchs. Ants, wasps, mantids, spiders, stinkbugs such as the invasive Brown Marmorated Stink Bug, and even other Monarch caterpillars can be predators. To reduce predation, habitats should be as heterogeneous as possible. For instance, mowing some but not all areas will help to provide predator-free space on new milkweed growth. Also, habitat with a variety of grasses and wildflowers interspersed with milkweeds can reduce predation.

Ophryocystis elektroscirrha (OE) is an obligate protozoan parasite that infects Monarch butterflies and contributes to mortality. This protozoan reduces the survival of Monarch caterpillars as well as adult mass and lifespan. OE can be an issue when raising Monarchs in captivity and has also been noted in wild populations (Bartel *et al.* 2011, Satterfield *et al.* 2015).

CLIMATE CHANGE

Under a changing climate, parts of Saskatchewan may become increasingly important for Monarchs, as their suitable habitat may shift northwards into the central part of the province. However, while warmer temperatures result in increased growth for some milkweed species, drought reduces growth, survivorship, seed production and germination, and nutritional quality. Climate change may also bring more severe droughts that can desiccate milkweeds, therefore removing a food source for the sedentary caterpillars. Monarch eggs do not hatch in very dry conditions. Temperatures above 35^{o}C may be lethal for all life stages.

Crewe *et al.* (2019) found that annual fluctuations of migratory butterflies related to the Monarch are positively correlated to the number of 21°C days during spring migration and recolonization. Therefore, a reduction in the number of 21°C days during that critical period could be detrimental, and conversely, an increase may be beneficial to Monarch populations.

PESTICIDES

Milkweed is susceptible to any herbicide that kills broadleaf weeds. Impacts of herbicides are discussed under the Habitat Loss section.

Insecticides sprayed on crops or soil drenched have the potential to kill Monarchs. Recently, systemic insecticides, such as neonicotinoids, have received the most attention as threats to Monarch. Neonicotinoid insecticides were introduced in the 1990s, and are present in various farm and garden products in the form of imidacloprid, dinotefuran, clothianidin, and thiamethoxam. In Ontario nearly 100% of corn and 60% of soybean seeds are treated with neonicotinoid insecticides. While only the agricultural seeds are treated with neonicotinoids, these pesticides persist in the soil, where they can be translocated to Monarch host and nectar plants. The impacts of these pesticides are not necessarily lethal, but may decrease development, which disproportionately affects Monarchs as they undergo long-distance migration. In addition, puddles of water in or adjacent to crop fields may contain residue levels of neonicotinoids lethal to pollinators, as well as several herbicide and fungicide residues.

BEHAVIOUR AND HABITAT USE IN CANADA

In the spring, Monarchs migrate northward, arriving in southern Canadian provinces in early summer. As they move north, following the warming weather and emergence of milkweeds, adult Monarchs mate and lay eggs. When they arrive in Canada, the butterfly may complete 1-3 life cycles (generations) before individuals return south to the winter range.

Monarchs leave Saskatchewan as early as August to journey south, with a destination of the high-altitude Oyamel fir (*Abies religiosa*) forests located in the highlands of central Mexico. On their journey south, they often utilize trees to roost in where they rest and avoid inclement weather.

Ranging in elevation from 2900-3300m, the climate of the overwintering sites is cool and humid; a microclimate imperative for Monarch's winter survival. The final generation of Monarchs to emerge in late summer will conserve energy for migration by delaying reproductive activity until they have completed their migration from Saskatchewan to Central Mexico. They will breed next during their migration north the following spring. In Mexico, Monarchs overwinter in large colonies around a dozen mountaintops for 4-5 months. The number of hectares occupied by the Monarch in the overwintering habitat is the best measure we have of the Eastern Population's status in any given year, and counts are made mid-winter by World Wildlife Fund Mexico in collaboration with Comisión Nacional de Áreas Naturales Protegidas and the Monarch Butterfly Biosphere Reserve. In late February or early March, overwintering Monarchs become reproductively active adults and begin the migration north again, dying soon after mating and laying eggs.

In their larval (caterpillar) form, Monarchs are specialist herbivores. In Canada, Monarch caterpillars feed solely on milkweeds in the genus *Asclepias*. Monarchs take advantage of a wide range of habitats that support both milkweed and other flowering plants across North America.

There are 14 milkweed species present in Canada, six of which are found in Saskatchewan (Table 1). While the Monarch may use nectar from a variety of flowers in addition to milkweed (as well as artificial nectar sources), they require milkweeds to complete their life cycle. Milkweeds are tolerant of a wide range of conditions. Habitat for the larval stage and some of the nectaring stage of the Monarch's life cycle is wherever milkweed grows. Milkweed prefers sandy soil or disturbed loamy soil, and occurs in the Mixed Grassland, Moist Mixed Grassland, Aspen Parkland and Cypress Upland ecoregions of Saskatchewan.

While much attention for Monarch conservation is understandably focused on milkweed availability, it is also imperative that mid and late-season nectar sources are available. As Monarchs pupate, nectar availability is critical for adult development and to prepare adults for their fall migration. Table 2 presents known native flowering plants that are known to provide high quality nectar for Monarchs in Saskatchewan. However, many other flowering plant species may also provide a source of food for adult Monarchs. For example, many plants in the genus *Aster (Eurbia* and *Symphyotrichum)* are considered to be important sources of nectar. These include several of the common asters in Saskatchewan such as *Aster conspicuous* (*Eurybia conspicua*), *Aster ciliolatus* (*Symphyotrichum ciliolatum*), and *Aster falcatus* (*Symphyotrichum falcatum*). Introduced clovers (*Trifolium* spp. and *Melilotus* spp.), alfalfa (*Medicago sativa*) and dandelion (*Taraxacum officinale*) are also observed to be commonly used for nectaring. Many other introduced species, such as some knapweeds and thistles provide good nectar sources but are either designated as noxious weeds or are considered invasive species in Saskatchewan and are not recommended for use in programs to increase nectaring sources for Monarchs.

Table 1. Extant milkweed species in Saskatchewan (sources of information include Saskatchewan Conservation Data Centre, Alberta Biodiversity Monitoring Institute).

Common Name	Scientific Name	Rarity	Habitat
Dwarf milkweed	*Asclepias ovalifolia*	Very common	Mixed Grasslands, Moist Mixed Grasslands, Aspen Parkland ecoregions and southern margin of the Boreal Transition; open woods, slopes and moist grassland, roadside ditches
Showy milkweed	*Asclepias speciosa*	Very common	Mixed Grasslands, Moist Mixed Grasslands, Cypress Uplands and Aspen Parkland ecoregions; Moist grassland around lakes, along streams and rivers, irrigation canals, roadside ditches; rapidly-drained soils
Common milkweed	*Asclepias syriaca*	Uncommon	SE SK; Moist Mixed Grasslands and Aspen Parkland ecoregions; moist, sandy soil, riverbanks
Whorled milkweed	*Asclepias verticillata*	Uncommon	Extreme SE SK; Aspen Parkland; dry soil, roadside ditches
Narrow-leafed green milkweed	*Asclepias viridiflora var. linearis*	Common	Moist Mixed Grasslands and Aspen Parkland ecoregions, occasional in the Mixed Grasslands; dry or sandy soil, hillsides, riparian areas
Green milkweed	*Asclepias viridiflora var. viridiflora*	Common	Mixed Grasslands, Moist Mixed Grasslands and Aspen Parkland ecoregions; dry or sandy soil, hillsides, riparian areas

Table 2. Native plants species that are sources of nectar for Monarchs in Saskatchewan (data from Monarch Joint Venture, NRCS (2018), Nature Canada and the Native Plant Society of Saskatchewan).

Species	Common name	Flowering Period	Habitat
Wildflowers (Forbs)			
Achillea millefoilum	Common yarrow	June - August	Grasslands, fencerows, wildflower gardens
Agastache foeniculum	Giant hyssop	July-August	Dry, open woodlands, semi-open grasslands, roadside ditches
Aster (Symphyotrichum) ericoides	Many-flowered aster	August - October	Open grasslands, roadside ditches
Aster laevis (Symphyotrichum leave)	Smooth aster	August - October	Moist prairie, around bluffs of aspen of patches of shrubs, open woodlands
Echinacea angustifolia	Narrow-leaved purple coneflower	June-July	Grasslands, woodland edges and openings, cultivated fields
Eupatorium (Eutrochium)	Spotted joe-pye weed	August - September	Moist grassland and moist, low woodland openings

maculatum			
Euthamia graminifolia	Flat-top goldentop	Late August	Fallow fields, fencerows and other disturbed areas
Gaillardia aristata	Gaillardia	July-August	Grasslands, roadside ditches and other disturbed areas
Geum triflorum	Prairie smoke	May-June	Open grasslands
Glycyrrhiza lepidota	Wild licorice	May-June	Depressions in grasslands, wetland margins, river banks, lake shores, shrubby coulees, irrigation canals
Helianthus annuus	Common sunflower	July - September	Clay, heavier soils, roadsides and disturbed areas
Helianthus pauciflorus	Stiff sunflower	July - September	Dry grasslands, roadsides and other disturbed areas
Helianthus maximilianii	Maximilian sunflower	July - October	Grasslands, roadside ditches and other disturbed areas
Liatris ligulistylis	Meadow blazing star	July-October	Open sandy woodlands
Liatris punctata	Dotted blazing star	August - October	Dry grasslands, exposed hillsides, sandy soil
Monarda fistulosa	Wild bergamot	May - September	Grasslands, sandy soil
Petalostemon candidum (Dalea candida)	White prairie clover	May - August	Dry grassland and hillsides
Ratibida columnifera	Prairie coneflower	July-August	Dry grasslands, roadside ditches and other disturbed areas
Rudbeckia hirta	Black-eyed Susan	June-September	Native and tame grasslands, woodland edges, along rivers, lakeshores and roadsides
Solidago sp. (e.g., canadensis, rigidum)	Goldenrod	June - September	Native and tame grasslands, riparian areas, forests, cultivated fields, rights-of-way (utility, road, rail), fencerows
Shrubs & Trees			
Potentilla fruticosa	Shrubby cinquefoil	June - August	Moist grasslands, slopes, open woodlands
Rubus sp.	Raspberry, cloudberry	June-August	Mixedwood and deciduous forests, riverbanks, roadsides, trails
Spiraea alba	White meadowsweet	July-September	Aspen and mixedwood forests, shores, sandy soils

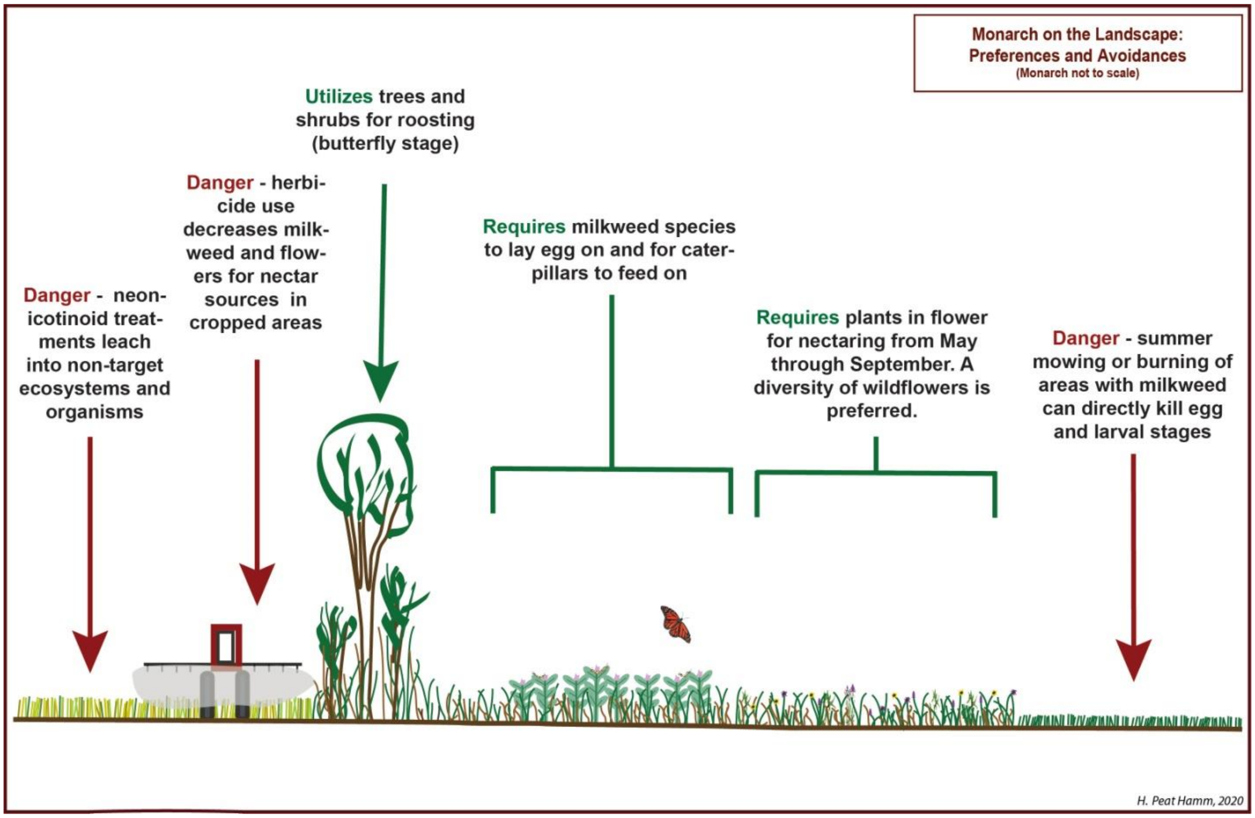


Figure 2. Habitat diagram for Monarch Butterfly.

HABITAT REQUIREMENTS FOR MONARCH BUTTERFLY IN SASKATCHEWAN

May through September represents the portion of the year in Saskatchewan that is important for Monarchs (Table 3).

Table 3. Critical dates for Monarchs in Saskatchewan.

Month	**Monarch activities**
May - June	Monarchs may reach Saskatchewan as early as late May and begin nectaring and breeding.
July	Monarchs begin laying eggs. Caterpillars feed on milkweeds. Larval stage takes 8 – 15 days to complete all five instar stages.
August	There may be Monarchs in all life stages during this period.
August - September	Monarchs begin staging, shifting metabolic activity from reproduction to storing energy for migration. The timing of migration depends largely on annual weather patterns and can begin as early as late July.

The Monarch requires four types of habitat for survival over its life cycle including breeding, nectaring, staging and overwintering habitats. Canada provides mainly breeding and nectaring habitat, along with some staging habitat. The preferred habitat features of the Monarch Butterfly are presented in the following sections and listed in Table 4.

BREEDING HABITAT CHARACTERISTICS

The breeding, or more specifically, the egg laying and larval habitat of the Monarch is limited to locations where milkweed grows. In Saskatchewan, milkweed habitat includes:

- Moist grassland throughout the grassland and parkland ecoregions;
- Riparian areas around lakes, along rivers and streams;
- Open woods in Aspen Parkland and southern margin of Boreal Transition;
- Dry, sandy soil in grassland and parkland ecoregions;
- Milkweed in annual cropland;
- Urban flower gardens with milkweed as a component;
- Rights-of-way (utility, roads, railways) with milkweed as a component.

It is thought that the breeding habitat of the Eastern population of Monarchs has changed over the last 50 years (COSEWIC 2016; Brower 1995). Until the 1880s, the Great Plains of North America appear to have been the main breeding habitat. With conversion of the Midwestern prairies to cropland and the concurrent clearing of the eastern deciduous forests, common milkweed was able to colonize and spread rapidly after about 1910. With the increased use of in-crop herbicides over the past few decades, however, milkweed populations have declined in anthropogenic habitat and Monarch populations have correspondingly declined.

Different milkweed species grow in a variety of habitats (see Table 1). Around 85% of Monarchs have been found to have developed on either common or showy milkweed. This is likely due to the greater availability of these species on the landscape, but could also reflect a preference for these species (Ladner and Altizer 2005). Common milkweed is uncommon in Saskatchewan, whereas showy milkweed is very common. Therefore, the most important breeding habitat for Monarchs in Saskatchewan is associated with the presence of showy milkweed. A substantial amount of research has been done on the suitability of common and showy milkweed as host species for Monarchs. Pocius *et al.* (2017) determined that survival and growth of Monarch caterpillars on showy milkweed is relatively good. Cardenelides are steroids found in milkweed and are toxic to many Monarch predators. As the toxicity of cardenalides increases, the instances of predation on Monarch larvae and adults is reduced (Fink and Brower 1981; Brower 1995), However, the quality of cardenolides in common and showy milkweed is inferior to many of the less common milkweed species (Roeske *et al*. 1976).

Dwarf milkweed is one of the most common milkweeds in Saskatchewan. Research information on Monarch use of this species of milkweed is limited. As such, the quality of its cardenalides, amount of use by egg-laying female Monarchs, and larval survival and growth rates on dwarf milkweed are unknown. However, there is observational information from Saskatoon (C. Neufeld, pers comm.) that Monarchs readily lay eggs on Dwarf milkweed and that the larvae using it develop normally.

There is some evidence that a non-native milkweed, *Asclepias curassavica*, may facilitate the build-up of the Monarch parasite, *Ophryocystis elektroschirra* (Satterfield *et al*. 2015). Seasonal availability may also affect Monarch migratory behaviour by providing larval hosts during times that native milkweeds are not available (Oberhauser *et al*. 2017*a*). Availability of non-native milkweed host plants may encourage Monarchs to remain in their breeding habitat longer than is usual. Postponing their southward migration increases the likelihood of exposure to cold, wet weather increasing related mortality, therefore, planting non-native milkweeds should be avoided.

Predation of eggs and larvae is high. Only about 5% of eggs deposited survive to pupate (NRCS 2018). Females prefer to lay only 1 -2 eggs per milkweed plant to minimize the risk of predation (NRCS 2018). Therefore, it is critical that there are sufficient milkweed stems to support reproduction. Multiple eggs or larvae on a single plant may be an ecological indicator that the site is deficient in suitable milkweed stems (NRCS 2018). The percent of milkweed stems used by egg-laying females is generally between 5 and 25% (Kasten *et al*. 2016) depending on the density of milkweed stems. A scattered distribution of milkweed will support more eggs overall spread between different stems. It is estimated that approximately 30 milkweed plants are required to produce one adult Monarch that will participate in the southward migration (Nail *et al.* 2015).

Monarch production is assumed to increase linearly with the area of suitable habitat (Oberhauser *et al.* 2017*a*). Urban gardens and large agricultural or natural areas can all contribute suitable Monarch habitat. Small sites tend to support a higher density of eggs on milkweed, but larval survival tends to be lower than larger sites (Stenoien *et al*. 2015; Nail *et al.* 2015). However, the higher egg density likely offsets lower survival rates (Oberhauser *et al.* 2017*a*).

NECTARING HABITAT CHARACTERISTICS

Monarch adults acquire energy and nutrients from nectar in the form of lipids. These lipids can be stored for a relatively long period of time in the Monarch body and are rapidly metabolized when required. The ability to store lipids is one of the adaptations that makes it possible for the Monarch to undertake the long southward migration in fall from its breeding habitat to its overwintering habitat. However, Brower *et al.* (2006) suggest that Monarchs may not start storing lipids immediately on their migration as that would increase their weight and make flying more difficult. Thus, they need to drink nectar from flowering plants to replenish energy stores.

Monarchs can obtain nectar from a wide variety of flowering plants (Table 2) including the various species of milkweed. In Saskatchewan, plants that provide suitable nectar are associated with the following broad habitats:

- Natural grasslands, open forest and riparian areas with nectaring plant species
- Nectaring plant species such as milkweed or goldenrod within agricultural crops
- Flowering alfalfa or clover in tame grassland or hay fields July into September
- Urban flower gardens with nectaring plant species
- Rights-of-way (utility, roads, railways) with nectaring plant species as a component

While non-native species can be used for nectar, native nectar producing plants are often more beneficial to an ecosystem. Native nectaring plants are well suited for the local climatic conditions and may be responsible for important ecosystem functions, such as erosion control and filtration (Oberhauser *et al.* 2017*a*).

Of critical importance is the availability of nectar from flowers during the entire season that the Monarchs are in Canada (late May to the end of September). Achieving this availability entails promoting the establishment and growth of a variety of plant species that flower at different times during the growing season. Summer blooming nectar sources (blooming approximately June 2—August 15) throughout the breeding range are vital to sustain a healthy breeding population of Monarchs (Oberhauser *et al.* 2017*a*). Fall blooming nectar plants (blooming approximately August 01—September 30) are equally important as the adult Monarchs prepare for and begin to migrate south.

MIGRATING AND STAGING HABITAT CHARACTERISTICS

Much is unknown about the habitat required for Monarch staging and migrating in Saskatchewan. It is likely that migrating and staging habitats are associated with the following broad types of habitat:

- Nectaring plant species in natural grasslands and open woods
- Riparian buffers with nectaring plant species along rivers and streams
- Nectaring plant species along roads and railways

During migration, Monarchs need staging areas where they can rest and feed. Monarchs tend to congregate in staging areas, indicating that these sites are not chosen at random. They rest overnight in large numbers on roosts, which in the flyway zone nearest to Saskatchewan include primarily maples, conifers and willows (Davis *et al*. 2012). Information on roosts used in Saskatchewan is lacking, but it is likely that Monarchs would use the woody vegetation that provides the best available protection from weather within the broader habitats as they migrate.

Davis *et al.* (2012) also looked at Monarchs'selection of landcover in flyway zones. The preferred land cover selected more often than random in the flyway nearest to Saskatchewan was open water (Davis *et al.* 2012). However, this flyway includes the Great Lakes which pose a significant geographic obstacle to Monarchs during migration. Large aggregations of Monarchs rest and feed along the shorelines of these large waterbodies, before undertaking the flight across water. These aggregations may skew the data and, the selection for open water may reflect a barrier rather than a preference.

Urban areas also appeared to be selected as staging areas more than available in the flyway nearest to Saskatchewan. However, this study was based on citizen science which could reflect a predominance of observations in proximity to urban areas.

Table 4. Optimal habitat targets for Monarch Butterfly by habitat feature.

Habitat Features	**Habitat Targets**		
	Natural Habitat	**Agricultural Habitat**	**Restored Habitat**
Breeding Habitat (Egg Laying and Larval Stages)			
Patch Configuration	Optimal: Many small patches (≤5m^2) of milkweed Suboptimal: Large patches of milkweed	Optimal: Many small patches (≤16m^2) of milkweed Suboptimal: Large patches of milkweed	Optimal: Many small patches (≤5m^2) of milkweed Suboptimal: Large patches of milkweed
	Optimal: Milkweed patches shaded on one side by trees, topography or structures Suboptimal: Milkweed patches not shaded		
Habitat Isolation	Optimal: Suitable milkweed patches separated by not more than 7 km Suboptimal: Suitable milkweed patches separated by 7 – 15 km		
Native Milkweed Density	Optimal: >0.15 stems/m^2	Optimal: 0.5 - 2 stems/m^2 Suboptimal: 0.12 – 0.49 stems/m^2	Optimal: >0.15 stems/m^2
Native Milkweed Abundance	More than 10 stems/patch of any combination of native milkweed species		
Native Milkweed Diversity	Optimal: 2 species of milkweed/patch Suboptimal: 1 species of milkweed/patch		
Nectaring Forb Abundance	Optimal: Milkweed patches containing > 8 nectaring plants additional to milkweed Suboptimal: Milkweed patches containing 4 – 8 nectaring plants additional to milkweed		
Vegetation buffers	Optimal: Milkweed patches surrounded by at least 200 m of perennial herbaceous vegetation Suboptimal: Milkweed patches surrounded by 38 -	N/A	N/A

	200 m of perennial herbaceous vegetation		
Nectaring Habitat (Adult Foraging)			
Nectaring Forb Diversity	Optimal: ≥ 6 species blooming between May 15 and July 1 AND ≥ 10 species blooming between July 1 and September 30 Suboptimal: 2 – 5 species blooming between May 15 and July 1 AND/OR 4 – 9 species blooming between July 1 and September 30		
Blooming Forb Frequency	Optimal: 6 – 16 stems/m^2 Suboptimal: 4 – 6 OR 16 – 25 stems/m^2		
Vegetation Buffers	Optimal: Nectaring patches surrounded by at least 200 m of perennial herbaceous vegetation Suboptimal: Nectaring patches surrounded by 38 - 200 m of perennial herbaceous vegetation	N/A	N/A
Migrating and Staging Habitat (Adult Migrating)			
Nectaring Forb Diversity	Optimal: ≥6 stems/m^2 of high quality, late blooming nectar plants Suboptimal: 4 – 6 stems/m^2 of high quality, late blooming nectar plants		
Roosting Locations	Optimal: Occasional sheltered shrubs or trees within 1 km of late season nectaring habitat		

OTHER OPTIMAL MANAGEMENT PRACTICES FOR MONARCH BUTTERFLY

There is a number of management issues unrelated to the natural characteristics of the landscape or site that should be taken into consideration when managing to optimize habitat for Monarch butterflies. These include:

- Avoid the use of insecticides and broad application of herbicides in natural or restored habitat suitable for Monarchs.
- Avoid fogging for mosquitos during Monarch migration which occurs in August and September in Saskatchewan.
- Leave a vegetative buffer of at least 38 m between areas where insecticides or herbicides have been used on agricultural cropland and land that is managed as habitat for Monarchs.
- Avoid mowing or burning suitable Monarch habitat between June 1 and September 15. Mowing part, but not all, of an area of Monarch habitat could occur during a short window between the first and second generations of Monarchs when benefits of reducing unsuitable vegetation may enhance milkweed growth, and direct mortality of eggs and larvae is minimized. This window would normally occur during late June or early July. Check milkweed plants for eggs and larvae before mowing.
- Ensure milkweed or nectaring plant seed for Monarch habitat restoration has not been treated with neonicotinoids.
- Milkweed species planted for the benefit of Monarchs should be native to Saskatchewan and adapted to the Saskatchewan climate.
    - Tropical milkweed is often sold in seed mixes for Monarchs. These non-native milkweeds can support a protozoan parasite (*Ophryocystis elektroscirrha)* of Monarchs.
    - Tropical milkweed species' often produce foliage and blooms late into the fall, which can interfere with the timing of Monarch migration.
- Do not order commercial Monarch butterflies for the purposes of release, or rear wild-caught Monarchs indoors as they may not migrate and cannot survive the Saskatchewan winter (Tenger-Trolander *et al.* 2019). Rearing wild-caught Monarchs outdoors may be an acceptable option for trained individuals.
- Report Monarch sightings to the Saskatchewan Conservation Data Centre, and an online citizen science site (e.g., eButterfly, Journey North, Mission Monarch). Take photos of the Monarch observed.
- Upload milkweed locations to an online citizen science sites (e.g., milkweedwatch.ca, Mission Monarch). Take photos of the observed milkweed plants.

INFORMATION GAPS

Little research has focused on the natural habitat of the Monarch Butterfly in Canada, and even less on their habitat prior to European settlement, which is assumed to have been primarily the Great Plains of North America. For example, in Saskatchewan, dwarf milkweed (*Asclepias ovalifolia*) is one of the most common milkweeds, yet use of that species as a host plant by Monarchs and rates of productivity for Monarchs using it are unknown. Corroboration of the encouraging observational information for Monarchs use of dwarf milkweed with research would be most useful, as this milkweed may provide high quality habitat.

There is little information available about what Monarchs use as roosts in Saskatchewan. Although Monarchs use trees and shrubs in other jurisdictions, their Saskatchewan range has limited tree cover. Further research is needed to determine what Monarchs use for roosting in Saskatchewan.

Not enough information is available to determine the migration corridor(s) within and from Saskatchewan. Patterns of Monarch movements through the province in the summer and fall, and changes to those patterns during dry and wet years are important clues to understanding habitat requirements. Monitoring and tagging of Monarchs and more citizen science programming will be necessary to answer this and other questions.

ENVIRONMENTAL BENEFIT INDEX FOR MONARCH HABITAT

CRITERIA AND SCORING

The Environmental Benefit Index (EBI) was developed by compiling comprehensive categories of criteria based on available knowledge, such as Monarch population and habitat research, expert opinion, and species recovery documents.

The EBI begins with three screening criteria. These criteria are either met, in which case the user continues to the next criterion, or not met, in which case the property or potential project is eliminated from further consideration. The remaining criteria are grouped into site scale habitat features by life stage.

A scoring system was devised for the EBI. Each criterion is weighted out of 300, 200, or 100 based on its relative importance to the species.

The total scores are calculated based on the following formula:

EBI Natural Habitat = ((1)(2)[(3.1+3.2+3.3+3.4+3.5+3.6)+(4.1+4.2+4.3) +(5.1+5.2)+6])

EBI Agricultural Habitat = ((1)(2)[(3.1+3.2+3.3+3.4+3.5)+(4.1+4.2)+(5.1+5.2)+6])

EBI Restored Habitat = ((1)(2)[(3.1+3.2+3.3+3.4+3.5)+(4.1+4.2)+ (5.1+5.2)+6])

Where the numbers refer to scoring sections described below.

The EBI result may then be divided by the costs of the proposed project or the bid for the project to determine cost effectiveness. The cost to achieve the habitat requirements could include added management, added infrastructure or inputs, or lost opportunities.

The range of possible scores for candidate sites that pass the screening criteria is wide. The lowest possible total score for all habitat types is 0 and the highest possible score is 2100, 1700, and 1800 for natural habitat, agricultural habitat and restored habitat, respectively. When evaluating candidate properties for a project or program, it may be possible to divide the scores into more general High, Moderate and Low priority ranks. There are many uses for a general ranking. For example, a more general ranking could be used to determine the total cost of implementing results-based programming on all high priority sites.

SCREENING CRITERIA FOR ALL HABITAT TYPES

Suitable milkweed habitat is defined as any habitat supporting milkweed plants native to Saskatchewan, and may occur in a natural setting, agricultural cropland, industrial and road rights-of-way or urban parks and flower gardens.

1. Suitable milkweed habitat is present in the area of consideration.
   Yes=1, No=0.

Milkweed is susceptible to any herbicide that kills broadleaf weeds. Insecticides sprayed on crops or soil drenched has potential to kill Monarchs. The risk to Monarchs from neonicotinoids has been raised as an issue because of research showing the amount of neonicotinoids in water running off agricultural fields (Samson-Robert *et al.* 2014). Any drift or runoff of herbicides or insecticides poses a risk to Monarchs or their habitat.

2. Suitable milkweed habitat exists on land where herbicides and/or insecticides (including neonicotinoids) are not used in the normal course of business.
   Yes=1, No=0.

Between criteria 2 and 6, the EBI provides scoring criteria that are divided into three categories of habitat:

- **Natural habitat,**
- **Agricultural cropland habitat, and**
- **Restored habitat.**

Choose the appropriate category for the area of consideration.

NATURAL HABITAT

EGG LAYING AND LARVAL HABITAT

3. The habitat for egg laying and larval stages of the Monarch has been separated from other habitat requirements because it is dependent on the presence of milkweed. Although milkweed can be used for nectaring, other plant species also provide nectaring opportunities for Monarchs.

3.1. Studies have not found there to be an optimal patch size of milkweed habitat for Monarchs (Blader 2018, UTSA 2019) in natural habitat. Many smaller patches (<5m^2 (Blader 2018)) may be preferable to a few large patches. Because mortality of eggs and larvae are high due to predation, parasitism, disease, weather etc., Monarch females will distribute their eggs among milkweed patches if many patches are available, thereby increasing the chances of individual larvae reaching an adult stage.

Monarch females tend to prefer to lay eggs on patches of milkweed that are shaded on one side by trees or other structures. However, in urban flower gardens they prefer patches with unimpeded north-south access (Baker and Potter 2019), therefore shade from east or west of a patch may be preferable.
(Max 100 points)

Patch Size and Configuration

100	Area of consideration contains at least 3 patches of milkweed (≤5 m^2) AND patch is shaded on one side by trees, topography or structures.
50	Area of consideration contains fewer than 3 patches of milkweed of any size OR patches are not shaded OR patch is shaded on more than one side.

3.2. The greater the distance a female Monarch has to travel between patches, the less distributed (or more concentrated) eggs will be over an area. Patches of suitable milkweed habitat may not attract any females if they are 15 km or more from another suitable patch. **(Max 300 points)**

Habitat Isolation

300	Area of consideration contains suitable patches of milkweed <7 km from other suitable patches
100	Area of consideration contains suitable patches of milkweed 7-15 km from other suitable patches
0	Area of consideration contains suitable patches of milkweed >15 km from other suitable patches

3.3. Numerous studies have looked at milkweed density within patches and attempted to determine whether there is an optimal density or spacing that would maximize monarch productivity. Most studies have evaluated stems/area as the measure of density. This measure is different from the number of plants as a single milkweed plant can have tens to thousands of stems (UTSA 2019). Discussion of density and spacing in this section refers to milkweed stems.

Distance between plants (spacing) within a patch has not been found to influence Monarch productivity. When females lay their eggs on numerous as opposed to few stems, productivity is higher (UTSA 2019, Blader 2018, Zalucki and Suzuki 1987). This relationship may exist because the maximum number of larvae that can co-exist on a single milkweed stem is 3 to 4. At greater larval densities, larvae begin to die. Therefore, higher densities of eggs/stem may not be desirable, although a greater availability of stems on which to lay eggs is desirable.

Milkweed stem densities in natural habitat are highly variable ranging from 0.15 (Kasten *et al.* 2016) to several thousand stems/m^2 (UTSA 2019). However at stem densities higher than about 2/m^2 (~8000/acre) Monarchs tended to lay fewer eggs (Pitman *et al.* 2018) perhaps because pest species such as aphids can infest a site with high stem density reducing the quality of milkweed as a food source for both larval and adult Monarchs.

Some studies have shown that greater numbers of stems within a milkweed patch result in higher monarch productivity (UTSA 2019, Blader 2018) independent of stem density. Maximum productivity occurred in patches of 10 stems (Blader 2018) and patches of 16 stems (UTSA 2019). Therefore, productivity may be more related to number of available stems in a patch rather than either spacing or density. **(Max 300 points)**

Habitat Quality - Native Milkweed Density and Abundance

300	>0.15 stems/m^2 within patches AND >10 stems per patch
150	>0.15 stems/m^2 within patches OR >10 stems per patch
0	<0.15 stems/m^2 AND <10 stems per patch

3.4. Oberhaeuser *et al.* (2017a) recommend an optimal diversity of milkweed in farmland of 3 to 4 species. Milkweed species have different tolerances to annual climatic conditions and a greater number of species ensures that at least one species should grow robustly in any given year.

Natural habitat in Saskatchewan is unlikely to support more than two species of milkweed in a given location. In addition, the quality of dwarf milkweed (*A. ovalifolia*) as a host plant for Monarch larvae is unknown. **(Max 100 points)**

Habitat Quality - Native Milkweed Diversity

100	A area of consideration supports 2 or more species of milkweed
50	A area of consideration supports 1 species of milkweed

3.5. Experiments within restored habitats indicate that Monarchs are more attracted to milkweed patches that also contain other species of nectaring plants. Experts suggest Monarchs may key on the variation in color of flowers.

In Texas, Monarch productivity in mixedwood forests was highest when the number of nectaring plants in a plot was between 4 and 16 with the optimal density varying between years (UTSA 2019). **(Max 100 points)**

Habitat Quality - Forb Abundance

100	Milkweed patches contain >8 nectaring plants
50	Milkweed patches contain 4 – 8 nectaring plants
0	Milkweed patches contain <4 nectaring plants

3.6. Setback distances from agricultural cropland have been determined for some species to prevent runoff of nutrients, sediments or pesticides from reducing the quality of habitat. Although no setbacks have been developed for Monarchs to prevent impacts from runoff and drift of pesticides, we have adopted a 200 m setback established for Northern Leopard Frog (SK PCAP 2018a). **(Max 200 points)**

Habitat Quality – Vegetative Buffers

200	Milkweed patches surrounded by at least 200 m of perennial herbaceous vegetation
100	Milkweed patches surrounded by 38 – 200 m of perennial herbaceous vegetation
0	Milkweed patches adjacent to cropland without a vegetative buffer OR adjacent to other developments where insecticides or herbicides might be used in the normal course of business

4. Adult Monarchs use a broad diversity of nectar sources for food. Table 2 contains a list of forbs native to Saskatchewan that are known to provide nectaring opportunities for Monarchs. Additionally, we know that they use a number of noxious weeds (e.g., thistles and knapweeds) and introduced forages (e.g., alfalfa and clover). However, it is not recommended that management of natural habitat favour non-native species due to the negative impacts to biodiversity and other ecological values.

4.1. Critical to the survival and productivity of the Monarch is the requirement for sources of nectar throughout the breeding range in Saskatchewan. A variety of nectaring species that provide blooms from May through September are necessary.

Oberhaeuser *et al.* 2017a determined that optimal nectaring forb richness within a patch maximized at 6 species during the period from May 15 to July 1, and at 10 species during the period from July 1 to September 15. Although Oberhaeuser *et al.* (2017a) gave greater weighting to forb density, our experts indicated that the timing of blooming was critical for Saskatchewan, with the greatest need being late blooming species. **(Max 200 points)**

Habitat Quality - Forb Diversity

200	≥ 6 species blooming between May 15 and July 1 AND ≥ 10 species blooming between July 1 and September 30
100	2 – 5 species blooming between May 15 and July 1 AND/OR 4 – 9 species blooming between July 1 and September 30
0	< 2 species blooming between May 15 and July 1 OR <4 species blooming between July 1 and September 30

4.2. Oberhaueser *et al*. (2017a) measured forb frequency and determined that optimal blooming forb densities occurred at ≥ 6.4 stems/m^2 for all regions in the US. They transformed the data into a suitability index that could be used in association with monitoring.

In Texas, Monarch productivity in mixedwood forests was highest when the number of nectaring plants in a plot was between 4 and 16 with the optimal density varying between years (UTSA 2019). It appears there may be a maximum density of nectaring plants as, at densities of 25 plants/plot, they found utilization by Monarchs dropped substantially during both years of monitoring. **(Max 200 points)**

Habitat Quality - Forb Density

200	6 – 16 stems/m^2
100	4 – 6 OR 16 – 25 stems/m^2
0	<4 stems/m^2

4.3. Setback distances from agricultural cropland have been determined for some species to prevent runoff of nutrients, sediments or pesticides from reducing the quality of habitat. Although no setbacks have been developed for Monarchs to prevent impacts from runoff and drift of pesticides, we have adopted a 200 m setback established for Northern Leopard Frog (SK PCAP 2018a). **(Max 200 points)**

Habitat Quality – Vegetative Buffers

200	Nectaring patches surrounded by at least 200 m of perennial herbaceous vegetation
100	Nectaring patches surrounded by 38 – 200 m of perennial herbaceous vegetation
0	Nectaring patches adjacent to cropland without a vegetative buffer OR adjacent to other developments where insecticides or herbicides might be used in the normal course of business

5. Adult Monarchs will begin their southward migration from Saskatchewan in August or September. The exact timing of migration varies annually depending on weather conditions. Experts speculate that Monarchs move in a southeasterly direction out of Saskatchewan and then follow the main migration corridor through the mid-west US to their wintering grounds in Mexico. However, location specific information on whether or not there are migration corridors, and the location of any such corridors is unknown.

   5.1. Most critical to this life stage of the Monarch is the requirement for widespread late-season nectaring plants (see Table 2) to provide energy needed for daily movement during migration. Natural habitat used for migration tends to be native prairie, parkland edges and riparian corridors. Patches of nectaring plants of any size must be available along their migration route. Monarchs travel on average 40 to 50 km daily on their southward migration. Therefore, an area of consideration would need only a few small patches or even one large patch of late blooming nectar-producing plants to support migration. **(Max 300 points)**

Habitat Quality - Forb Density

300	≥ 6 stems/m^2 of high quality, late blooming nectaring plants
150	4 – 6 stems/m^2 of high quality, late blooming nectaring plants
0	<4 stems/m^2 of high quality, late blooming nectaring plants

   5.2. Also important for migration are roosts where Monarchs can take shelter from weather or rest. Ideally roosts would be in close proximity to nectaring plants, so they can easily obtain energy before embarking on the next leg of their journey. Suitable roosts are usually woody vegetation located in a localized area that is sheltered from wind and rain. Information from jurisdictions near Saskatchewan indicates that roosts are most often willows, maples or conifers. In addition, Monarchs may also choose roosts in close proximity to water sources. **(Max 100 points)**

Habitat Quality – Roost Location

100	Occasional sheltered shrubs or trees within 1 km of late season nectaring habitat.
0	Occasional sheltered shrubs or trees more than 1 km from late season nectaring habitat.

EGG LAYING AND LARVAL HABITAT

3. The habitat for egg laying and larval stages of the Monarch has been separated from other habitat requirements because it is dependent on the presence of milkweed. Although milkweed can be used for nectaring, other plant species also provide nectaring opportunities for Monarchs.

3.1. Studies have not found there to be an optimal patch size for milkweed habitat (Blader 2018, UTSA 2019) in natural habitat. Many smaller patches (<5m^2 (Blader 2018)) may be preferable to a few large patches because Monarch females will distribute their eggs among patches if many patches are available, thereby increasing the chances of individual larvae reaching an adult stage. Mortality of eggs and larvae are high due to predation, parasites, disease, weather etc.

Pitman *et al.* (2018) found higher egg densities in patches <16m^2 in agricultural cropland than in larger (>29 m^2), denser milkweed patches. However, in agricultural cropland, large single patches of milkweed may be equally optimal for Monarchs if patchiness occurs due to agricultural operations such as tilling. In addition, milkweed in agricultural cropland will tend to have a greater percentage of new milkweed shoots, which are more palatable for Monarch larvae, than natural or restored habitat because of annual disturbance.

Monarch females tend to prefer to lay eggs on patches of milkweed that are shaded on one side by trees or other structures. However, a study of urban flower gardens indicated that they prefer patches with unimpeded north-south access (Baker and Potter 2019), therefore shade from east or west of a patch may be preferable.
(Max 100 points)

Patch Size and Configuration

100	Area of consideration contains at least 3 patches of milkweed (≤16 m^2), or fewer large patches with variable densities of milkweed AND patch is shaded on one side by trees, topography or structures.
50	Area of consideration contains fewer than 3 patches of milkweed with uniform densities of any size OR patches are not shaded OR patch is shaded on more than one side.

3.2. The greater the distance a female Monarch has to travel between patches, the less distributed (or more concentrated) eggs will be over an area. Patches of suitable milkweed habitat may not attract any females if they are 15 km or more from another suitable patch. **(Max 300 points)**

Habitat Isolation

300	Area of consideration contains suitable patches of milkweed <7 km from other suitable patches
100	Area of consideration contains suitable patches of milkweed 7-15 km from other suitable patches
0	Area of consideration contains suitable patches of milkweed >15 km from other suitable patches

3.3. Numerous studies have looked at milkweed density within patches and attempted to determine whether there is an optimal density or spacing that would maximize monarch productivity. Most studies have evaluated stems/area as the measure of density. This measure is different from the number of plants as a single milkweed plant can have tens to thousands of stems (UTSA 2019).

Distance between plants within a patch has not been found to influence Monarch productivity. Enticing females to lay their eggs on numerous as opposed to few stems has been shown to increase productivity (UTSA 2019, Blader 2018, Zalucki and Suzuki1987). This relationship may exist because the maximum number of larvae that can co-exist on a single milkweed stem is 3 to 4. At greater larval densities, larvae begin to die. Therefore, higher densities of eggs/stem may not be desirable.

Oberhaeuser *et al.* (2017a) recommend milkweed densities in agricultural land of up to 2000 stems/acre (0.5 stems/m^2). However, at stem densities higher than about 2/m^2 (~8000/acre) Monarchs tended to lay fewer eggs (Pitman *et al.* 2018) perhaps because pest species such as aphids can infest a site reducing the quality of milkweed as a food source for both larval and adult Monarchs.

Some studies have shown that greater numbers of milkweed stems within a patch result in higher monarch productivity (UTSA 2019, Blader 2018) regardless of density. Maximum productivity occurred in patches of 10 stems (Blader 2018) and patches of 16 stems UTSA 2019). Therefore, productivity may be more related to number of available stems in a patch rather than spacing or density. **(Max 200 points)**

Habitat Quality - Native Milkweed Density

200	0.5 – 2.0 stems/m^2
100	0.12 – 0.49 stems/m^2
0	<0.12 stems/m^2 OR >2 stems/m^2

3.4. Oberhaeuser *et al.* (2017a) recommend an optimal diversity of milkweed in farmland of 3 to 4 species. Milkweed species have different tolerances to annual climatic conditions and a greater number of species ensures that at least one species should grow robustly in any given year.

Agricultural cropland in Saskatchewan is unlikely to support more than two species of milkweed in any location. In addition, the quality of dwarf milkweed (*A. ovalifolia*) as a host plant for Monarch larvae is unknown. **(Max 100 points)**

Habitat Quality - Native Milkweed Diversity

100	A area of consideration supports 2 or more species of milkweed
50	A area of consideration supports 1 species of milkweed

3.5. Experiments within restored habitats indicate that Monarchs are more attracted to milkweed patches that also contain other species of nectaring plants. Experts suggest Monarchs may key on the variation in color of flowers.

In Texas, Monarch productivity in mixedwood forests was highest when the number of nectaring plants in a plot was between 4 and 16 with the optimal density varying between years (UTSA 2019). **(Max 200 points)**

Habitat Quality - Forb Abundance

200	Milkweed patches contain >8 nectaring plants
100	Milkweed patches contain 4 – 8 nectaring plants
0	Milkweed patches contain <4 nectaring plants

4. Adult Monarchs use a broad diversity of nectar sources for food. Table 2 contains a list of forbs native to Saskatchewan that are known to provide nectaring opportunities for Monarchs. Additionally, we know that they use a number of noxious weeds (e.g., thistles and knapweeds) and introduced forages (e.g., alfalfa and clover). However, it is not recommended that management of natural habitat favour non-native species due to the negative impacts to biodiversity and other ecological values.

4.1. Critical to the survival and productivity of the Monarch is the requirement for sources of nectar throughout the breeding range in Saskatchewan. A variety of nectaring species that provide blooms from May through September are necessary.

Oberhaeuser *et al.* (2017a) determined that optimal nectaring forb richness within a patch maximized at 6 species during the period from May 15 to July 1, and at 10 species during the period from July 1 to September 15. Although Oberhaeuser *et al.* (2017a) gave greater weighting to forb density, our experts indicated that the timing of blooming was critical for Saskatchewan, with the greatest need being late blooming species. **(Max 200 points)**

Habitat Quality - Forb Diversity

200	≥ 6 species blooming between May 15 and July 1 AND ≥ 10 species blooming between July 1 and September 30
100	2 – 5 species blooming between May 15 and July 1 AND/OR 4 – 9 species blooming between July 1 and September 30
0	< 2 species blooming between May 15 and July 1 OR <4 species blooming between July 1 and September 30

4.2. Oberhaueser *et al.* (2017a) measured forb frequency and determined that optimal blooming forb densities occurred at ≥ 6.4 stems/m2 for all regions in the US. They transformed the data into a suitability index that could be used in association with monitoring.

In Texas, Monarch productivity in mixedwood forests was highest when the number of nectaring plants in a plot was between 4 and 16 with the optimal density varying between years (UTSA 2019). It appears there may be a maximum density of nectaring plants because above densities of 25 plants/plot, they found utilization by Monarchs dropped substantially during both years of monitoring. **(Max 200 points)**

Habitat Quality - Forb Density

200	6 – 16 stems/m^2
100	4 – 6 OR 16 – 25 stems/m^2
0	<4 stems/m^2

5. Adult Monarchs will begin their southward migration from Saskatchewan in August or September. The exact timing of migration varies annually depending on weather conditions. Experts speculate that Monarchs move in a southeasterly direction out of Saskatchewan and then follow the main migration corridor through the mid-west US to their wintering grounds in Mexico. However, location-specific information on whether or not there are migration corridors, and the location of any such corridors is unknown.

   5.1. Most critical to this life stage of the Monarch is the requirement for widespread late-season nectaring plants (see Table 2) to provide energy needed for daily movement during migration. Agricultural habitat used for migration may include fencerows or late blooming legumes, or possibly shelterbelts. Patches of nectaring plants of any size must be available along their migration route. Monarchs travel on average 40 to 50 km daily on their southward migration. Therefore, an area of consideration would need only a few small patches or even one large patch of late blooming nectar-producing plants to support migration. **(Max 200 points)**

Habitat Quality - Forb Density

200	≥ 6 stems/m^2 of high quality, late blooming nectaring plants
100	4 – 6 stems/m^2 of high quality, late blooming nectaring plants
0	<4 stems/m^2 of high quality, late blooming nectaring plants

   5.2. Also important for migration are roosts where Monarchs can take shelter from weather or rest. Ideally roosts would be in close proximity to nectaring plants, so they can easily obtain energy before embarking on the next leg of their journey. Suitable roosts are usually woody vegetation located in a localized area that is sheltered from wind and rain. Information from jurisdictions near Saskatchewan indicate that roosts are most often willows, maples or conifers, and therefore may use shelterbelts. **(Max 100 points)**

Habitat Quality – Roost Location

100	Occasional sheltered shrubs or trees within 1 km of late season nectaring habitat.
0	Occasional sheltered shrubs or trees more than 1 km from late season nectaring habitat.

EGG LAYING AND LARVAL HABITAT

3. The habitat for egg laying and larval stages of the Monarch has been separated from other habitat requirements because it is dependent on the presence of milkweed. Although milkweed can be used for nectaring, other plant species also provide nectaring opportunities for Monarchs.

3.1. Studies have not found there to be an optimal patch size for milkweed habitat (Blader 2018, UTSA 2019) in natural habitat. Many smaller patches ($<5m^2$ (Blader 2018)) may be preferable to a few large patches because Monarch females will distribute their eggs among patches if many patches are available, thereby increasing the chances of individual larvae reaching an adult stage. Mortality of eggs and larvae are high due to predation, parasites, disease, weather etc.

Monarch females tend to prefer to lay eggs on patches of milkweed that are shaded on one side by trees or other structures. However, a study of urban flower gardens indicated that they prefer patches with unimpeded north-south access (Baker and Potter 2019), therefore shade from east or west of a patch may be preferable.

Baker and Potter (2019) also found that Monarch eggs and larvae were more abundant in gardens where milkweed plants were located on the perimeter of the garden as opposed to intermixed with, or surrounded by other plant species.

A linear configuration may also be advantageous because it facilitates movement of Monarchs.
(Max 100 points)

Patch Size and Configuration

100	Area of consideration contains at least 3 patches of milkweed (≤ 5 m^2) AND milkweed plants are located on the perimeter of the garden AND patches are shaded on one side by trees, topography or structures.
50	Area of consideration contains fewer than 3 patches of milkweed of any size OR milkweed is intermixed with or surrounded by other plant species OR patches are not shaded OR patches are shaded on more than one side.

3.2. The greater the distance a female Monarch has to travel between patches, the less distributed (or more concentrated) eggs will be over an area. Patches of suitable milkweed habitat may not attract any females if they are 15 km or more from another suitable patch. **(Max 300 points)**

Habitat Isolation

300	Area of consideration contains suitable patches of milkweed <7 km from other suitable patches
100	Area of consideration contains suitable patches of milkweed 7-15 km from other suitable patches
0	Area of consideration contains suitable patches of milkweed >15 km from other suitable patches

3.3. Numerous studies have looked at milkweed density within patches and attempted to determine whether there is an optimal density or spacing that would maximize monarch productivity. Most studies have evaluated stems/area as the measure of density. This measure is different from the number of plants as a single milkweed plant can have tens to thousands of stems (UTSA 2019).

Distance between plants within a patch has not been found to influence Monarch productivity. Enticing females to lay their eggs on numerous as opposed to few stems has been shown to increase productivity (UTSA 2019, Blader 2018, Zalucki and Suzuki 1987). This relationship may exist because the maximum number of larvae that can co-exist on a single milkweed stem is 3 to 4. At greater larval densities, larvae begin to die. Therefore, higher densities of eggs/stem may not be desirable.

Milkweed densities in natural habitat is highly variable ranging from 0.15 (Kasten *et al.* 2016) to several thousand stems/m^2 (UTSA 2019). However at stem densities higher than about 2/m^2 (~8000/acre) Monarchs tended to lay fewer eggs (Pitman *et al.* 2018) perhaps because pest species such as aphids can infest a site reducing the quality of milkweed as a food source for both larval and adult Monarchs.

Some studies have shown that greater numbers of milkweed stems within a patch result in higher monarch productivity (UTSA 2019, Blader 2018) regardless of density. Maximum productivity occurred in patches of 10 stems (Blader 2018) and patches of 16 stems UTSA 2019). Therefore productivity may be more related to number of available stems in a patch rather than spacing or density. Additionally, it is important to note that new shoots of milkweed are more palatable to Monarchs than older stems. **(Max 200 points)**

Habitat Quality - Native Milkweed Density and Abundance

200	>0.15 stems/m^2 within patches AND >10 stems per patch
100	>0.15 stems/m^2 within patches OR >10 stems per patch
0	<0.15 stems/m^2 AND <10 stems per patch

3.4. Oberhaeuser et al. (2017a) recommend an optimal diversity of milkweed in farmland of 3 to 4 species. Milkweed species have different tolerances to annual climatic conditions and a greater number of species ensures that at least one species should grow robustly in any given year.

Natural habitat in Saskatchewan is unlikely to support more than two species of milkweed in any location. In addition, the quality of dwarf milkweed (*A. ovalifolia*) as a host plant for Monarch larvae is unknown. **(Max 100 points)**

Habitat Quality - Native Milkweed Diversity

100	A area of consideration supports 2 or more species of milkweed
50	A area of consideration supports 1 species of milkweed

3.5. Experiments within restored habitats indicate that Monarchs are more attracted to milkweed patches that also contain other species of nectaring plants. Experts suggest Monarchs may key on the variation in color of flowers.

In Texas, Monarch productivity in mixedwood forests was highest when the number of nectaring plants in a plot was between 4 and 16 with the optimal density varying between years (UTSA 2019). **(Max 200 points)**

Habitat Quality - Forb Abundance

200	Milkweed patches contain >8 nectaring plants
100	Milkweed patches contain 4 – 8 nectaring plants
0	Milkweed patches contain <4 nectaring plants

4. Adult Monarchs use a broad diversity of nectar sources for food. Table 2 contains a list of forbs native to Saskatchewan that are known to provide nectaring opportunities for Monarchs. Additionally, we know that they use a number of noxious weeds (e.g., thistles and knapweeds) and introduced forages (e.g., alfalfa and clover). However, it is not recommended that management of natural habitat favour non-native species due to the negative impacts to biodiversity and other ecological values.

4.1. Critical to the survival and productivity of the Monarch is the requirement for sources of nectar throughout the breeding range in Saskatchewan. A variety of nectaring species that provide blooms from May through September are necessary.

Oberhaeuser *et al.* (2017a) determined that optimal nectaring forb richness within a patch maximized at 6 species during the period from May 15 to July 1, and at 10 species during the period from July 1 to September 15. Although Oberhaeuser *et al.* (2017a) gave greater weighting to forb density, our experts indicated that the timing of blooming was critical for Saskatchewan, with the greatest need being late blooming species.

Although some restoration guidelines for Monarch recommend 50% grass and 50% forb cover, the greater the percentage of forbs the better.
(Max 200 points)

Habitat Quality - Forb Diversity

200	≥ 6 species blooming between May 15 and July 1 AND ≥ 10 species blooming between July 1 and September 30
100	2 – 5 species blooming between May 15 and July 1 AND/OR 4 – 9 species blooming between July 1 and September 30
0	< 2 species blooming between May 15 and July 1 OR <4 species blooming between July 1 and September 30

4.2. Oberhaueser *et al.* (2017a) measured forb frequency and determined that optimal blooming forb densities occurred at ≥ 6.4 stems/m^2 for all regions in the US. They transformed the data into a suitability index that could be used in association with monitoring.

In Texas, Monarch productivity in mixedwood forests was highest when the number of nectaring plants in a plot was between 4 and 16 with the optimal density varying between years (UTSA 2019). It appears there may be a maximum density of nectaring plants as at densities of 25 plants/plot, they found utilization by Monarchs dropped substantially during both years of monitoring. **(Max 200 points)**

Habitat Quality - Forb Density

200	6 – 16 stems/m^2
100	4 – 6 OR 16 – 25 stems/m^2
0	<4 stems/m^2

5. Adult Monarchs will begin their southward migration from Saskatchewan in August or September. The exact timing of migration varies annually depending on weather conditions. Experts speculate that Monarchs move in a southeasterly direction out of Saskatchewan and then follow the main migration corridor through the mid-west US to their wintering grounds in Mexico. However, location specific information on whether or not there are migration corridors, and the location of any such corridors is unknown.

    5.1. Most critical to this life stage of the Monarch is the requirement for widespread late-season nectaring plants (see Table 2) to provide energy needed for daily movement during migration. Patches of nectaring plants of any size must be available along their migration route. Monarchs travel on average 40 to 50 km daily on their southward migration. Therefore, an area of consideration would need only a few small patches or even one large patch of late blooming nectar-producing plants to support migration. Experts have noted that the railway from Saskatoon to Winnipeg may provide a suitable migration corridor for Monarchs providing late season nectaring sources are available adjacent to the route. Large transmission lines are also often used for migration if they go in the right direction and have sources of nectar. These linear developments may provide opportunities for habitat restoration for Monarchs. **(Max 300 points)**

Habitat Quality - Forb Density

300	≥ 6 stems/m^2 of high quality, late blooming nectaring plants
150	4 – 6 stems/m^2 of high quality, late blooming nectaring plants
0	<4 stems/m^2 of high quality, late blooming nectaring plants

    5.2. Also important for migration are roosts where Monarchs can take shelter from weather or rest. Ideally, roosts would be in close proximity to nectaring plants, so they can easily obtain energy before embarking on the next leg of their journey. Suitable roosts are usually woody vegetation located in a localized area that is sheltered from wind and rain. Information from jurisdictions near Saskatchewan indicate that roosts are most often willows, maples or conifers. **(Max 100 points)**

Habitat Quality – Roost Location

100	Occasional sheltered shrubs or trees within 1 km of late season nectaring habitat.
0	Occasional sheltered shrubs or trees more than 1 km from late season nectaring habitat.

6. Interaction with other species at risk (SAR): Other SAR may exist in the area. The presence of optimal Monarch habitat may have a positive, negative or neutral effect on the other SAR found in the area of consideration.
 (**Max points 100**)

Interaction with other Species at Risk

100	Monarch habitat contributes positively to other area SAR.
0	Monarch habitat has no impact on other area SAR.
-100	Monarch habitat has a negative impact on other area SAR.

EBI Natural Habitat = ((1)(2)[(3.1+3.2+3.3+3.4+3.5+3.6)+(4.1+4.2+4.3)+(5.1+5.2)+6])
EBI Agricultural Habitat = ((1)(2)[(3.1+3.2+3.3+3.4+3.5)+(4.1+4.2)+(5.1+5.2)+6])
EBI Restored Habitat = ((1)(2)[(3.1+3.2+3.3+3.4+3.5)+(4.1+4.2)+ (5.1+5.2)+6])

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