COSEWIC
Assessment and Status Report

on the

Monarch
Danaus plexippus

in Canada

Photo/image: Bob Graham, Point Pelee National Park

SPECIAL CONCERN
2010

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment Canada
Ottawa, ON
K1A 0H3

Tel.: 819-953-3215
Fax: 819-994-3684
E-mail: COSEWIC/COSEPAC@ec.gc.ca
http://www.cosewic.gc.ca

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COSEWIC
Assessment Summary

Assessment Summary – April 2010

Common name
Monarch

Scientific name
Danaus plexippus

Status
Special Concern

Reason for designation
This species has a population of millions to over one billion individuals. The most sensitive stage of its annual cycle is overwintering. There are two main overwintering areas: the Oyamel Fir forests of Central Mexico, where 90% of the population overwinters, and coastal regions of California. The overall area of these sites is relatively small, and threats, especially from logging in the Oyamel Fir forests, are sufficient to suggest that the species could become Threatened in the near future.

Occurrence
British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia

Status history
Designated Special Concern in April 1997. Status re-examined and confirmed in November 2001 and in April 2010.

COSEWIC
Executive Summary

Monarch
Danaus plexippus

Species information

The Monarch is a large, showy, orange and black butterfly. The wings, which span 93-105 mm, are mostly orange with a broad black border and two rows of circular white spots. The chrysalis is of a spectacular green and gold. The larva is distinctively white, yellow, and black-banded, with a pair of black filaments at its head and tail.

Distribution

The Monarch is widely distributed in the New World and is found from Central America northwards to southern Canada, and from the Atlantic Coast westward to the Pacific Coast. Populations have been introduced to numerous other parts of the world. The Monarch has been recorded from all ten provinces and in the Northwest Territories. The northern limit of the breeding range corresponds with the northern range limit of milkweeds at about 54 ˚N in the central prairie provinces. Monarch populations in Canada overwinter in two distinct regions: over 90% of the Canadian population overwinter mostly in the mountains of Central Mexico whereas the southern British Columbia individuals overwinter in coastal California.

Habitat

The Mexican overwintering sites (for populations referred to below as “eastern”) are in the Oyamel Fir Forests of Central Mexico where millions of adult Monarchs aggregate in a small number of sites. In California, the overwintering habitat is along the coast south to Baja California where ~400 overwintering sites have been recorded. Individuals from these sites are referred to as “western”.

The breeding habitat of the Monarch is confined to sites where milkweeds, the sole food of the caterpillars, grow. Different milkweed species grow in a variety of environments and are also planted in gardens.

Biology

The Monarch, like all butterflies, has a life cycle that is composed of four stages: egg, larva (or caterpillar), pupa (or chrysalis), and imago (or adult butterfly). Female Monarchs lay up to 500 eggs on the undersides of milkweed leaves. The caterpillar transforms into a chrysalis, metamorphoses, and emerges later as a butterfly. In most of southern Canada, the late summer adults migrate south to Mexico, where they overwinter. Overwintered adults begin flying north in late February or early March. Females that leave the overwintering sites breed in the coastal states of the Gulf of Mexico and die. Adults of the following generations continue the migration north, although some stay to breed locally. Butterflies from southern British Columbia undergo a shorter migration from the overwintering sites along the coast of California to the breeding range, which includes areas in Arizona and New Mexico north to southern British Columbia. There is exchange of individuals across the Rocky Mountains: Central Mexican and Californian overwintering individuals are not genetically distinct.

Population sizes and trends

Eastern and Western populations fluctuate frequently, sometimes dramatically, as a result of overwintering mortality, poor breeding conditions, mortality due to pesticides and herbicides, and predation. The Western population likely numbers in the millions. The overwintering Eastern population is estimated to range from 110 million to nearly 1 billion. Since 1993, the combined area of all overwintering colonies in Mexico measured in any one year ranges from 0.02 to 0.181 km^2. Large numbers of Monarchs breed in Canada each year and the breeding range varies from year to year depending on weather conditions and the abundance of the larval plant host.

Limiting factors and threats

Forest degradation at the overwintering sites is likely the biggest threat facing the Monarch. For the Eastern population, the various causes of this include conversion of forest to agriculture and pastures, excessive commercial logging (legal and illegal) and, more recently, tree mortality due to bark beetle damage. Some of the habitat is protected by presidential decree but is still being logged. These logging practices create openings and thinned areas in the forest, which increase the exposure of overwintering Monarchs to winter storms, cold temperatures and wet conditions, resulting in increased and sometimes substantial mortality.

Modelling of future climate scenarios suggests that climate change will reduce the area of suitable forest at the overwintering sites in Mexico. Increased frequency of cool, wet summers reduces the Monarch population growth rates.

For the Western population, habitat degradation is caused mainly by real estate development along the California coast and by elimination of introduced eucalyptus upon which the butterflies overwinter.

Herbicide and pesticide use across North America is a threat. Milkweeds are still listed under the Noxious Weed acts of Manitoba, Ontario, Quebec and Nova Scotia.

Special significance of the species

The migration that is undertaken by the Eastern population is unique, is currently facing numerous obstacles, and has been described as an endangered biological phenomenon. The Monarch is an international symbol of nature; cooperation among Canada, Mexico and the USA as part of the free trade agreement; and is used in classrooms all over North America to teach children about life, biology, metamorphosis, conservation, and an appreciation for nature.

Existing protection

The Monarch was designated as Special Concern by COSEWIC in 1997. The status was re-examined and confirmed in 2001. In Ontario, Monarchs receive protection under the *Fish and Wildlife Conservation Act*.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS (2010)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune
Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

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2010

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SPECIES INFORMATION

Name and classification

The Monarch (French name Monarque), *Danaus plexippus* (L.) was previously placed in the separate family Danaidae, but this group is now considered a subfamily of the family Nymphalidae: a diverse family which also includes nymphs, satyrs, arctics, morphos, heliconiines, owl butterflies and snouts (Wahlberg *et a*l., 2003). It is the only Canadian representative of the subfamily Danainae, which is also known as the Milkweed Butterflies (Marshall 2006).

Morphological description

Egg

The Monarch's egg is whitish, somewhat oval in shape with a flat base and bluntly pointed apex. It has a series of approximately 18 ridges that run from base to apex.

Larva (or caterpillar)

The Monarch's caterpillar is one of the most easily recognized caterpillars in Canada. It is distinctively white, yellow, and black banded, with a pair of black filaments at its head and tail; it can measure up to 5 cm in length (Carmichael and Vance 2004). In Canada, Monarch caterpillars feed only on milkweeds (Marshall 2006).

Pupa (or chrysalis)

The Monarch's chrysalis is green and gold, and is attached to a substrate, often the milkweed plant, by a pad of silk spun by the caterpillar before pupation (Marshall 2006).

Imago (or adult butterflies)

The Monarch is a large, showy, orange and black butterfly. The wings, which span 93-105 mm, have a thick black border containing two rows of circular white spots (Carmichael and Vance 2003). Male Monarchs have a distinct black spot (scent gland) on their hind wings which is lacking in female Monarchs (Carmichael and Vance 2003).

In Central Canada and the Eastern USA where their ranges overlap, the Monarch can be confused with the Viceroy (*Limenitis archippus*), which mimics the Monarch, but is larger and lacks the black line crossing the veins on the hind wing that is characteristic of the Viceroy (Carmichael and Vance 2003; Marshall 2006).

Genetic description

A recent study by Brower and Jeansonne (2004) indicates that a close genetic similarity exists among individuals and that no phylogenetic structure exists among populations throughout the species' range in North and South America. The lack of differentiation in the mtDNA of the two populations suggests that the Monarch colonized its current distribution in relatively recent evolutionary time (Brower and Jeansonne 2004).

Designatable units

The distribution of the Monarch in North America comprises two mostly disjunct populations. The Western population includes all Monarchs found west of the Rocky Mountains and the Eastern population includes all Monarchs found east of the Rocky Mountains. Recent findings suggest that there is mixing of the two populations and it has been suggested that the Western population is reinforced from Eastern butterflies (Brower and Pyle, 2004). Consequently, and despite the threats at the two overwintering areas being substantially different, the Monarch is considered to be a single designatable unit. Nonetheless, because most individuals found in British Columbia are from stock that overwinters in California, and most of the individuals from east of the Rocky Mountains in Canada overwinter in Central Mexico, it is convenient to refer to western and eastern populations and this shortform is used below without meaning to imply separate designatable units.

DISTRIBUTION

Global range

The Monarch is found naturally from Central America northwards to southern Canada, and from the Atlantic Coast westward to the Pacific Coast. It is sporadically distributed throughout the world due to introductions into the Caribbean, Hawaii, and larger islands in the Pacific Ocean (Galapagos, Solomons, Norfolk, Philippines, Taiwan, New Zealand and Australia). In the Eastern Atlantic, Monarchs are found on the Canary Islands, Madeira, the southern mainland (Spain and Portugal) and northwest Africa (Schappert, 2004).

In the Americas, Monarchs comprise five populations with different overwintering areas but without discrete genetic differentiation: the Eastern, Western, southern Florida, Cuban and Central American populations. The status of the butterfly has not been evaluated in detail on additional Caribbean Islands.

The small, resident, non-migrating population in southern Florida (see Altizer *et al.* 2000) has been breeding near the Miami airport since at least the early 1970s (L. Brower pers. comm.). Some resident populations have also been reported in Texas, but these are likely lost periodically due to freezing (L. Brower pers. comm.).

The Central American population occurs from southern Mexico to Panama (Crolla and Lafontaine 1996). Unlike the more northern populations, the Central American population is relatively sedentary and is reproductively active throughout the year (Haber 1993). It does not contribute to the numbers of Monarchs found in Canada and the United States (Crolla and Lafontaine 1996). Similarly, while the Southern Florida and Cuban populations are both reinforced by migrants from more northern populations, there is no evidence of northward movement from these populations the following spring (Dockx *et al*. 2004; Knight and Brower 2009).

The Eastern population's annual breeding range extends from the Gulf Coast States (Texas, Louisiana, Mississippi, Alabama, Georgia, and Florida) northwards to southern Canada (Alberta to New Brunswick and Nova Scotia), and from the Great Plains States and Prairie Provinces eastwards to the Atlantic Coast and the Maritime Provinces (Crolla and Lafontaine 1996). The entire Eastern population migrates annually to sites in the Oyamel Fir (*Abies religiosa*, Pinaceae) Forests of Michoacan, Mexico (Urquhart 1976; Crolla and Lafontaine 1996). The Western population's annual breeding range extends from the southwestern United States (Arizona and New Mexico) northwards to southern Canada (British Columbia) and from the Rocky Mountains westwards to the Pacific Coast (Crolla and Lafontaine 1996). The Western population overwinters at numerous sites along the coast of California (Lane 1984; Crolla and Lafontaine 1996).

Canadian range

The approximate distribution of the Monarch in Canada is shown in Figure 1. The map includes both historic and current collections and observations based on information in the database of the Canadian National Collection (CNC) of Insects at Agriculture Canada. Each dot can represent one or many records of occurrence and may indicate the presence of adult butterflies, caterpillars, or pupae (Crolla and Lafontaine 1996). Monarchs have been seen in locations not shown in Figure 1 but these omissions are vagrants outside the normal range of the species. The normally occupied portion of the species' distribution remains unchanged since 1996.

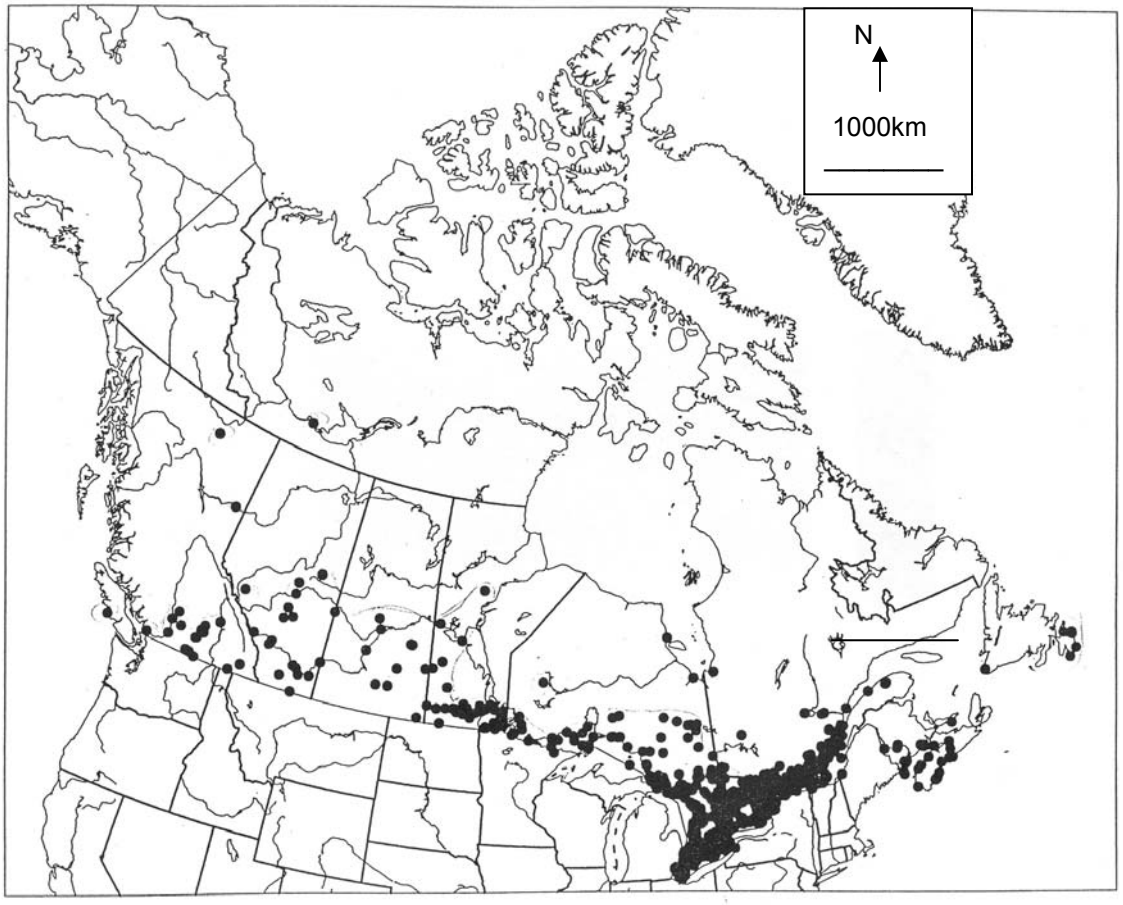

Figure 1. The distribution of the Monarch (*Danaus plexippus*) in Canada (Crolla and Lafontaine 1996).

In Canada, the Monarch has been recorded from all 10 provinces and in the Northwest Territories (Crolla and Lafontaine 1996; Layberry *et al*. 1998). The Monarch's breeding range is mainly south of the 50^{o} latitude, although in the Prairie Provinces the breeding range extends north to about 54^{o} latitude. This northern limit of the breeding range corresponds with the northern range limit of milkweeds (*Asclepias* spp.) (Crolla and Lafontaine 1996; Brower 1996). Butterflies observed north and east of the native range of milkweeds are vagrants; these include the northernmost sites shown in Figure 1 and also Newfoundland.

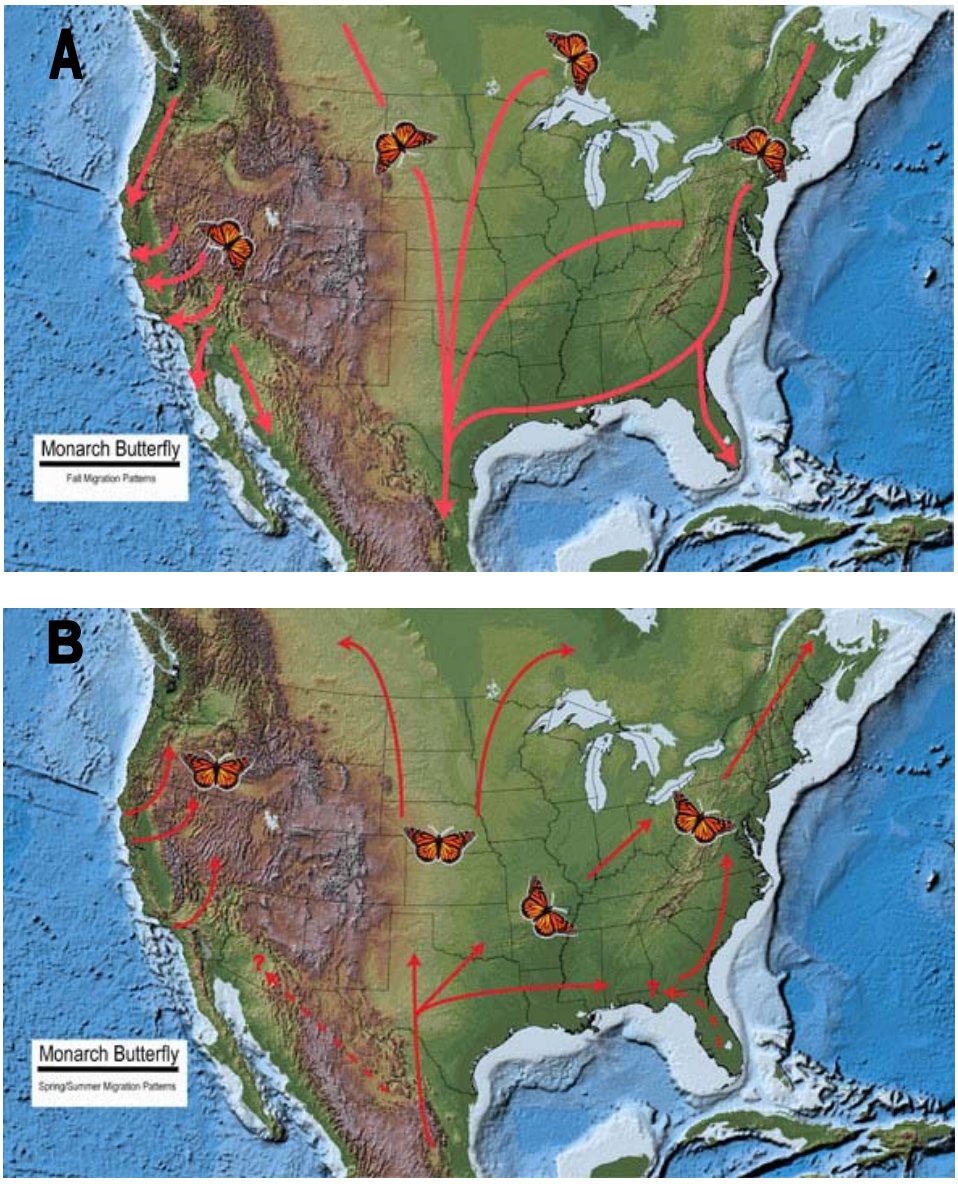

Figure 2. A. Fall migration of Monarch butterflies. B. Spring/summer migration of Monarch butterflies (Adapted from U.S. Fish and Wildlife Service. 2007. Provided by Environment Canada.).

The Eastern population of the Monarch occurs from Alberta to Newfoundland, and accounts for over 90% of the Canadian distribution of the species (Crolla and Lafontaine 1996). In the Prairie provinces and British Columbia, the breeding distribution is concentrated in the southern portion where Showy Milkweed (*Asclepias speciosa*) occurs. The abundance of Monarchs decreases northwards and westwards from Manitoba to Alberta. Southern Ontario and southern Quebec represent the most extensive area of breeding in Canada, where abandoned farmland and other open areas such as ditches, meadows and hedgerows, the prime habitat for Common Milkweed (*Asclepias syriaca*), are widespread (Crolla and Lafontaine 1996). In the Maritime provinces, breeding occurs only at scattered locations due to the limited

distribution of milkweed. In New Brunswick, breeding occurs mainly along the banks of the Saint John River, and in Nova Scotia breeding is confined mainly to the Annapolis Valley (Crolla and Lafontaine 1996; see Figure 1). Monarchs reach Newfoundland as migrants, sometimes in significant numbers, but do not breed there due to the lack of milkweeds and consequently, those found there do not contribute to future generations. In some years, Monarchs breed on Prince Edward Island on patches of Swamp Milkweed (*Asclepias incarnata*), which is native, and on Common Milkweed, which has been introduced.

The Western population of the Monarch in Canada occurs only in southern British Columbia. Breeding records are reported from scattered locations in the province, particularly in the Okanagan Valley and along the Fraser River Valley (Crolla and Lafontaine 1996; Guppy and Shepard 2001).

When vagrants are excluded, the Canadian extent of occurrence for the Monarch butterfly based upon collection records matches the combined distributions of its foodplants. The combined Extent of Occurrence for Eastern and Western populations is 3,723,867km² based upon the maps for all *Asclepias* species (Woodson 1954). Although these maps are old, the general distributions of the relevant milkweed species have not changed (Catling pers. comm.). Given the migratory nature of this species and the weather-induced variance in the extent to which it spreads north each year, the actual EO occupied fluctuates considerably from one year to the next.

HABITAT

Habitat requirements

Monarchs require four main types of habitat: overwintering, breeding, staging areas and nectaring habitat. Breeding and nectaring habitats may overlap in space but provide vary different resources. Without any one of these four types of habitats populations of Monarchs would likely not persist.

For the Eastern population, overwintering habitat is located in the Oyamel Fir Forests of Central Mexico. Millions of adult Monarchs in reproductive diapause aggregate on Oyamel Fir trees on mountains west of Mexico City (Brower 1996). The Oyamel forest is a Pleistocene relictual ecosystem that is now limited to 13 of the highest mountain areas of Mexico (2,400 to 3,600 metres elevation) and is similar in some aspects to the Boreal forest of Canada (Snook 1993). The overwintering Monarch colonies are spread over an estimated extent of occurrence of roughly 80 km x 80 km (WWF Mexico, 2007a), but GIS analysis indicates that the suitable forested areas within the right elevation cover only approximately 562 km^2 of the entire region (Slayback *et al*. 2007). Within the 562 km^2 area, the butterfly colonies are not randomly distributed. In some years, some overwintering individuals settle on the same stands of trees as their predecessors 2-4 generations removed did in previous winters, and in other years, they may settle in the same general area and elevation but up to 1.5 km away

(Slayback *et al*. 2007; see also Figure 3, especially movement between 1996/7 and 1997/8). Known overwintering colonies were found in areas of the Fir forests that had greater forest cover than randomly selected non-colony areas (Williams *et al*. 2007). From year to year, individual colonies at any one site cover from 0.0001 to 0.061 km^2, and the combined forest area of the 30 or so known overwintering colonies measured in any one year ranges from 0.022 to 0.181 km^2 (Garcia-Serrano *et al*. 2004), which is an area less than one-millionth that of the Monarch's breeding ranges (Brower 1999 as cited in Brower *et al.* 2002). The up to approximately 30 overwintering sites (WWF Mexico, 2007a) give a maximum Index of Area of Occupancy (IAO) of 120km^2 using the 2X2 grid. The high altitude forests provide a specific and unique microhabitat which allows a reduction of the metabolic rate and lowered activity from mid-November to mid-March (Brower 1996). Though usually quiescent in dense, heavy clusters on the firs, large numbers of butterflies occasionally fly to drink water from nearby streams and dewy fields, while others, possibly overheated from exposure to the sun, fly in the cold air above the canopy and reduce their body temperature (Masters *et al*. 1988).

The overwintering habitat of the Western population is located along the coast of California south into northern Baja California. Approximately 400 sites have been recorded (Schappert 2004) the vast majority of them associated with stands of non-native Australian eucalyptus trees (Crolla and Lafontaine 2006; MonarchWatch 2005), that were introduced in the 1850s (Lane 1993). The eucalyptus were widely planted for landscaping, as windbreaks, and for use as fuel, resulting in an increase in suitable overwintering habitat for Monarchs (Crolla and Lafontaine 1996). This growth of eucalyptus coincided with cutting of the dense coastal stands of native tree species, such as Monterey Pine (*Pinus radiata*) and Monterey Cypress (*Cupressus macrocarpa*), which are also used by the Monarchs as overwintering sites where they persist (Lane 1993).

The overwintering distribution of the Western population of the Monarch extends from Ensenada in Baja California to Rockport California and rarely extends more than 1 or 2km from the coast (Sakai, 2008). The distance between the northern and southern extremes is 1225km and assuming a mean width of the overwintering locations to be 2km, this gives a maximum overwintering EO of 2450km^2 for the western DU. Assuming that the approximately 400 sites are discrete and separated by 2km, the maximum IAO would be 1600km^2.

The staging areas for the butterfly along the north shores of the Great Lakes, and elsewhere, are important for both roosting and feeding. These sites include Point Pelee, Rondeau and Long Point. Given the intensive agriculture outside these protected areas, these staging areas are likely irreplaceable.

The breeding habitat of the Eastern and Western populations in Canada is confined to where milkweeds grow, since leaves of these plants are the sole food of the caterpillars. The different species of milkweeds grow in a variety of environments, including meadows in farmlands, along roadsides and in ditches, open wetlands, dry sandy areas, short and tall grass prairie, river banks, irrigation ditches, arid valleys, and south-facing hillsides. Milkweeds are also often planted in gardens.

The Monarch is known to breed on native milkweeds within their natural ranges from Nova Scotia to British Columbia, although abundantly only in southern Ontario and southern Quebec where the Common Milkweed is the principle larval foodplant (White, 1996).

Adult Monarchs will nectar (i.e. feed) at milkweed flowers but require other wildflowers especially when milkweeds are not in bloom (Crolla and Lafontaine 1996). The most commonly used other sources of nectar are goldenrods (*Solidago* spp.), asters (*Doellingeria, Eurybia, Oclemena, Symphyotrichum* and *Virgulus*), the introduced Purple Loosestrife (*Lythrum salicaria*), and various clovers (*Trifolium* spp. and *Melilotus* spp.) (Crolla and Lafontaine 1996). Some of these nectar sources are especially important during the fall migration when sugars from the nectar are converted to fat, which allows for long storage and rapid metabolization of energy reserves (Urquhart 1987; Gibo and McCurdy 1993), and which is then used to overwinter successfully (Crolla and Lafontaine 1996).

Habitat trends

Overwintering habitat

As described above, overwintering habitat for the Eastern population is located in the Oyamel Fir forests of Central Mexico. Stereographic aerial photographs of a 420.2km^2 area of the Oyamel Fir forest taken in 1971, 1984, and 1999 were analyzed using GIS (Brower *et al.* 2002). The analysis indicates that what in 1971 was a nearly continuous high-quality forest is now fragmented and severely degraded. Between 1971 and 1999, 44% of conserved forest (forest with >80% cover) was degraded, and the largest patch of high-quality forest was reduced from 271.15 km^2 to 58.27 km^2, a decrease of more than 75% (Brower *et al.* 2002). In addition, during this period, the number of conserved-forest patches increased from 13 to 60, but their mean size decreased from 21.14 to 2.54 km^2 (Brower *et al.* 2002). The annual rate of degradation from 1971 to 1984 was 1.70% and increased to 2.41% from 1984 to 1999 (Brower *et al.* 2002). At the rate of decline of 2.41% per annum, <100 km^2 of high-quality forest will remain in 20 years and <45 km^2 in 50 years.

Additional analyses quantified changes in an area measuring 66 km^2 that was divided among three of the five massifs/reserves that were declared protected by presidential decree in 1986 (Sierra Chincua, Sierra Campanario, and Cerro Chivati Huacal). Annual rates of degradation within these reserves increased threefold, from 1.3% between 1971 to 1984 to 3.17% between 1984 and 1999 (Brower *et al.* 2002).

Also from these reserves, models predict that conserved forest will have decreased by 63% in 2020 and by 90% in 2050 (from forest conditions in 1971; Brower *et al.* 2002). These projected rates of decline in conserved forest are certainly underestimates, as qualitative observations in the area indicate that logging rates (one of the major causes of decline) are sharply increasing (Brower *et al.* 2002). In addition, the data indicate that the rate of decline of conserved forest is higher in reserves than in non-reserve areas, and that the rate increased after the creation of the reserves. Declines in forest cover in areas used by the Monarch are continuing even in the core area of the reserves (Figure 3; Williams and Brower, 2007; NASA 2008).

The latest available information demonstrates that there were only 7 overwintering sites for the Monarch butterfly in 2009/2010 with a total area occupied of only 1.92 ha; the lowest area occupied by the butterflies in Central Mexico ever recorded (Rendón-Salinas *et al*. 2010).

Further difficulties are posed by the recent increase in intensity of bark beetle-induced fir mortality in the overwintering grounds. The beetles have become a problem because of decreased humidity in the area (MonarchWatch, 2009). Although less than 0.5% of the total area has been affected, the beetle outbreak is occurring in multiple sites within the area. In order to stop the spread of the beetle, Monarch conservation workers performed selective logging in 2009 with up to 9,000 trees being felled. It is estimated that 15 years of continued beetle population growth could remove the Oyamel Fir trees in the area (Taylor, personal communication).

The ecological niche modelling (ENM) approach was used to identify areas suitable for overwintering Monarch colonies in central Mexico under both current and future climate scenarios (i.e. future climate change effects) (Oberhauser and Townsend 2003). The models predicted the recent distribution of Monarchs with a high degree of accuracy, and identified specific key environmental factors which make overwintering sites suitable for Monarchs: temperature and precipitation. Two general models that differed in assumptions about CO_2 levels and sulphate aerosols predict similar temperatures to those found currently, but the predicted increase in precipitation combined with the cool temperatures is likely to result in more frequent large-scale mortality events (Oberhauser and Townsend 2003). The models also suggest that none of the current overwintering sites in the Oyamel Fir forest will be suitable for overwintering Monarchs in 50 years (Oberhauser and Townsend 2003). However, there are numerous higher altitude sites within the overwintering EO that the butterflies can return to which will likely retain suitable overwintering site characteristics with global warming.

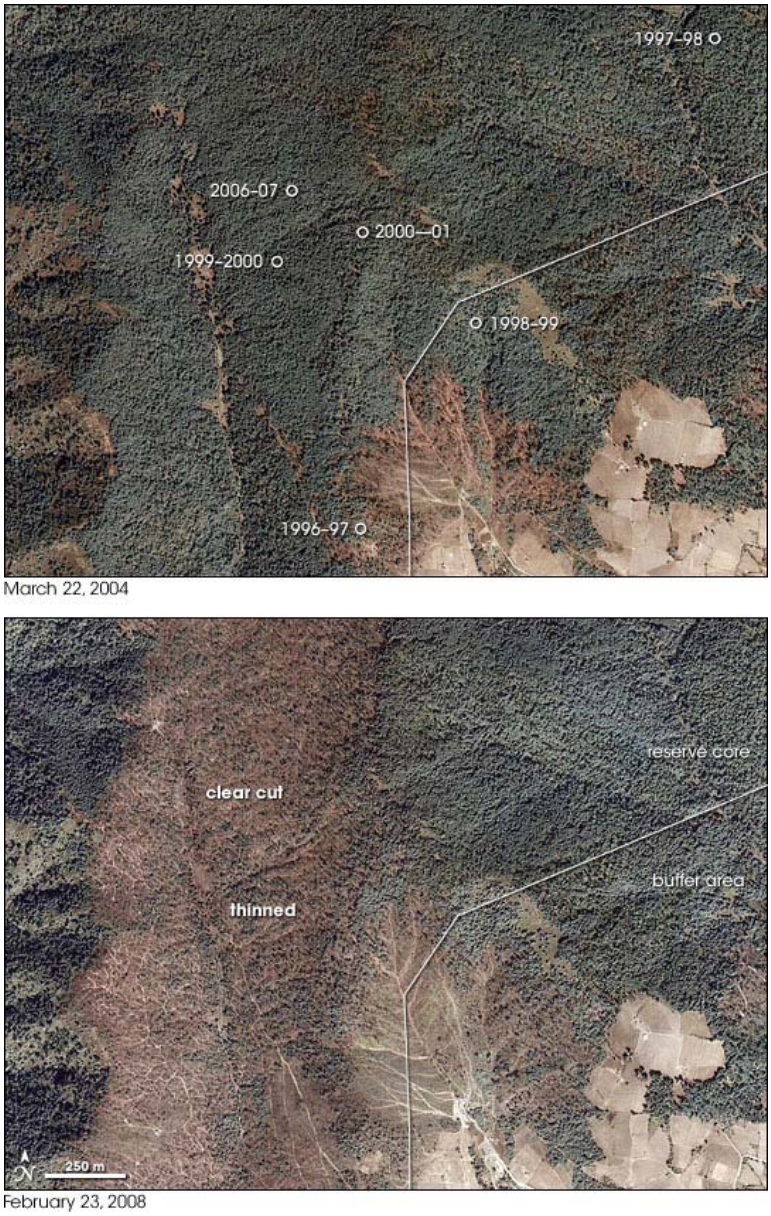

Figure 3. Aerial photographs of part of the core and buffer regions of a Monarch Preserve in Mexico in 2004 (top) and 2008 (bottom), showing loss of forest in the core area. The top figure also shows the locations of overwintering sites in different years and clearly indicates that these areas move. The size of the circles indicating overwintering sites are not scaled to fit different sizes of overwintering sites in different years. Taken from NASA (2008).

The overwintering habitat of the Western population is located along the coast of California, although, the trend in availability of overwintering habitat here has not been quantified. However, real estate development is occurring along the coast and, in addition, there are active programs in place to eliminate introduced eucalyptus trees (Crolla and Lafontaine 1996).

Breeding habitat

The breeding habitat of the Eastern population of the Monarch, which is confined to the area occupied by milkweeds, has changed over the last 150 years (Brower 1995). Until the 1880s, the prairies of central North America appear to have been the main breeding area of the Eastern population (Crolla and Lafontaine 1996). In the latter half of the 19th century, plowing destroyed 175 million hectares of the Midwestern prairie, which by 1910 had mostly been converted to cropland (Brower 1995). Concurrent with the destruction of the prairies, the deciduous forest of eastern North America was being cleared on a vast scale (Crolla and Lafontaine 1996). One result of the vast clearing and opening of the eastern deciduous forest was the rapid spread of Common Milkweed (*Asclepias syriaca*) (Crolla and Lafontaine 1996). So, the destruction of native prairie and its associated milkweeds, and the concurrent, swift spread of Common Milkweed in cleared areas in the northeast, appears to have resulted in a major shift in the core breeding range of the Eastern population, from the Great Plains to northeastern North America (Crolla and Lafontaine 1996). The historically cleared deciduous forest corresponds to the main current breeding range of the Eastern population of the Monarch (Urquhart 1960). Some people disagree regarding the supposed shift in suitable breeding habitat partly because of indigenous burning of the habitat and natural prairie in more arid areas such as oak savannah (P. Catling pers. comm., A. Wormington pers. comm.). Trends in breeding habitat of the Western population are mostly unknown, but the popularity of milkweeds as garden plants has probably increased the amount of breeding habitat in parts of British Columbia, especially since Showy Milkweed is the only native milkweed in British Columbia (Guppy and Shepard 2001).

During the middle and latter part of the 20th century it has become increasingly uneconomical to maintain small farms, and the consequent increase in abandoned farmland in the east created a substantial amount of suitable habitat for breeding and nectaring Monarchs (Crolla and Lafontaine 1996). There may be more Monarch habitat now than there ever was; especially since milkweeds are now commonly sold in nurseries and butterfly gardens have gained popularity (Rod Parrott pers. comm.). However, much of this habitat will be lost, as this abandoned farmland naturally regenerates into forest, or is converted to housing (Crolla and Lafontaine 1996). It should also be added that breeding and nectaring habitat may be lost because some of these small abandoned farms could return into active production as it becomes economically viable to grow crops, like corn, again, since growing corn as a source of biofuel is a practice subsidized by the federal government (Marketwire 2007).

Habitat protection/ownership

Shortly after the overwintering forests in Mexico were discovered in 1975 (Urquhart 1976), many authors warned of their degradation due to various factors including the logging industry (Brower *et al.* 2002). As a result, in 1980, President Jose Lopez-Portillo issued a proclamation declaring all overwintering areas of the Monarch in Mexico as wildlife reserves and refuge zones that would be protected from all uses for an indefinite

period of time (Brower *et al.* 2002). Due to the vagueness of the proclamation, Mexican federal agencies, various scientists, and environmental organizations called for a specific conservation plan (Brower *et al.* 2002). On 9 October 1986, President Miguel de la Madrid issued a decree protecting 16,110 ha of forest on 5 of the 13 mountain ranges (Brower *et al.* 2002). The area was increased by a second decree in 2000 which formed the Monarch Biosphere Reserve (Williams and Brower, 2007). Unfortunately, the decrees have not prevented the deforestation of the mountain massifs, indeed, deforestation and degradation is occurring faster in the reserves than in other parts of the Oyamel Fir forest (Brower *et al.* 2002; NASA 2008; Figure 3).

The majority of overwintering sites in California are not protected, although several sites are located within state, county, or town parks. However, this does not guarantee protection or even recognition of the overwintering sites by the park managers (Crolla and Lafontaine 1996). In the town of Pacific Grove, there has been a city ordinance against molestation of overwintering Monarchs since 1938. Yet, it affords little to no protection since it rules only against disturbing the butterflies themselves and does not protect the overwintering habitats from destruction and some of these habitats have since disappeared (Lane 1984). Fortunately, a number of coastal counties have passed ordinances protecting known overwintering trees (Malcolm 1993).

Little protection currently exists in Canada for the Monarch and its habitat. However, in October 1995, Point Pelee National Park, Long Point National Wildlife Area, and Prince Edward Point National Wildlife Area on the shores of Lake Ontario and Erie in southern Ontario were designated as Monarch reserves as part of an international agreement with Mexico (HWW 2003). These areas were already protected and it seems unlikely that additional protection is given to the butterfly as a result of these designations.

Portions of the breeding and nectaring habitats occur within several provincial and municipal parks, ecological reserves, National Wildlife Areas, etc., but road sides in these “protected” areas aren’t exempt from grading and mowing. Although Monarchs themselves may receive protection in parks and other areas, the Monarch’s main host plant, Common Milkweed, is not protected; indeed, it is considered a noxious weed in Manitoba, Ontario, Quebec and Nova Scotia. However, the abundance of this plant suggests that the legislation is having no noticeable impact upon the plants.

BIOLOGY

Life cycle and reproduction

The Monarch, like all butterflies, has a life cycle that is composed of four stages: egg, larva (or caterpillar), pupa (or chrysalis), and imago (or adult butterfly).

Monarchs mate on their overwintering grounds (in Mexico) and the frequency of mating increases as spring arrives and temperatures increase (Brower 1996). Mating continues until the start of migration in spring (Brower 1996). The first generation of the year that emerges as butterflies is immediately reproductively active and so are the following 2-3 generations. Female Monarchs may mate up to 10 times, receiving a nuptial gift in the form of a spermatophore (sperm plus vital nutrients and salts) (Suzuki and Zalucki 1986) and then probably lay up to 500 eggs on the underside of milkweed leaves (Oberhauser 1997). Each egg is laid singly, and several eggs are often laid on different leaves of the same plant or on nearby plants, occasionally resulting in dense aggregations of caterpillars in stands of milkweed (Crolla and Lafontaine 1996). The eggs hatch in 3 to 8 days (Schappert 2004) and the larvae feed on the leaves for 9 to 14 days under normal summer temperatures (Oberhauser 2004). The caterpillar moults four times and grows to a total length of 5 cm (Urquhart 1987; Carmichael and Vance 2003). In preparation for the pupal stage, the caterpillar spins a pad of silk secreted from its spinnerets on a suitable substrate, backs onto the silk pad and attaches itself with its anal claspers. It hangs upside down in the “J’ form for 16 – 23 hours (depending on temperature) as it transforms into a chrysalis (Urquhart 1987) and then undergoes metamorphosis and emerges later as a butterfly (Oberhauser 2004). Development from egg to adult butterfly can range from 20 to 45 days depending on factors such as temperature, day length, and availability of the foodplant (Crolla and Lafontaine 1996). The average is approximately 30 days (Crolla and Lafontaine 1996), although 45 days is typical for the production of a new brood for Monarchs on Point Pelee National Park (A. Wormington 2008).

In southern Canada, the Eastern population of the Monarch produces two to three generations each year between June and October (Crolla and Lafontaine 1996, Holmes *et al.* 1991). The Western population of the Monarch produces at least one generation each summer (Guppy and Shepard 2001). In the fall, the last generation that emerges is in reproductive diapause and migrates to the overwintering grounds (Crolla and Lafontaine 1996).

Feeding and predation

Adult Monarchs will feed on the nectar of many wildflowers (Crolla and Lafontaine 1996; Schappert 1996), see **Habitat requirements**.

In Canada, eggs are laid exclusively on *Asclepias* spp. In the United States of America Honeyvine Milkweed (*Cynanchum laeve*) is also used (Yeargan and Allard 2005). In Canada, the caterpillars of the Eastern population of the Monarch feed primarily on Common Milkweed (*A. syriaca*) (Crolla and Lafontaine 1996; Schappert 1996). Other larval food plants include Swamp Milkweed (*A. incarnata*), Showy Milkweed (*A. speciosa*), Low or Dwarf Milkweed (*A. ovalifolia*), and Butterfly Weed (*A. tuberosa*) (Crolla and Lafontaine 1996). Butterfly Weed is less used due to its low nitrogen and water content (Ericson 1973). Swamp Milkweed is only found in small stands in open wetlands, on river edges, and in irrigation ditches (Crolla and Lafontaine). Showy Milkweed (*A. speciosa*) is the primary larval hostplant for the Western population that breeds in British Columbia (Crolla and Lafontaine 1996). For the vast majority of Monarchs found at the Mexican overwintering site, 85% developed on Common Milkweeds and Showy Milkweeds (Showy Milkweed is very common in the U.S.) (Seiber *et al.* 1986; Malcolm 1987). When given the choice between *A. incarnata*, *A. syriaca*, *A. speciosa*, and *A. fascicularis* (Narrow-leaf Milkweed; found in British-Columbia south to Mexico), Monarchs from both the Eastern and Western populations had highest oviposition preferences for *A. incarnata* and lowest for *A. fascicularis* (Ladner and Altizer 2005). Although Monarchs will oviposit on Dog-strangling Vine (*Vincetoxicum rossicum*, an invasive introduced species in the milkweed family), larvae on this plant either have a significantly lower survival (44% versus 100% on *A. syriaca*) (DiTommaso and Losey 2003) or do not develop past the first instar, and die within 3 days (Mattila and Otis 2003). It has also been shown that Monarch larvae cannot persist on the related Dogbanes, *Apocynum* sp. (Borkin 1993).

The choice of food plant for the larva can affect predation risk for the adult since the quality of the cardenolides in the more common species of milkweed (*A. syriaca*, *A. incarnata*, *A. tuberosa*, and *A. speciosa*) is lower (i.e. less protective to the butterflies) than that found in rarer species (Roeske *et al.* 1976). Concern has been expressed regarding this reduced toxicity and the impact this may have on the level of predation, both on the feeding/breeding grounds and at the overwintering sites (Brower 1995). Two species of birds, the Black-headed Grosbeak (*Pheucticus melanocephalus*) and the Black-backed Oriole (*Icterus galbula abeillei*), feed extensively on Monarchs at the overwintering sites in Mexico. Predation has occurred at a rate of up to 34,000 butterflies killed per day (Snook 1993). For example, at one overwintering colony comprising approximately 20 million Monarch butterflies, nearly 10% (2 million) were eaten by birds over the winter (Arellano *et al.* 1993). Smaller colonies, which have a proportionally greater circumference, suffer greater rates of predation since the birds feed on the perimeter of the colony. Predation in those smaller colonies may reach as high as 44% (Calvert *et al.* 1979). The Black-eared Mouse (*Peromyscus melanotis*) also feeds extensively on both live and dead Monarchs (Glendinning 1993). This level of predation at the overwintering sites is likely a recent phenomenon, linked to the increase of Common Milkweed in eastern North America (Fink and Brower 1981). The assumption is that prior to the expansion of Common Milkweed, Monarch larvae fed on more toxic species, were more toxic as adults, and colonies suffered lower levels of predation.

Physiology

The toxicity of the Monarch butterfly comes from the plants on which the larvae feed. Cardenolides are toxic to most North American birds and vomiting is often elicited in those individuals that consume a Monarch. Common Milkweed has cardenolide concentrations ranging from 0 to 792 µg /0.1g dry weight (Malcolm and Brower 1989) and larvae that feed on plants that contain little or no cardenolides are palatable and transform into palatable butterflies (Brower *et al*. 1967).

The long migration undertaken each fall by the adult Monarchs in North America is only possible due to specific adaptations, one of which is the ability of the butterflies to store nutrients acquired from nectar sources in the form of lipids. These lipids allow for long storage and rapid metabolization of energy reserves (Gibo and McCurdy, 1993).

Dispersal and migration

The overwintering colonies in Mexico typically break up and start their northward migration in March and early April. Females that leave the overwintering sites lay eggs on the resurgent milkweed in the Gulf coast states, and die (Brower 1996). Generally, adults of subsequent generations continue the migration to the northernmost breeding range, and reach southern Canada several generations later, near the end of May and the first week of June (Wormington 2008) (Figure 2). However, some individuals that have wintered in Mexico have made the return journey to Ontario; such individuals have been recorded at Point Pelee in late April and early May (worn condition) (A. Wormington pers. comm.). It is unknown whether the bulk of the Monarchs that reach Canada are the Monarchs that came from the first generation produced in the Gulf States or if they are from subsequent cohorts, though the latter may be more prevalent.

The southward migration typically starts in early August although Monarchs can be seen heading south through to early November (A. Wormington pers. comm.). In the southernmost portion of Ontario some individuals have remained as late as December 17 and presumably died before reaching the overwintering grounds (Crolla and Lafontaine 1996). During the fall migration, Monarchs cluster together on trees along the north shores of Lake Ontario and Lake Erie to form overnight roosts. Overnight roosts can contain a few hundred to thousands of individuals and are generally located in the same areas every year. Some areas where roosts can be predictably found include Presqu'ile Provincial Park, Long Point Provincial Park, Long Point National Wildlife Area, Rondeau Provincial Park, and Point Pelee National Park (Crolla and Lafontaine 1996). The apparent reluctance of the Monarchs to fly over large bodies of water—unless climactic conditions are right (see below)—is likely the cause of the formation of these aggregations on the peninsulas. The departure of hundreds of thousands of Monarchs from Point Pelee N.P. in a given year has been observed numerous times (Wormington 1994, 1997, 2008).

The migratory routes taken by the Eastern population either concentrate in a "central flyway" which involves migration through Kansas, Oklahoma and Texas en route to Mexico, or a "eastern flyway" that travels along the Atlantic seaboard and then along the Gulf Coast (Brindza *et al*. 2008; Howard and Davis 2009). The butterflies following the central route seem to be more successful in attaining the overwintering grounds in Mexico and the more eastern ones may reinforce the Southern Florida and Cuban populations (Brindza *et al*. 2008; Howard and Davis 2009). These latter populations do not contribute returning individuals the following spring.

The Western population undergoes a similar but shorter migration from the overwintering sites (along the coast of California and south to Mexico) to the breeding range, which includes areas in Arizona, New Mexico, and inland southern British Columbia as well as the Pacific coastal states of the USA (Crolla and Lafontaine 1996) (see Figure 2). In California, fewer males than females remigrate inland.

Monarchs can reduce their energy expenditure during the fall migration to the overwintering grounds by soaring, gliding and riding columns of rising warm air to reach altitudes where strong prevailing winds speed their flight (Gibo and Pallett 1979; Gibo 1981).

A study conducted at Long Point (from 1995-2006) recorded counts that were greatest during northwest to southwest winds, which suggests that Monarchs accumulate on Long Point during unfavourable headwinds (Crewe *et al.* 2007). Monarch counts were also highest at 60-80% cloud cover and at temperatures above 20°C and below 27°C (Crewe *et al.* 2007).

Interspecific interactions

The completion of the Monarch's life cycle depends solely on a few species of milkweed; without these it cannot produce viable offspring. It is one of only a few butterflies whose larva is known to feed on milkweeds (Marshall 2006) but the milkweeds' flowers are a source of nectar for a plethora of butterflies and other insects.

The obligate protozoan parasite, *Ophryocystis elektroscirrha*, is present in Monarch populations from North America, South America, and Australia (Altizer and Oberhauser 1999). The parasite has little effect on Monarch survival or reproduction, except at high levels (1000 spores per larva) (Altizer and Oberhauser 1999). Monarchs inoculated with 1000 spores per larva had decreased survival to eclosion (hatching), emerged with smaller wingspans and lower body mass than noninoculated adults (Altizer and Oberhauser 1999). Heavily infected adults captured breeding in western North America and southern Florida were smaller than uninfected Monarchs; and among overwintering adults in Mexico and California, the proportion of adults with low and intermediate spore loads (as opposed to no spores) was higher among adults with greater wing tatter and scale loss (Altizer and Oberhauser 1999). The effects of *O. elektroscirrha* on the survival and reproduction of Monarchs are minor, but, when Monarchs from a migratory population were infected with the parasite, they exhibited

shorter flight distances, slower flight speeds, and lost proportionately more body mass per km flown compared to non-infected Monarchs (Bradley and Altizer 2005). Also, the prevalence of the parasite is associated negatively with host dispersal distance. Therefore, a continuously breeding, nonmigratory population, such as the one in southern Florida, shows high prevalence (over 70% of individuals are heavily infected); the Western population, which migrates moderate distances to overwintering sites on the Pacific Coast, shows intermediate prevalence (30% heavily infected); and the Eastern population, which travels the longest distance to the overwintering sites in Mexico, exhibits less than 8% infection (Altizer *et al.* 2000). The parasite is transmitted from mother to offspring and also during migration and overwintering, possibly when butterflies aggregate (Altizer *et al.* 2000). One possible explanation for this pattern is that long-distance migration weeds out infected Monarchs, thus reducing parasite prevalence and transmission between generations (Bradley and Altizer 2005).

Adaptability

The Monarch is an adaptable species in regards to certain aspects of its ecology. This species has withstood dramatic ecological changes (Crolla and Lafontaine 1996) and has colonized newly suitable habitat and expanded its breeding range. For example, the Western population has successfully shifted parts of its overwintering habitat from the native coastal forests of California to stands of imported, ornamental Australian eucalyptus trees. The Eastern population, however, returns to similar overwintering sites year after year; some colonies locate to unsuitable trees in degraded fir forests, only to suffer high mortality later due to increased exposure to unsuitable weather, and predation (L. Brower pers. comm.). Moreover, there have been some reports of overwintering individuals in southern Florida and Texas, but detailed information regarding these resident populations is lacking (R. Parrot pers. comm.). However, the Eastern population has undergone, in the last 150 years or so, a major shift in its main breeding range, from the Great Plains to northeastern North America, which coincided with a huge demographic and species shift in *Asclepias* (Crolla and Lafontaine 1996). Monarchs are also able to find small patches of milkweed and do not seem to be influenced by nearby human disturbances, such as roads, railways and agriculture, as long as the host plants are healthy (Crolla and Lafontaine 1996).

Monarchs have successfully rebounded from very high mortality rates at the overwintering sites in Mexico, such as occurred during the winter of 2001-2002 when a massive moisture-bearing weather system dumped over 10 cm of rain followed by ~10cm of snow, killing 74% of butterflies at Llano del Toro and 81% at El Rosario (Taylor 2002).

Monarchs have been successfully introduced to numerous countries around the world where suitable host plants grow. For more details see section on **Global range**.

POPULATION SIZES AND TRENDS

Search effort

Since the discovery of the overwintering sites in Mexico in 1975 (Urquhart 1976) , people all over North America have reported their sightings of migrating Monarchs first in journals published by the Urquharts and now on websites such as Monarch Watch. Every year, numerous Mexican researchers monitor the overwintering Monarchs and record data on survivorship and size of overwintering colonies. Participants in Monarch Watch and other programs track the progress of the migration and the distribution of Monarchs in their cities and neighbourhoods and post their findings and observations on websites and blogs such as www.Monarchwatch.org; www.mlmp.org; www.Monarchlab.org; www.hww.ca; www.naba.org. Also, organizations such as Bird Studies Canada have daily and yearly counts of adult Monarchs roosting on trees in Long Point during the migration south (Crewe *et al*. 2007). This is a species that has been and still is extensively studied, observed and admired. However, even with thousands of people observing, tagging, and studying this species, the exact migration routes are still speculative (Figure 2), and the status of the resident populations in Florida and Texas still raises questions.

In California, the most detailed data available have been collected by the Ventana Wildlife Society in Monterey County (Ventana Wildlife Society 2008). Suitable sites for butterfly overwintering are inspected at least twice annually. If Monarchs are found at a site, repeat visits are made approximately weekly to estimate abundance from October through to February.

Abundance, fluctuations and trends

Monarchs reach their lowest population levels in late winter / early spring, and reach their highest population levels in late summer and fall. Comparison of both historical and recent data indicate that the size of both Eastern and Western populations fluctuates irregularly, sometimes dramatically, as a result of variation in overwintering mortality, breeding conditions, mortality due to pesticides and herbicides, predation (Crolla and Lafontaine 1996), and weather-induced changes in population growth rates during the spring and summer (Taylor, 2009).

Based on estimates of the number of Monarch butterflies overwintering in California, the Western population likely numbers in the millions (Crolla and Lafontaine 1996) although there is substantial fluctuation among years (Ventana Wildlife Society 2008; Figure 4).

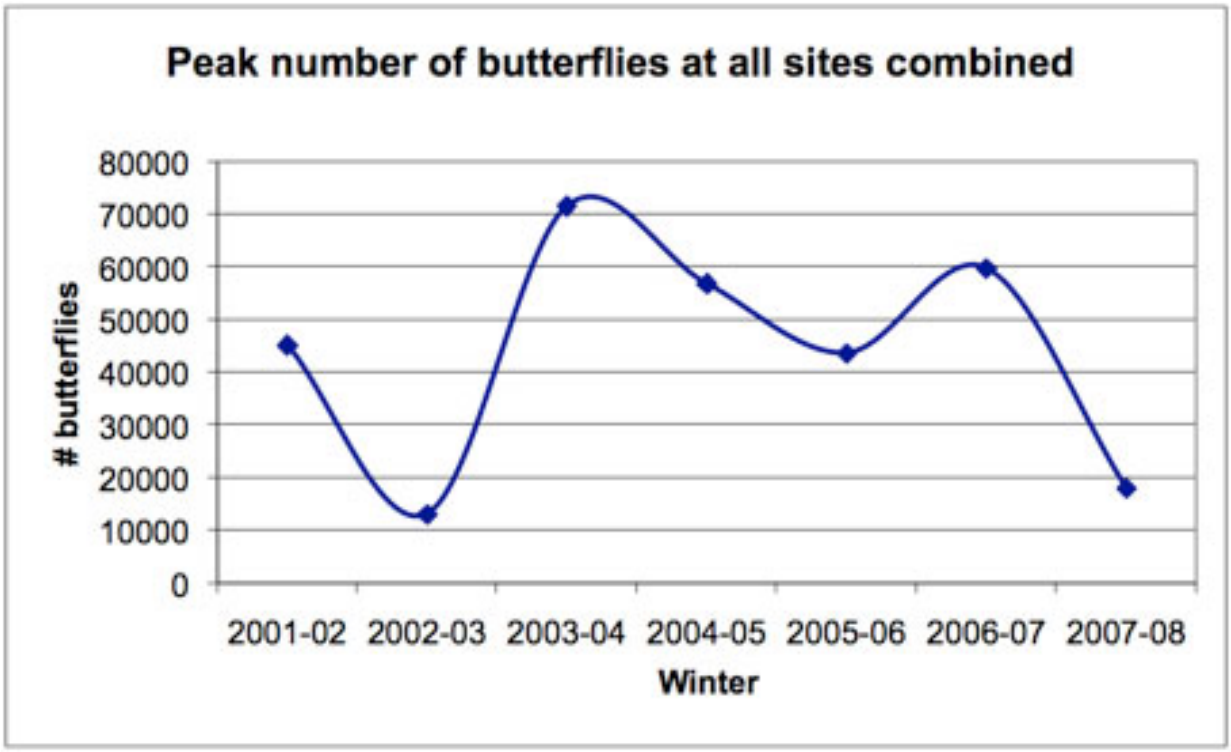

Figure 4. Changes in number of overwintering Monarch butterflies in Monterey County, California summed for all census areas (Ventana Wildlife Society, 2008).

From 1993 to 2006, in Mexico, the area covered by the ~30 overwintering colonies of the Eastern population has fluctuated between approximately 0.022 and 0.181 km^2 (Garcia-Serrano *et al.* 2004; also see MonarchWatch 2005; see Figure 5). Roosting butterflies in Mexico, on average, are found in densities of 5,000/m^2 (Brower *et al.* 2004), which means that even during the year where the area occupied by the Monarchs was the lowest (<0.02 km^2 during the winter of 2009-2010), there would have been almost 100 million butterflies. In 1996-1997, the year with the largest total area occupied by all overwintering colonies, there would have been nearly 1 billion Monarchs (Slayback *et al*. 2007).

Since monitoring began in 1993, major storms have hit the overwintering colonies in Mexico (Taylor 2002). Increased humidity at the overwintering sites causes increased Monarch mortality (Taylor, 2009). A storm in 1999-2000 caused the overwintering colony to occupy the smallest area recorded to that date. From 2001-2003 the Eastern population seemed to recover as the total area occupied by the overwintering colony increased, but then hit another all time low in the winter of 2004-2005 (Figure 5). Five reasons were stated as potential causes for this low abundance: winter storm mortality during the 2003-2004 season was high; weather during the 2004 summer breeding season in the eastern USA and southern Canada was cold and wet; colony mortality was exacerbated by habitat deterioration of the overwintering sites in Mexico; summer breeding habitat in the USA and Canada was impacted by herbicides; and herbicides also impacted adult nectar resources in the USA and Canada (ICMBSAC 2005).

Although there is no evidence that indicates that the use of herbicides was higher than average in 2004, the use of herbicides is part of the cumulative stress to which the species is exposed. Since 2004, the total area of overwintering colonies in Mexico initially increased (Figure 5) but has since declined to the lowest area on record with less than 0.02km^2 being occupied by only 7 overwintering colonies (Rendón-Salinas *et al*., 2010). Again, weather patterns are thought to be the main cause (Taylor, 2009).

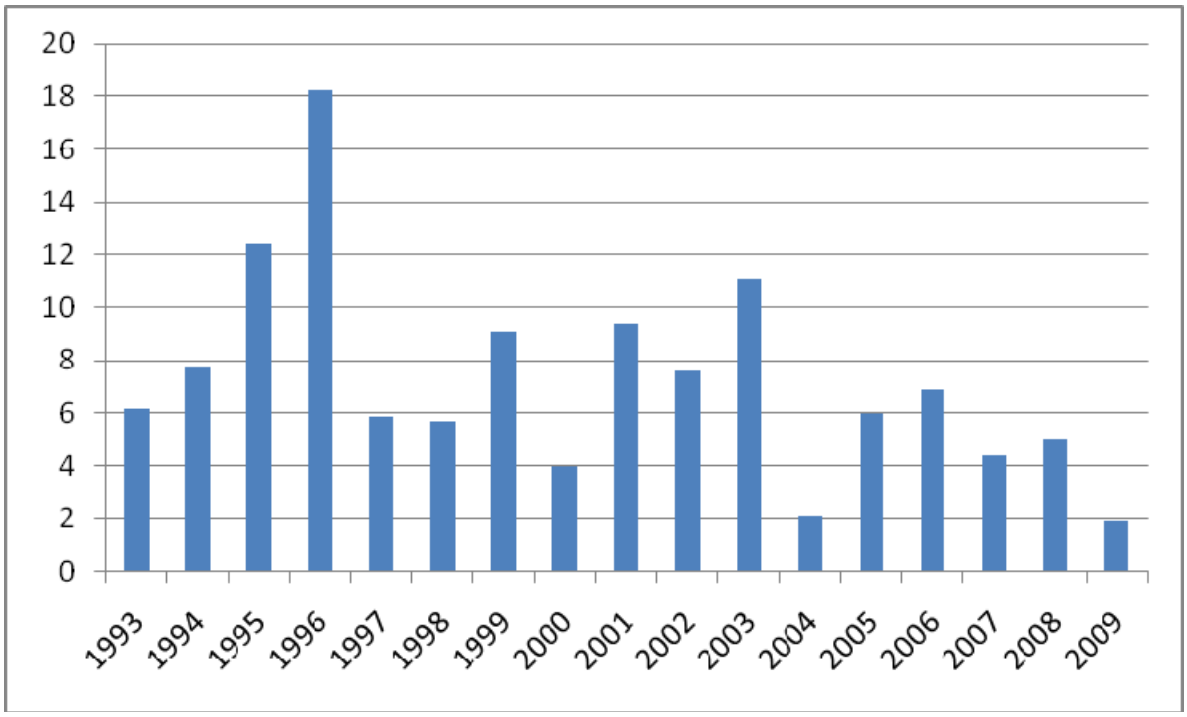

Figure 5. Total December colony area (in hectares) for Monarch butterflies overwintering in Mexico from 1993 to 2009 (modified from Rendón-Salinas *et al*., 2009).

That low populations of overwintering Monarchs are associated also with cold and wet summers is illustrated in Figure 6. The small area occupied by adults in winter 2009/2010 resulted from the cold and wet summer of 2009. Indeed, 1992, 2004 and 2009 are the coolest summers in the main breeding range of the Monarch butterfly since 1928 (Figure 6; Taylor, 2009). The 1992 event was caused by the eruption of Mount Pinatubo; the two more recent ones seem to have resulted from climate change-induced increased variance in weather conditions. The extreme low of 2009/2010 seems also to have been caused by unusually dry conditions early in the northward migration of overwintered butterflies.

Fluctuations in numbers of butterflies at the Oyamel Fir forest and California overwintering sites seem not to be coupled with each other.

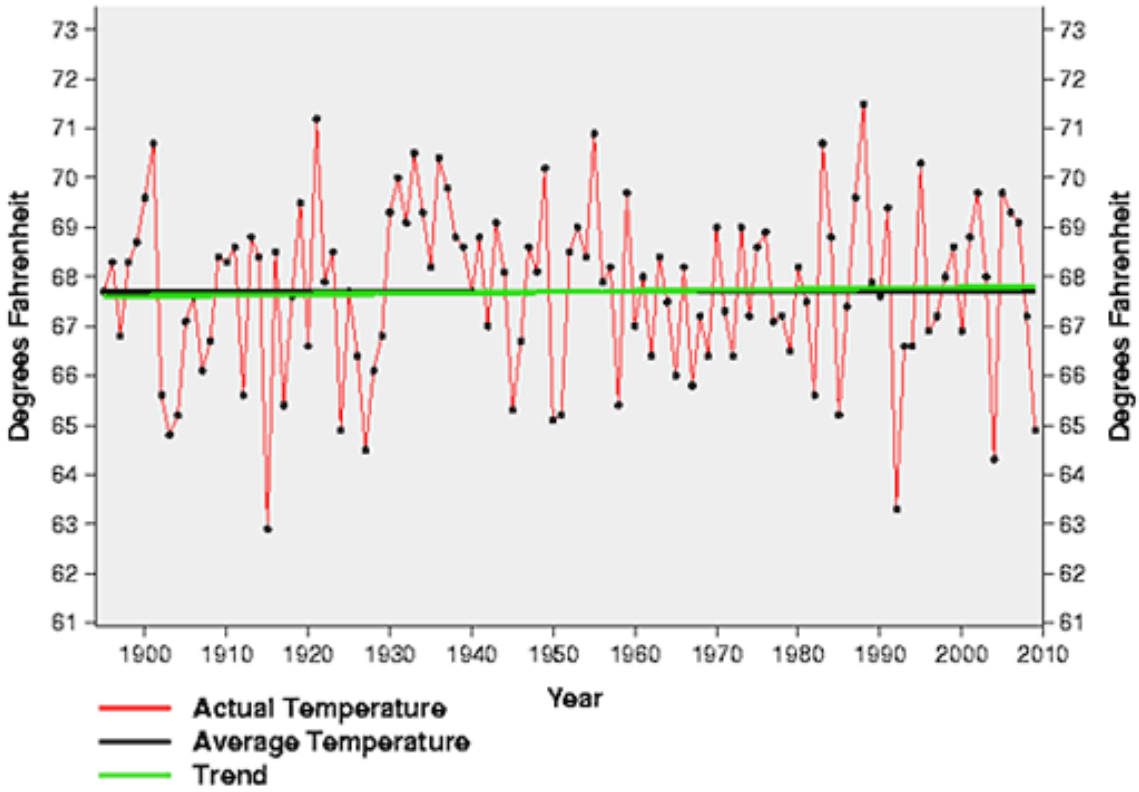

Figure 6. Mean summer (June- August) temperatures for the East North Central climatic region from 1895-2009 (from Taylor, 2009).

Monarch occurrence in each province and/or region of Canada is described in more detail below.

British Columbia

Monarchs occur erratically in British Columbia and are mostly seen in the Okanagan Valley (Crolla and Lafontaine 1996) and in low elevation areas of southern British Columbia (Guppy and Shepard 2001). Monarchs occur frequently in the 'dry' interior where the native Showy Milkweed grows, and infrequently in areas such as the Lower Fraser Valley, Vancouver Island, and the Rocky Mountain trench (Guppy and Shepard 2001). However, in 2007 Monarchs were seen west of Jasper National Park and on an island between Campbell River on Vancouver Island and the mainland (D. Davis pers. comm.).

Alberta

In Alberta, Monarchs occur rarely, and breeding occurs only in the southern region of the province where *Asclepias* can be found (Crolla and Lafontaine 1996). In 2007, Monarchs were seen breeding as far north as Edmonton and west, half way to Banff National Park (Don Davis pers. comm.).

Saskatchewan

In Saskatchewan, Monarchs are scarce and occur irregularly. In 2004, no Monarchs were seen or reported, but in 2007 several incidental reports came from Regina and Fort Qu'Appelle.

Manitoba

Few data are available as the Monarch is not tracked in the province. According to Crolla and Lafontaine (1996), Monarchs are fairly common in the south of the province, except in the southeast which is extensively wooded and supports less Monarch habitat.

Ontario and Quebec

In southern Ontario and southern Quebec, Monarchs occur annually, frequently in abundance (Crolla and Lafontaine 1996). This region is likely a significant breeding area for Monarchs overwintering in Mexico (Williams and Brower, 2007). Areas such as Long Point and Point Pelee National Park are important staging areas where Monarchs cluster by the thousands on trees that may bow under the collective weight of the butterflies that are preparing to cross the Great Lakes. Tagging programs exist at Rondeau Provincial Park and Long Point Provincial Park, and daily counts are taken during the migration at several places at Long Point (but not the Park itself) (Bradstreet pers. comm.).

In 2004 and 2005, researchers at La Mauricie National Park conducted a protection and monitoring program for the Monarch. Sections of the roadside harbouring a high number of *A. syriaca* were exempt from cutting and monitored for the presence of all life stages of Monarchs. The number of Monarchs went from 3 caterpillars and one adult in 2004 to 205 caterpillars, 7 chrysalis, and 35 adults in 2005 with the same search effort in both years (Domaine 2005).

Monarchs are very common in southern Quebec but are rarely observed north of 50^{o} latitude. In the fall, large concentrations of migrating Monarchs occur in specific areas in southern Quebec such as along Valleyfield and Missiquoi Bays (Handfield *et al.* 1999).

Atlantic Provinces

Monarchs are never common in the Atlantic Provinces due to the scarcity of milkweeds. In Nova Scotia and New Brunswick, some breeding occurs on localized patches of Swamp Milkweed (*A. incarnata*) (Crolla and Lafontaine 1996). On Prince Edward Island, where Swamp Milkweed is a rare plant (Curley, pers. comm.), breeding occurs on milkweed in the Confederation Trail. While Monarchs are seen most years in Newfoundland and the adjacent French Territory of St. Pierre and Miquelon, milkweed is not native in these areas and does not grow there (D. Davis pers. comm.); these individuals are vagrants and do not reproduce.

Yukon Territory, Northwest Territories, Nunavut

Asclepias species are absent from these regions but one vagrant Monarch has been observed in the Northwest Territories (Layberry *et al.* 1998).

Rescue effect

There is exchange of individuals between the western and eastern populations, suggesting that, in the event of the loss of one population, rescue from the other may be possible. However, it has been suggested that the western population relies on migrants from the eastern population for its persistence. The status of the resident populations in Florida and Texas remains uncertain, although presumably rescue of the eastern populations from them may be possible. These rescue effects may occur under natural conditions, rescue from the species' introduced range (see **Global range**) would not occur naturally.

LIMITING FACTORS AND THREATS

Forest degradation at the overwintering sites is probably the biggest threat facing the Monarch. For the Eastern population, the causes of forest degradation at the overwintering sites are conversion of forest to agriculture and pasture, excessive commercial logging (legal and illegal), uncontrolled harvesting of wood for domestic use, charcoal production, damage from periodic agricultural fires escaping into adjacent forests and destruction of trees by forest pests (Snook 1993; Brower and Missrie 1998 as cited in Brower *et al*. 2002; Williams and Brower, 2007). These logging practices are largely illegal, but are carried out by heavily armed gangs, thus creating openings and thinned areas in the forest (Figure 3), which expose overwintering Monarchs to winter storms, cold temperatures and wet conditions, resulting in mass mortality (Crolla and Lafontaine 1996; Taylor 2009). However, suitable forested habitat remains around each overwintering location and the precise coordinates where the butterflies congregate shifts among winters suggesting that they will shift to nearby suitable habitat for as long as appropriate conditions persist. However, suitable sites are predicted to decline in area. The modelling of future climate scenarios suggests that climate change will have an effect on the overwintering sites in Mexico. The exact effect that climate change will have on the Oyamel Fir forest is unknown but according to two general models, the current overwintering sites will become significantly less suitable for Monarchs in the next 50 years (Oberhauser and Townsend 2003). See section on **Habitat trends** for more details. The recent increased tree mortality due to bark beetles could remove all suitable tree cover in 15 consecutive years of unusually dry weather (Taylor, 2009).

Increased variance in weather conditions can both increase mortality at the overwintering site (through increased humidity causing direct mortality and increased aridity causing bark beetle-induced mortality of the trees) and over the breeding grounds (cold and wet weather, and also drought, decreases the reproductive rate) (see section on **Habitat trends** for more details).

For the Western population, forest degradation is caused mainly by real estate development along the California coast and by active programs to eliminate introduced eucalyptus trees (Crolla and Lafontaine 1996). It is not possible to estimate the impact of these small-scale events for the entire overwintering area (Sakai, 2008).

Another threat is the widespread conventional use of herbicides and pesticides across North America (Crolla and Lafontaine 1996; L. Brower pers. comm.). With the increasing use of crops such as corn (maize) and soy, and more specifically Roundup Ready crops, the spraying of pesticides and herbicides has increased in areas known to support milkweed plants (e.g. open farm fields) (Brower 2001). In the Okanagan Valley in British Columbia, vineyards and fruit orchards are prevalent and increasing in extent. Although both of these agricultural systems use large amounts of pesticides, the effects of the application of pesticides in the vineyards and fruit orchards on Monarch breeding habitat is unknown. The increase in chemical use in agriculture may have effects far beyond our current understanding. For example, the impact of *Bt* corn pollen on caterpillar larvae is a contentious issue. Some researchers report reduced survivorship of Monarch caterpillars that feed on the pollen (Hansen Jesse and Obrycki 2000; Losey *et al*. 1999), while others conclude that the impact of *Bt* corn pollen from current commercial hybrids on Monarchs is negligible (Sears *et al*. 2001). The contradiction in the conclusions may be a result of the type of transgenic corn used for the experiments as research indicates that some “strains” of transgenic corn are more toxic to butterflies than others (Zangerl *et al*. 2001).

An additional issue is that milkweeds are still listed as noxious weeds in the Noxious Weed acts of Manitoba, Ontario, Quebec (OMAFRA 2006; Schappert 1996) and Nova Scotia (NS Dep. of Agri. 2007). However, given the general observation of these plants, it seems that these acts are rarely enforced.

In Mexico, predation on adults at the overwintering sites has been listed as a potential threat. See section on **Feeding and predation** for a detailed account.

The collision of Monarchs with vehicles has been identified as a threat (Damus 2007). That Common Milkweed grows in abundance along road sides exacerbates the threat in some areas more than others, but vehicle collision is likely a threat throughout the summer range of the Monarch in Canada. The collision of Monarchs with wind turbines has been identified as a potential threat, although a dearth of research exists on that topic (Damus 2007). In Ontario, Monarchs congregate in roosts on the north shores of lakes Erie and Ontario, where wind plants are already built, planned, or proposed, and an environmental assessment is currently being reviewed for a wind plant in western Canada that is proposed for an area traversed by migrating Monarchs (Damus 2007). Wind turbines are possibly double threats as they cause habitat loss and, possibly, casualties to migrating Monarchs (Damus 2007).

The increasing prevalence of invasive species is also a threat. Although Monarchs will oviposit on Dog-strangling Vine (*Vincetoxicum rossicum*, an invasive introduced species in the milkweed family), the larvae that hatch cannot survive (for more details, see section on **Feeding and predation**).

The obligate protozoan parasite *Ophryocystis elektroscirrha* may be an additional limiting factor. The prevalence of the parasite is associated negatively with host dispersal distance and can affect flight distance (see **Interspecific interactions** for more details).

SPECIAL SIGNIFICANCE OF THE SPECIES

The migration that is undertaken by the Eastern population is unique, is currently facing numerous obstacles, and has been described as an endangered biological phenomenon (Brower 1996). The Monarch is an international symbol of nature and is used in classrooms all over North America to teach children about life, biology, metamorphosis, conservation, and an appreciation for nature. The Monarch is a poster species for international issues, conservation, and almost anything that is related to nature or wilderness, and is the centre of a large tourism industry. Many individuals have made a living using Monarchs, from selling live Monarch butterflies to promoting and selling urban butterfly gardens. From insect collectors seeking aberrant white Monarchs to researchers attempting to understand the physiology behind the incredibly long trek to the overwintering grounds, people have spent their lives chasing the Monarch and endeavoring to understand the mystery behind this insect that travels thousands of kilometres to a remote place far away, a place they've never been before.

From a research standpoint, Canada has played a significant role with regard to Monarch research. Some examples include the famous Dr. Fred and Mrs. Norah Urquhart; Monarch flight strategy research by Dr. David Gibo; studies on Monarchs and hydrogen isotope (deuterium measurements) by Dr. Keith Hobson and Dr. Len Wassenaur; and the discovery that Monarchs navigate using a time-compensated sun compass (Dr. Barrie Frost, Queen's University).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The Monarch received status under COSEWIC in 1997 when it was designated as Special Concern. The status was re-examined and confirmed in 2001. Reason for Designation (COSEWIC 2001): Although the population numbers are high and the Monarch still occurs over its entire range, it is highly restricted and vulnerable in its wintering range.

List and description of various conservation statuses for the Monarch, *Danaus plexippus* (from NatureServe)

	G-Rank	N-Rank	S-Rank	COSEWIC
Monarch (***Danaus plexippus***)	**G5 (secure)**	**N4N5B (apparently secure/ demonstrably widespread, abundant, and secure / breeding)**	Alberta (S3) British Columbia (S3B) Manitoba (S5) New Brunswick (S2B) Newfoundland (SNA) Nova Scotia (SNA) Ontario (S4) Prince Edward Island (SNA) Quebec (S5B) Saskatchewan (S3B)	SC (special concern)

S1: Critically Imperiled; S2: Imperiled; S3: Vulnerable; S4: Apparently Secure; S5: Secure; SNR: Unranked; SNA: Not Applicable; B: Breeding.

TECHNICAL SUMMARY

Danaus plexippus
Monarch Monarque
Range of Occurrence in Canada: BC, AB, SK, MB, ON, QC, NB, NS, PE

Demographic Information

Generation time (average age of parents in the population)	<6 months (probable maximum longevity of overwintering individuals)
[Observed] percent [increase] in total number of mature individuals over the last [10 years].	Both increases and decreases have been observed with a general downward trend.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [2 generations].	Hard to predict. Based upon overwintering habitat loss for the eastern population, a decline of <5% in total may be predicted in Mexico, but this is swamped by other unpredictable factors that can cause increases and decreases in populations.
[Observed] percent [reduction AND increase] in total number of mature individuals over any [10 years] period, over a time period including both the past and the future.	80% decrease in area of overwintering in Mexico in the winter of 2003/2004 likely reflects a similar decrease in number of overwintering adults. These most dramatic declines are likely due to unpredictable weather events, ongoing loss of forest habitat is more deterministic but gradual. Increases have also occurred.
Are the causes of the decline clearly reversible?	The most dramatic weather-related ones are not reversible as the weather is not reversible (though the populations have recovered from the reductions it has caused so far). The loss of forest is reversible in theory, but unlikely in practice because most of the illegal logging is performed by folks who do not seem interested in reforestation programs.
Are the causes of the decline understood?	Reasonably.
Have the causes of the decline ceased?	No.
[Observed] trend in number of populations	Likely stable.
Are there extreme fluctuations in number of mature individuals?	Almost, if area of overwintering habitat is considered as a proxy for absolute numbers: 80% decline observed 2003/2004 in the eastern population, albeit with subsequent recovery.
Are there extreme fluctuations in number of populations?	No.

Extent and Area Information

Estimated extent of occurrence	~3,843,592 km² (in Canada) For overwintering: 562km^2 for the overwintering sites in the Oyamel Fir forest 2450 km^2 for the California coastal sites.
[Observed] trend in extent of occurrence	In overwintering grounds fairly stable in California, and currently fairly stable in Mexico due to the species' ability to move from forest patch to forest patch if conditions in one become unsuitable.
Are there extreme fluctuations in extent of occurrence?	Fluctuations yes, extreme (order of magnitude?) no, its Canadian EO may perhaps be reduced by 50% in a year with bad weather in spring as butterflies move northwards.
Index of area of occupancy (IAO) *Estimated for the limiting overwintering areas outside of Canada,*	1720km^2 when a 2X2 grid is used for all overwintering sites combined.
[Observed] trend in area of occupancy	Likely declining due to destruction of forest habitat in the main overwintering areas.
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	Probably not, because of exchange of individuals during the summer generations and its highly migratory habits.
Number of current locations.	If different stands of overwintering trees are taken as locations and single logging events can remove a whole stand - <430.
Trend in number of locations	Likely stable but possibly declining given the large number of small sites in California and the small number of larger sites that seem to be declining in Mexico.
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Overall decline.

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Western	From over 200,000 to several millions
Eastern	Millions to a billion
Total	Millions to over one billion
Number of locations	~<430 locations for overwintering sites

Quantitative Analysis

	Not performed

Threats (actual or imminent, to populations or habitats)

- Destruction of overwintering habitat by logging, especially for the eastern population.
- Climate change will reduce the total area of suitable habitat especially for the eastern population which overwinters in montane areas. Bark beetles are killing trees in this same region.
- Increasing weather variability can result in decreased survival overwinter, decreased success of northward migration and decreased reproduction away from the overwintering grounds.
- Pesticides, herbicides, destruction of habitat for the larval foodplant throughout.

Rescue Effect (immigration from an outside source)

Status of outside populations? Many extralimital populations are known, their status and sizes are variable	
Is immigration known?	Origin of the non-migratory populations in Florida and Texas is unknown; they receive individuals from migratory populations but may not contribute to them. Exchange with the Central American and other populations outside of North America does not occur naturally.
Would immigrants be adapted to survive in Canada?	In summer, yes.
Is there sufficient habitat for immigrants in Canada?	For the summer, yes.
Is rescue from outside populations likely?	Unlikely naturally from Florida and Texas. All Canadian individuals arrive from the USA and Mexico.

Current Status

COSEWIC: Special Concern (April 2010)
Ontario: Special Concern

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Special Concern	Not applicable

Reasons for Designation:
This species has a population of millions to over one billion individuals. The most sensitive stage of its annual cycle is overwintering. There are two main overwintering areas: the Oyamel Fir forests of Central Mexico, where 90% of the population overwinters, and coastal regions of California. The overall area of these sites is relatively small, and threats, especially from logging in the Oyamel Fir forests, are sufficient to suggest that the species could become Threatened in the near future.

Applicability of Criteria

Criterion A (Declining Total Population): Not applicable. Rate of decline likely does not meet level required for Threatened.

Criterion B (Small Distribution, and Decline or Fluctuation): Not applicable. EO is well above 20,000 km². IAO is below 2,000 km² but does not meet enough of the subcriteria.

Criterion C (Small Total Population Size and Decline): Not applicable. Population estimated to be in the millions.

Criterion D (Very Small Population or Restricted Distribution): Not applicable. Population estimated to be in the millions and the total IAO for the overwintering sites is large.

Criterion E (Quantitative Analysis): Not done.

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Authorities consulted

Anderson, Robert
Entomology Research Scientist
Canadian Museum of Nature
P.O. Box 3443 - Station D
Ottawa ON

Brower, Lincoln
Research Professor of Biology
Sweet Briar College
Sweet Briar, VA 24595

Cannings, Syd
Coordinator, NatureServe Yukon
Canadian Wildlife Service
91780 Alaska Highway
Whitehorse YT

Carriere, Suzanne
Ecosystem Management Biologist
Wildlife Division
Department of Environment
and Natural Resources (ENR)
Government of the Northwest Territories
600 - 5102 50th Avenue
Scotia Centre, 5th Floor
Yellowknife

Catling, Paul
Research Scientist and Curator
Saunders Bldg., Central Experimental Farm
Ottawa ON

Davis, Don
Toronto, Ontario

Djan-Chékar, Nathalie
Curator of Botany
Natural History Unit
Provincial Museum of Newfoundland & Labrador
St. John's NL

Filion, Alain
Scientific and Geomatics Project Officer
Assessment Section, COSEWIC Sec.
Species at Risk Division
Ottawa, Ontario
Canadian Wildlife Service

Lakusta, Thomas
Manager, Forest Resources
Forest Management Division
Department of Environment
and Natural Resources (ENR)
Government of the Northwest Territories
Box 4354, #173 Hay River Dene Reserve
Hay River NT

Nantel, Patrick
Conservation Biologist
Species at Risk Program
Ecological Integrity Branch
Parks Canada
25 Eddy St., 4th Fl., 25-4-S
Gatineau QC

Oldham, Michael J.
Botanist/Herpetologist
Natural Heritage Information Centre
Robinson Pl 2nd Flr N
Peterborough, Ontario

Packer, Laurence
Department of Biology
York University
4700 Keele Street
Toronto ON

Parrot, Rod
Butterfly Farming Specialist
69 Francis Street
Port Hope, Ontario

Pepper, Jeanette
Zoologist
Biodiversity Conservation Section
Fish and Wildlife Branch
Saskatchewan Environment
3211 Albert Street - Room 436
Regina SK

Powers, John
Butterfly Expert
240 Waterloo Street North
Cambridge, Ontario

Taylor, Orley
Entomologist
University of Kansas
Lawrence, KS
USA 66045

Toner, Maureen
Biologist
Species at Risk Program
Fish and Wildlife Branch
Department of Natural Resources
Hugh John Flemming Forestry Centre
P.O. Box 6000
Fredericton, NB

Watkins, William
Wildlife and Ecosystem Protection
Branch
Manitoba Department of Conservation
P.O. Box 24
200 Saulteaux Crescent
Winnipeg MB

INFORMATION SOURCES

Altizer, S.M. and K.S. Oberhauser. 1999. Effects of the Protozoan Parasite *Ophryocystis elektroscirrha* on the Fitness of Monarch Butterflies (*Danaus plexippus*). Journal of Invertebrate Pathology 74(1): 76-83.

Altizer, S.M., K.S. Oberhauser and L.P. Brower. 2000. Associations Between Host Migration and the Prevalence of a Protozoan Parasite in Natural Populations of Adult Monarch Butterflies. Ecological Entomology 25: 125-139.

Arellano, G., J.I. Glendinning, J.B. Anderson, and L.P. Brower. 1993. Interspecific comparisons of the foraging dynamics of black-backed orioles and black-headed grosbeaks on overwintering Monarch butterflies in Mexico. pp. 315-322. *In* Malcolm, S.B. and M.P. Zalucki (eds.), Biology and conservation of the Monarch butterfly. Publications of the Natural History Museum of Los Angeles County, Los Angeles, California. Science series no.38

Borkin, S.S. 1993. Rejection of *Apocynum androsaemifolium* and *A. sibiricum* (Apocynaceae) as food plants by larvae of *Danaus plexippus*: Refutation of Early Accounts. pp. 125-128. *In* Malcolm, S.B. and M.P. Zalucki (eds.), Biology and conservation of the Monarch butterfly. Publications of the Natural History Museum of Los Angeles County, Los Angeles, California. Science series no.38

Bradley, C.A. and S. Altizer. 2005. Parasites Hinder Monarch Butterfly Flight: Implications for Disease Spread in Migratory Hosts. Ecology Letters 8(3): 290-300.

Bradstreet, Michael. Personal Communication. April 20, 2010.

Brindza, L.J., L.P. Brower, A.K. Davis and T. van Hook. 2008. Comparative success of Monarch Butterfly migration to overwintering sites in Mexico from inland and coastal sites in Virginia. Journal of the Lepidopterist's Society 62:189-200.

Brower, Andrew V.Z. and Miranda M. Jeansonne. 2004. Goegraphical Populations and "Subspecies" of New World Monarch Butterflies (Nymphalidae) Share a Recent Origin and Are Not Phylogenetically Distinct. Annals of the Entomological Society of America. pp. 519-523.

Brower, Lincoln P. Personnal communications July and August 2007.

Brower, Lincoln P. 1995. Understanding and Misunderstanding the Migration of the Monarch Butterfly (Nymphalidae) in North America: 1857-1995. Journal of the Lepidopterists Society. 49: 304-385.

Brower, Lincoln P. 1996. Monarch Butterfly Orientation: Missing Pieces of a Magnificent Puzzle. The Journal of Experimental Biology 199:93-103.

Brower, Lincoln P. 1999. Biological Necessities for Monarch Butterfly Overwintering in Relation to the Oyamel Forest Ecosystem in Mexico. Pages 11-28 in J. Hoth, L. Merino, K. Oberhauser, I. Pisanty, S. Price, and T. Wilkinson, editors. Paper presentation: 1997 North American Conference on the Monarch Butterfly. The Commission for Environmental Cooperation, Montreal.

Brower, L.P. 2001. Canary in the Cornfield: the Monarch and the *Bt* Corn Controversy. Lepidoptera News 4: 8-15.

Brower, L.P., J.V.Z. Brower, and J.M. Corvino. 1967. Plant Poisons in a Terrestrial Food Chain. Zoology 57: 893-898.

Brower, Lincoln P., Guillermo Castilleja, Armando Peralta, Jose Lopez-Garcia, Luis Bojorquez-Tapia, Salomon Diaz, Daniela Melgarejo, and Monica Missrie. 2002. Quantitative Changes in Forest Quality in a Principal Overwintering Area of the Monarch Butterfly in Mexico, 1971-1999. Conservation Biology 16(2): 346-359.

Brower L.P., Kust D.R., Rendon-Salinas E, Serrano E.G., Kust K.R., Miller J, Fernandez del Rey C, Pape K. 2004. Catastrophic Winter Storm Mortality of Monarch Butterflies in Mexico During January 2002. *In* Oberhauser K.S., Solensky M.J., editors.The Monarch butterfly: biology and conservation. Ithaca: Cornell University Press. p. 151–66.

Brower, L.P. and M. Missrie. 1998. Fires in the Monarch Butterfly Sanctuaries in Mexico, Spring 1998. Que Pasa (Toronto) 3:9-11.

Brower, L.P., and R.M. Pyle. 2004. The interchange of migratory Monarchs between Mexico and the western United States, and the importance of floral corridors to the fall and spring migrations. In: Nabhan, G., ed., Conservation of migratory pollinators and their nectar corridors in North America. Arizona-Sonora Desert Museum, Natural History of the Sonoran Desert Region, No. 2. Tucson, Arizona: University of Arizona Press.

Calvert, W.H., L.E. Hedrick and L.P. Brower. 1979. Mortality of the Monarch Butterfly (*Danaus plexippus* L.): Avian Predation at Five Overwintering Sites in Mexico. Science 204: 847-851.

Catling, Paul. Personal communication. November 2007.

Carmichael, Ian and Ann Vance. 2003. Photo Field Guide to the Butterflies of Southern Ontario. St. Thomas Field Naturalist Club Inc., St. Thomas, Ont., Aylmer Express.

Carmichael, Ian and Ann Vance. 2004. Photo Field Guide to Some Caterpillars of Southern Ontario. St. Thomas Field Naturalist Club Inc., St. Thomas, Ont., Aylmer Express.

Crewe, T.L., J.D. McCracken, and D. Lepage. 2007. Population Trend Analyses of Monarch Butterflies Using Daily Counts During Fall Migration at Long Point, Ontario, Canada (1995-2006). Produced for the United States Fish and Wildlife Service. Bird Studies Canada, Port Rowan, ON, Canada.

Crolla, Jeffrey P. and J. Donald Lafontaine.1996. COSEWIC Status Report on the Monarch Butterfly. 23 pp.

Curley, Rosemary. Personal Communnication. April 20, 2010.

Damus, M. 2007. Wind Plant Consequences to Butterflies – How Much Do We Know? *In* Tall Structures and Birds/Bats Information Group Volume 4, Issue 1

Davis, Donald. Personal communications. May–December 2007.

DiTommaso, A. and J.E. Losey. 2003. Oviposition Preference and Larval Performance of Monarch Butterflies (*Danaus plexippus*) on Two Invasive Swallow-wort Species. Entomologia Experimentalis et Applicata 108(3): 205-209.

Dockx, X., L.P Brower, L.I. Wasserman and K.A. Hobson. 2004. Do North American Monarch Butterflies travel to Cuba? Stable isotope and chemical tracer techniques. Ecological Applications 14 :1106-1114.

Domaine, E. 2005. Protection Des Sites de Reproduction du Monarque (Danaus plexippus) et Suivi des Populations de 2004 et 2005. Presented to Parks Canada. Parc national de la Mauricie. 27 pp.

Ericson, J.M. 1973. The Utilization of Various *Asclepias* Species by Larvae of the Monarch Butterfly, *Danaus plexippus*. Psyche 80: 230-248.

Fink, L.S. and L.P. Brower. 1981. Birds Can Overcome the Cardelonide Defense of Monarch Butterflies in Mexico. Nature 291: 67-70.

Garcia-Serrano, E., J.L. Reyes, and B.X. Alvarez. 2004. Locations and Areas Occupied by Monarch Butterflies Overwintering in Mexico from 1993 to 2002, pp. 129-133. *In* K. Oberhauser and M.J. Solensky (eds.), Monarch Butterfly Biology and Conservation. Cornell University Press, Ithaca, NY.

Gibo, David L. 1981. Altitudes Attained by Migrating Monarch Butterflies, *Danaus plexippus* (Lepidoptera: Danaidae) as Reported by Glider Pilots. Canadian Journal of Zoology 59(3): 571-572

Gibo, D.L. and J.A. McCurdy. 1993. Lipid Accumulation by Migrating Monarch Butterflies, *Danaus plexippus*, (Nymphalidae). Canadian Journal of Zoology 71: 76-82.

Gibo, D.L. and M.J. Pallett. 1979. Soaring flight of monarch butterflies, *Danaus plexippus* (Lepidoptera: Danaidae), during the late summer migration in southern Ontario. Canadian Journal of Zoology. 57:1393-1401.

Glendinning, J.I. 1993. Comparative Feeding Responses of the Mice *Peromyscus melanotis*, *P. aztecus*, *Reithrodontomys sumichrasti*, and *Microtus mexicanus* to Overwintering Monarch Butterflies in Mexico. pp. 323-333. *In* Malcom, S.B. and M.P. Zalucki (eds.), Biology and conservation of the Monarch butterfly. Publications of the Natural History Museum of Los Angeles County, Los Angeles, California. Science series no.38

Guppy, C.S. and J.H. Shepard. 2001. Butterflies of British Columbia: Including Western Alberta, Southern Yukon, the Alaskan Panhandle, Washington, Northern Oregon, Northern Idaho and Northwestern Montana. UBC Press, Vancouver, B.C . 414 pp.

Haber, W.A. 1993. Seasonal migration of Monarchs and other butterflies in Costa Rica. pp. 201-207. *In* Malcom, S.B. and M.P. Zalucki (eds.), Biology and conservation of the Monarch butterfly. Publications of the Natural History Museum of Los Angeles County, Los Angeles, California. Science series no.38.

Handfield, L., J.D. Lafontaine, B. Landry, F. Lessard, D. Rancourt, E. Rassart and P. Thibault. 1999. Le Guide des Papillons du Québec. Volume 1. Broquet inc., Ottawa. 123 pp.

Hinterland Who's Who (HWW).2003. www.hww.ca [accessed in May 2007].

Holmes, A.M.; Hess, Q.F.; Tasker, R.R. and Hanks, A.J. 1991. The Ontario Butterfly Atlas. Toronto Entomologists' Association, Toronto, 167 pp.

Howard, E. and A.K. Davis. 2009. Fall migration flyways of monarch butterflies in eastern North America revealed by citizen scientists. Journal of Insect Conservation online doi 10.1007/s10841=008-9169-y accessed September 22nd 2009.

Informally Constituted Monarch Butterfly Scientific Advisory Committee (ICMBSAC). 2005. Reduced Numbers of Monarch Butterflies Overwintering in Mexico During the 2004-2005 Season: Evidence, Possible Causes and Recommendations. From www.monarchwatch.org/update/2005/0221_Sci_Adv_Rpt_11.pdf

Klinkenberg, Brian (editor). 2009. Biodiversity of British Columbia. Department of Geography, University of British Columbia Living Book (Second Edition--First Edition 2008).

Knight, A. and L.P. Brower. 2009. The influence of Eastern North American autumnal migrant Monarch Butterflies (*Danaus plexippus* L.) on continuously breeding resident Monarch populations in Southern Florida. Journal of Chemical Ecology online: doi 10.1007/s10886-009-9655-z accessed September 22nd 2009.

Ladner, D.T. and S. Altizer. 2005. Oviposition Preference and Larval Performance of North American Monarch Butterflies on Four *Asclepias* Species. Entomologia Experimentalis et Applicata 116(1): 9-20.

Lane, J. 1984. The Status of Monarch Butterfly Overwintering Sites in Alta California. Atala 9:17-20.

Lane, J. 1993. Overwintering Monarch Butterflies in California: Past and Present. pp. 335-344. *In* Malcolm, S.B., and M.P. Zaluchi (eds), Biology and Conservation of the Monarch Butterfly. Publications of the Natural History Museum of Los Angeles County, Los Angeles, California. Science series no.38.

Layberry, Ross A., Peter W. Hall, and J. Donald Lafontaine. 1998. Butterflies of Canada. University of Toronto Press. 280 pp.

Malcolm, S.B. 1987. Monarch Butterfly Migration in North America: Controversy and Conservation. Trends in Ecology and Evolution 2(5): 135-138.

Malcolm, S.B. 1993. Conservation of Monarch Butterfly Migration in North America: an Endangered Phenomenon. pp. 357-361. *In* Malcom, S.B., and M.P. Zaluchi (eds), Biology and Conservation of the Monarch Butterfly. Publications of the Natural History Museum of Los Angeles County, Los Angeles, California. Science series no.38.

Malcolm, S.B., and L.P. Brower. 1989. Evolutionary and Ecological Implications of Cardenolide Sequestration in the Monarch Butterfly. *Experientia* 45:284-295.

Marketwire 2007. http://www.marketwire.com/mw/release.do?id=748804 [accessed in September 2007]

Marshall, Stephen A. 2006. Insects: Their Natural History and Diversity. Firefly Books Ltd., Richmond Hill, Ont., pp. 166-68, 185.

Masters, A.R., S.B. Malcolm, and Lincoln P. Brower.1988. Monarch Butterfly (*Danaus plexippus*) Thermoregulatory Behavior and Adaptations for Overwintering in Mexico. Ecology 69:458-467.

Mattila, H.R. and G.W. Otis. 2003. A Comparison of the Host Preference of Monarch Butterflies (*Danaus plexippus*) for Milkweed (*Asclepias syriaca*) Over Dog-strangler Vine (*Vincetoxinum rossicum*). Entomologia Experimentalis et Applicata 107(3): 193-199.

MonarchWatch. 2005. http://www.MonarchWatch.org/update/ 2005/0221_Sci_Adv _Rpt_11.pdf (Reduce Numbers of Monarch Butterflies Overwintering in Mexico During the 2004-2005 Season: Evidence, Possible Causes and Recommendations)[accessed July 2007]

NASA. 2008. http://earthobservatory.nasa.gov/IOTD/view.php?id=8506. [ccessed May 16th, 2009.]

Nature Serve. 2007. http://www.natureserve.org/ [accessed January 2008]

Nova Scotia Department of Agriculture (NS Dep of Agri.). 2007. http://www.gov.ns.ca/agri/rir/weeds/ [accessed August 2007]

Oberhauser K.S. 1997. Fecundity and Egg Mass of Monarch Butterflies: Effects of Age, Female Size and Mating History. Functional Ecology 11: 166-75.

Oberhauser K.S. (2004) Overview of Monarch Breeding Biology. Pp. 3-8 *In* The Monarch Butterfly: Biology and Conservation. Oberhauser K.S., Solensky M.J. (eds). Cornell University Press, Ithaca, NY

Oberhauser, K., and A. Townsend Peterson. 2003. Modeling Current and Future Potential Wintering Distributions of Eastern North American Monarch Butterflies. Proceedings of the National Academy of Sciences of the United States of America 100:14063-14068.

OMAFRA 2006. http://www.omafra.gov.on.ca/english/crops/facts/info_milkweed.htm [accessed in August 2007]

Parrot, Rod. Personal Communication. August 11, 2007.

Pepper, Jeanette. Personal Communication. June 28, 2007.

Pepper, Jeanette. Personal Communication. April 14, 2010.

Powers, John. Personal Communication. August 11, 2007.

Rendón-Salinas, E., C.A. Valeras_Bermejo, S. Rodríguez-Mejía and F. Martínez-Meza. 2010. Monitoreo de las colonias de Hibernación de Mariposa Monarca: Superficie Forestal de Ocupación en Diciembre de 2009. http://www.wwf.org.mx/wwfmex/descargas/rep-monitoreo-superficie-colonias-mariposa-monarca-2009-2010.pdf accessed February 13th 2010.

Ritland, D.B., and L.P. Brower. 1991. The Viceroy is Not a Batesian Mimic. Nature 350: 497-498.

Roeske, C.N., J.N. Seiber, L.P. Brower, and C.M. Moffit. 1976. Milkweed Cardenolides and their Comparative Processing by Monarch Butterflies (*Danaus plexippus* L.). Recent Advances in Phytochemistry 10: 93-167.

Sakai, W. 2008. Personal communication to Laurence Packer, May 19th, 2008.

Schappert, Phil. 1996. Distribution, Status and Conservation of the Monarch Butterfly, *Danaus plexippus* (L.), in Canada. Report Submitted to the Commission for Environmental Cooperation, Québec, Canada.

Shappert, Phil. 2004. Monarch Butterflies: Saving the King of the New World. Key Porter Books, Toronto, Ont., 128 pp.

Seiber, J.N., L.P. Brower, S.M. Lee, M.M. McChesney, H.T.A. Cheung, C.J. Nelson, and T.R. Watson. 1986. Cardelonide Connection Between Overwintering Monarch Butterflies from Mexico and Their Larval Food Plant *Asclepias syriaca*. Journal of Chemical Ecology 12: 1157-1170.

Slayback, D.A., L.P. Brower, M.I. Ramírez, and L.S. Fink. 2007. Establishing the Presence and Absence of Overwintering Colonies of the Monarch Butterfly in Mexico by the Use of Small Aircraft. American Entomologist: 27-40.

Snook, L.C. 1993. Conservation of the Monarch Butterfly Reserves in Mexico: Focus on the Forest. Pages 363-375 *In* Malcom, S. B. and M. P. Zalucki (eds.), Biology and conservation of the Monarch butterfly. Publications of the Natural History Museum of Los Angeles County, Los Angeles, California. Science series no.38.

Suzuki, Y. and M.P. Zalucki. 1986. The Influence of Sex Ratio on Female Dispersal in *Danaus plexippus* (L.)(Lepidopetra: Danaidae). Journal of the Australian Entomological Society 25: 31-35.

Taylor, O.R. 2002. Monarch Watch: 2001 Season Summary. 68 pp. Available at www.monarchwatch.org.

Taylor, O.R. 2009. Monarch population status. Available at www.monarchwatch.org.

Urquhart, F.A. 1960. The Monarch Butterfly. University of Toronto Press, Toronto. 361 pp.

Urquhart, F.A. 1976. Found at Last: The Monarch's Winter Home. National Geographic. 150: 160-173.

Urquhart, Fred A.1987. The Monarch Butterfly: International Traveller. Nelson-Hall, Chicago. 42 pp.

Urquhart, F.A. and N.R. Urquhart. 1979. Breeding Areas and Overnight Roosting Locations in the Northern Range of the Monarch Butterfly (*Danaus plexippus*) With a Summary of Associated Migratory Routes. Canadian Field-Naturalist. 93(1): 41-47.

Ventana Wildlife Society. 2008. http://www.ventanaws.org/conservation/monarchs.htm [accessed, May 16th, 2009]

Wahlberg, N., E. Weingartner and L. Soren 2003. Towards a better understanding of the higher systematics of Nymphalidae (Lepidoptera: Papilionoidea). *Molecular* Phylogenetics and Evolution 28: 473–484.

White, D.J. 1996. The milkweeds of Canada (*Asclepias*), Status, distribution, and potential impacts from noxious weeds legislation. Report prepared for the CWS, accessed from Monarch Watch, June 14, 2008. http://www.monarchwatch.org/read/articles/canweed6.htm#info

Williams, J., D. Stow, and L. Brower, 2007. The Influence of Forest Fragmentation on the Location of Overwintering Monarch Butterflies in Central Mexico, Journal of the Lepidopeterist's Society 61: 90-104.

Woodson, R.E., Jr. 1954. The North American species of *Asclepias* L. Annals of the Missouri Botanical Garden 41:1-211.

Wormington, Alan. Personal Communication. January 2007.

Wormington, A. 1994. A Mass Migration of Monarchs at Point Pelee, Ontario. Toronto Entomologists Association, Occasional Publication #26-94, pp. 26-27.

Wormington, A. 1997. Another Mass Migration of Monarchs at Point Pelee, Ontario. Toronto Entomologists Association, Occasional Publication #29-97, p. 11.

Wormington, A. 2008. The Butterflies of Point Pelee National Park, Ontario. Unpublished Manuscript.

WWF Mexico. 2007a. http://www.wwf.org.mx/wwfmex/ecot_mm.php [accessed May 2009]

WWF Mexico. 2007b. http://www.wwf.org.mx/wwfmex/ [accessed in August 2007]

Yeargan, K.V. and C.M. Allard. 2005. Comparison of Common Milkweed and Honeyvine Milkweed (Asclepiadaceae) as Host Plants for Monarch Larvae (Lepidoptera: Nymphalidae). Journal of the Kansas Entomological Society. 78(3): 247-251.

BIOGRAPHICAL SUMMARY OF REPORT WRITER

Karine Bériault is a BSc Honours graduate in Zoology from the University of Guelph. She also completed an MSc in Zoology from the same university where she studied the Jefferson Salamander for over three years. Her Master's thesis investigated the habitat selection and ecology of Jefferson Salamanders throughout their Canadian range. Karine is very interested in work related to endangered wildlife and species at risk, including both flora and fauna, and actively participating in their protection and recovery. She is also currently writing the Management Plan for the Monarch.

Appendix 1. List of Parks Canada lands and National Wildlife Areas where Monarchs have been reported.

British Columbia:

Pacific Rim National Park Reserve – probably present as vagrant, maybe resident, breeding has not been confirmed

Saskatchewan:

Prince Albert National Park – present, accidental-nonregular

Grasslands National Park – observed by Jeanette Pepper

Manitoba:

Riding Mountain National Park – regular (small populations are found every year in the park)

Ontario:

Bruce Peninsula National Park – present only as transient(?), regular (C. Jones, pers observation).

Fathom Five National Marine Park – present only as transient

Fort St. Joseph National Historic Site – present only as transient

Georgian Bay Islands National Park – regular

Point Pelee – Middle Island – National Park – Abundant Immigrant and

Uncommon Seasonal Colonist

Point Pelee National Park – Abundant Immigrant and Common Seasonal Colonist

Pukaskwa National Park – present only as transient

Rideau Canal National Historic Site – present

St. Lawrence Islands National Park – present, accidental-nonregular

Trent-Severn Waterway National Historic Site – regular

Big Creek National Wildlife Area – regular

Long Point National Wildlife Area – regular

Mississippi Lake NWA – present

Prince Edward Point NWA – regular

St Clair NWA – regular

Wye Marsh NWA – regular

Quebec:

Forillon National Park – regular
Mingan Archipelago National Park Reserve – probably present
La Mauricie National Park – regular
Saguenay-St. Lawrence Marine Park – probably present

Nova Scotia:

Cape Breton Highlands National Park – regular
Kejimkujik National Park and National Historic Site – regular

New Brunswick:

Fundy National Park – regular
Kouchibouguac National Park – regular

Newfoundland:

Gros Morne National Park – regular
Terra Nova National Park – present, accidental-nonregular

Prince Edward Island:

Prince Edward Island National Park – regular