Danaus plexippus

- NORTH AMERICAN MONARCH CONSERVATION PLAN
- PLAN DE AMÉRICA DEL NORTE PARA LA CONSERVACIÓN DE LA MARIPOSA MONARCA
- PLAN NORD-AMÉRICAIN DE CONSERVATION DU MONARQUE

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North American MONARCH Conservation Plan

Plan de América del Norte para la conservación de la MARIPOSA MONARCA

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North American Monarch Conservation Plan

MONARCH BUTTERFLY

Danaus plexippus

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MONARCH FACT SHEET

Common name:	Monarch Butterfly
Scientific name:	*Danaus plexippus*
Status:	Not an endangered species – IUCN recognizes the monarch migration as an endangered phenomenon.
Description:	• Large nymphalid butterfly (wingspan of 9–10 cm) • Warning coloration: orange and black • Toxic to most vertebrates with cardiac glycosides obtained from milkweed (*Asclepias* spp.) • Sexually dimorphic. Black veins are thicker on the female's wings and the male has small pouches on its hind wings where it stores pheromones. • Large populations spend the summer in temperate regions and migrate south to Mexico to spend the winter. There are small resident populations in Mexico. • The monarch butterfly is a species with tropical origins.
Habitat:	• Temperate to tropical regions • Anywhere milkweed grows • Fir, pine, oak and cedar forests during hibernation • Secondary vegetation • Disturbed habitats like roadsides and the surroundings of agricultural fields
Range:	• In America: southern Canada to Central and South America • In North America: at least three populations (Eastern, Western, and Mexican residents) • Western population from British Columbia to California • Eastern population from southern Canada and eastern United States (east of the Rockies) to central Mexico (Michoacán and the State of México). Some butterflies continue migration through Florida to the Caribbean • Mexican resident population (scattered throughout Mexico) • Through introductions in the 19th century, monarchs colonized sites in Australia, Indonesia, the Canary Islands and Spain
Migration:	Western population: Monarchs migrate in the fall from British Columbia, Washington, Oregon and other western states to roosting sites on the coast of California. Eastern population: Monarchs migrate south during the fall from southeastern Canada and the eastern United States to their wintering sites in central Mexico, and re-colonize their breeding range in Texas in the spring. During hibernation they concentrate in very small areas.
Life stages:	Egg – Larva, caterpillar – Pupa, chrysalis – Adult, imago
Diet:	Larvae feed only on leaves of milkweed (*Asclepias* spp). In this, they are strict specialists. Adults are generalists that feed on a wide variety of flowers, flower nectar and water.
Life span:	Adult life span varies from less than a month to nine months. Adults from spring and summer cohorts live about four weeks. However, the migratory generation can live up to nine months (Methuselah generation) and carry out the two-way trip. The boreal limits of the monarch distribution are reached by the second or third generation.
Impacts and Threats:	• Habitat destruction and fragmentation throughout the flyway, especially in overwintering and breeding sites • Habitat loss through urbanization • Use of toxic agrochemicals • Reduction of milkweed populations • Genetically modified organisms (GMOs), like soybeans, that tolerate herbicides (*Asclepias* does not) • Parasites (viruses, bacteria and protozoa) • Climate change • Lack of information/lack of environmental education

PREFACE

The 1994 *North American Agreement on Environmental Cooperation*, establishing the Commission for Environmental Cooperation (CEC), expresses the commitment of Canada, Mexico and the United states to increase cooperation to better conserve, protect and enhance the environment, including wild flora and fauna. The CEC's 2003 *Strategic Plan for North American Cooperation in the Conservation of Biodiversity* strengthens this commitment with an integrated perspective for conservation and sustainable use of biological resources. This North American Monarch Conservation Plan (NAMCP) is part of the effort to support and complement existing initiatives to maintain healthy monarch populations and habitats throughout the migration flyway.

The monarch butterfly: An opportunity for continental success

Following Dr. Fred Urquhart's identification of the wintering location of the monarch butterfly in the volcanic mountains of south-central Mexico more than 30 years ago, the phenomenon of their astonishing migratory journey became well known. This fragile, amazing creature, known to every child, became a sort of trinational emissary—representative of our common natural heritage and, consequently, of our shared responsibility to protect that heritage.

Each country in North America contains some combination of habitats in which monarchs breed, migrate and overwinter, and at each of these stages they require different resources. Any weak link in the chain of habitats threatens the integrity of the entire migratory phenomenon. And, just as these habitats differ, the socioeconomic and cultural characteristics of the places vary too, requiring different but complementary strategies. Recognizing our shared responsibility and differences, this trinational initiative is intended to enhance—through coordinated action—the effectiveness of conservation measures undertaken in each country to conserve this rare phenomenon.

Ensuring conservation: Promoting sustainable local livelihoods

As with many endangered species and natural phenomena, the monarch faces different threats throughout its migratory flyway, ranging from the disappearance of overwintering habitat, predation, to the impact of herbicides and insecticides in their breeding range. Each of these stressors presents itself in different economic, social and institutional contexts. This monarch conservation plan acknowledges that in order to be successful and enduring, it must thus address some of the local socio-economic challenges and incorporate innovative approaches to promote sustainable local livelihoods.

The North American Monarch Conservation Plan

On 27 June 2007, the CEC Council instructed the Secretariat, to support the existing multi-stakeholder, collaborative effort to develop a North American Monarch Conservation Plan, with the aim of maintaining healthy monarch populations and habitats throughout the migration flyway supported by a Trilateral Monarch Butterfly Sister Area Network and local community involvement. As a result, the CEC hosted a trinational workshop in Morelia, Michoacán, in December 2007, and obtained input from an extensive list of experts from diverse backgrounds from Canada, Mexico and the United States.

The preparation of this conservation plan has benefited from the valuable contributions and in-depth review of an extensive list of experts from diverse backgrounds from Canada, Mexico and the United States.

This plan provides an updated account of the species and its current situation, identifies the main risk factors affecting it and its habitat throughout the flyway, and summarizes the current conservation actions taken in each country. Against this background, it offers a list of key trinational collaborative conservation actions, priorities and targets to be considered for adoption by the three countries. The actions identified address the following main objectives: (1) decrease or eliminate deforestation in the overwintering habitat; (2) address threats of habitat loss and degradation in the flyway; (3) address threats of loss, fragmentation and modification of breeding habitat; (4) develop innovative enabling approaches that promote sustainable livelihoods for the local population; and (5) monitor monarchs throughout the flyway. The adoption of measures to address these objectives will help conserve the monarch and its habitats for future generations.

Acknowledgments

There is a long history of research and cooperation among government agencies, nongovernmental organizations, the public, and the scientific community to promote monarch conservation. This plan would not be possible without their dedicated efforts.

We owe an enormous debt of gratitude to the participants and experts who provided their wisdom and knowledge through participation in the various meetings and workshops (listed below) that led to the development of this plan. We thank the agencies and organizations who co-hosted workshops and meetings.

We are especially grateful to Karen Oberhauser, from the University of Minnesota and the Monarch Butterfly Sanctuary, for her role as coordinator and principal author of the NAMCP. Co-authors include Donita Cotter, Donald Davis, Robert Décarie, Alberto Elton Behnumea, Carlos Galindo-Leal, María Pía Gallina Tessaro, Elizabeth Howard, Jean Lauriault, Wendi Macziewski, Stephen Malcolm, Felipe Martínez, Javier Medina González, Maria McRae, Dean Nernberg, Irene Pisanty Baruch, Isabel Ramírez, Juan José Reyes and Ali Wilson. Peer reviewers of subsequent drafts were Lincoln P. Brower, Exequiel Ezcurra, Scott Hoffman Black, Jürgen Hoth, Fiona Hunter, Felix Sperling and Orley Taylor Jr. We also take this opportunity to acknowledge the leadership and contribution of Conanp, in particular, the staff of the Monarch Butterfly Biosphere Reserve (MBBR).

We would like to thank the CEC's Biodiversity Conservation Working Group (BCWG) for their support for this initiative. We also acknowledge the individuals and organizations who contributed data and analyses, as well as all those—too numerous to name—to whom we owe a huge debt for their support and cooperation. Grateful thanks go to Karen Schmidt, Jeffrey Stoub, Johanne David, Jacqueline Fortson and Douglas Kirk, of the CEC, who greatly helped the development and preparation of this plan, which was coordinated by Hans Herrmann, CEC Senior Program Manager, Biodiversity.

CEC's Trinational Experts Workshop: Developing a North American Monarch Butterfly Conservation Plan, Morelia, Michoacán, 5–7 December 2007

The Trinational Experts Workshop was organized by the Secretariat at the direction of the CEC Council through Resolution 07-09, *Trinational cooperation to conserve the monarch buttefly and promote sustainable local livelihoods*, to build upon the multi-stakeholder, collaborative NAMCP initiative launched at the 2006 Monarch Flyway Conservation Workshop.

Participants: Sandra Baumgartner, Flavio Cházaro Ramírez, Donita Cotter, Tara Crewe, Alfredo Cruz Colín, Andrew Davis, Donald Davis, María Guadalupe del Río Pesado, Dennis Frey, Carlos Enrique Galindo Leal, Eligio García Serrano, Elizabeth Howard, Jean Lauriault, Francisco Luna Contreras, Stephen Malcolm, Felipe Martínez Meza, Concepción Miguel Martínez, Eneida Beatriz Montesinos Patiño, Irene Pisanty Baruch, Héctor Quintanilla Heredia, Oscar Manuel Ramírez Flores, María Isabel Ramírez Ramírez, Eduardo Rendón Salinas, Juan José Reyes Rodríguez, Douglas Taron, Juan Francisco Torres Origel, María del Rocío Treviño Ulloa, Brian Houseal (facilitator), Hans Hermann, Karen Schmidt.

Monarch Flyway Conservation Workshop, Mission, Texas, 6–7 December 2006

The initiative to prepare an NAMCP was launched at the December 2006 Monarch Flyway Conservation Workshop in Mission, Texas. The workshop was sponsored by the US Forest Service (USFS)—International Programs; US Aid for International Development (USAI); Texas Parks and Wildlife Department (TPWD); the Wildlife Trust; and City of McAllen, Texas. The workshop was attended by representatives of agencies, academia, and NGOs from the three countries.

Participants: María Araujo, Lincoln Brower, Óscar Contreras Contreras, Donita Cotter, Carol Cullar, Don Davis, María Guadalupe del Río Pesado, Janet Ekstrum, Mike Engel, Dan Evans, Jesús Franco, Rebecca Goodwin, Mary Gustafson, Margee Haines, Richard Holthausen, Colleen Hook, Buddy Hudson, Mary Kennedy, Jean Lauriault, Carol Lively, Rolando Madrid, Helen Molina Sánchez, Sandra Nitchie, Karen Oberhauser, Mike Quinn, Jeff Raasch, Mike Rizo, Craig Rudolph, Phil Schappert, Evan Seed, Karen Shannon, Sue Sill, Chip Taylor, Carmen Téllez-O'Mahony, Matt Wagner, Don Wilhelm, Juan Manuel Frausto Leyva, José Andrés García Almanza, Eligio García Serrano, Tomás Martínez Ramírez, Lidia Miranda Sánchez, Eduardo Rendón Salinas, Juan José Reyes Rodríguez, Alfonso Rojas Pizano, Alejandro Torres, Xicoténcatl Vega, Adriana Vlera-Bermejo, Tiburcio Ybarra Caballero.

Workshop participants selected three representatives from each country to serve on a planning committee. The NAMCP Committee met twice to develop plan objectives and action items.

- **NAMCP Committee at 4th Monarch Butterfly Regional Forum (Foro Monarca), Morelia, Michoacán, 14–16 March 2007:** María Araujo, Jean Lauriault, Carlos Galindo Leal, Concepcíón Miguel Martínez, Karen Oberhauser, Juan José Reyes Rodríguez.

- **NAMCP Committee at XII Meeting of the Canada/Mexico/US Trilateral Committee for Wildlife & Ecosystem Conservation and Management, Quebec City, Quebec, 13 May 2007:** María Araujo, Donita Cotter, Donald Davis, María Pía Gallina Tessaro, Margee Haines, Karen Oberhauser, Irene Pisanty, Eduardo Rendón Salinas, Juan José Reyes Rodríguez, Mary Rothfels.

Trilateral Monarch Butterfly Sister Protected Area Workshop, Morelia, Michoacán, 27–30 March 2006

The initiative to establish a network of sister protected areas to collaborate on monarch conservation projects and seek CEC funding for a handbook of standardized monitoring protocols was launched at this workshop hosted by Mexico's National Commission of Natural Protected Areas (Conanp), the US Fish and Wildlife Service-National Wildlife Refuge System, and the Canadian Wildlife Service (CWS).

Participants: Martín Arriaga Pérez, Paul Ashley, James Burnett, Donita Cotter, Alberto Elton Benhumea, María Pía Gallina Tessaro, Nancy Gilbertson, Mónica Herzig, Mike Higgins, Deborah Holle, Jean Lauriault, André Mailloux, Felípe Martínez Meza, Tim Menard, Concepción Miguel Martínez, Ruth Morales, Angélica Narváez, Arturo Peña, Lisa Petit, Carlos A. Sifuentes Lugo, Yurico Siqueiros Jhimada, Marian Stranak, Melida Tajbakhsh, Rocío Treviño and Héctor Zepeda.

We trust the NAMCP will serve to enhance cooperation and networking among diverse sectors of society working on the well-being of the monarch and its habitats across North America.

1 EXECUTIVE SUMMARY

The monarch butterfly (*Danaus plexippus* L.) may be the most well-known butterfly in the world. The migrations of monarch butterflies in North America to overwintering sites in Mexico and California are among the most spectacular and unusual of the world's natural events. However, habitat loss and degradation pose threats to both the eastern and western migratory populations of North American monarchs throughout their annual cycle of breeding, migrating and overwintering. The decline of the migratory phenomenon is certain unless these threats are addressed.

Monarchs depend upon a wide range of habitats in Canada, the United States and Mexico, thus conservation of their migratory phenomenon requires trilateral cooperation. The North American Monarch Conservation Plan (NAMCP) is intended to provide a long-term cooperative agenda for conservation of the monarch butterfly.

This document summarizes evidence of the rate of habitat loss during each stage of the monarch's annual cycle. The relatively small size of the wintering sites make the loss of these habitats, from commercial and subsistence-scale timber harvesting in Mexico and commercial and municipal development in California, of the most immediate concern. Recent analyses of the overwintering area document an accumulated disturbance of a fifth of the forested land in the Monarch Butterfly Biosphere Reserve (MBBR) in Mexico from 1986 to 2006. Changing farm practices and suburbanization of agricultural land in the United States are resulting in losses of approximately 876,000 hectares/year of land that can support the host plants and nectar sources required for monarch reproduction and migration.

Habitat conservation and restoration are absolutely necessary for monarch survival.

Habitat conservation and restoration are absolutely necessary for monarch survival. Mexico, Canada and the United States must work together to ensure that: 1) sufficient suitable habitat is available on the overwintering grounds in the United States and Mexico for the populations to persist; and 2) sufficient breeding and migrating habitat is available in Canada, Mexico and the United States to maintain their current contribution to the overall North American population.

The NAMCP is divided into eleven sections. The initial seven sections provide an updated account of the species and its current situation. The eighth section identifies the main causes of loss or decline and puts in perspective the ensuing sections, related to current management actions taken in each country, as well as public perception of the species. Against this background, the last section offers a list of key trinational collaborative conservation objectives and actions. The objectives which are of the most immediate importance and have the most potential for trilateral cooperation are as follows:

- Decrease or eliminate deforestation due to unsustainable logging and habitat conversion in the overwintering habitat. This objective must be accomplished through a combination of surveillance and enforcement of existing laws, prevention and mitigation actions, and support for alternative and sustainable forest management and economic practices.

- Address threats of habitat loss and degradation in the flyway. Effective flyway conservation requires immediate management actions. These actions must be supported by research and monitoring to identify the habitat types and locations that are most important to monarchs during their spring and autumn migrations, and by an understanding of how human activities affect the availability and suitability of these habitats.

Although the species itself is not in danger of extinction, the North American migration is considered an endangered biological phenomenon due to threats to the monarch's habitats during its annual cycle of breeding, migrating and wintering.

- Address threats of loss, fragmentation, and modification of breeding habitat. Breeding habitat conservation will require better understanding of monarch host plants, including how land use practices affect the distribution and abundance of numerous milkweed (*Asclepias*) species. Land use practices that support monarch breeding should be encouraged among government agencies, private conservation organizations, and public and private landowners.

- Develop innovative enabling approaches. Incentives for conservation, such as payment for environmental services by the Monarch Butterfly Conservation Fund (within the *Fondo Mexicano para la Conservación de la Naturaleza*—FMCN) in the MBBR, could help to mitigate threats due to habitat loss. Cooperative trilateral actions, such as supporting and expanding the network of sister protected areas involved in monarch conservation will protect habitat, support environmental education, and reinforce monitoring efforts. Such efforts should be expanded and duplicated in other areas and by other organizations.

- Monitor monarch population distribution, abundance, and habitat quality, including water availability. Government and nongovernmental agencies should support the development and dissemination of a monitoring program, and a diagnosis of biological and socioeconomic drivers of monarch population dynamics. Coordinated monitoring throughout the monarch's annual cycle and open sharing of the data are key to understanding the status of the population and effectiveness of conservation actions.

2 BACKGROUND

Probably the world's most familiar butterfly, the monarch (*Danaus plexippus* L.) has been the focus of research on insect and host plant interactions, insect defenses, mimicry, migration, reproductive physiology, overwintering biology, habitat conservation, community management, ecotourism, and many other topics. This butterfly is best known for the incredible migration made by the eastern North American population, in which individuals fly from summer breeding grounds located as far north as southern Canada to their overwintering habitat in central Mexico. Although the species itself is not in danger of extinction, the North American migration is considered an endangered biological phenomenon due to threats to the monarch's habitats during its annual cycle of breeding, migrating and wintering. Because monarchs depend upon a wide range of habitats in Canada, the United States and Mexico, conservation of the migratory phenomenon requires trilateral cooperation.

3 DESCRIPTION OF SPECIES

Monarch butterflies are in the family *Nymphalidae*, sub-family *Danainae*. The monarch was named *Papilio plexippus* by Linnaeus in 1758 (Vane-Wright 2007). It is the type species of the genus *Danaus*, which was named by Kluk in 1780. While a recent catalogue of Latin American butterflies recognized six subspecies of *D. plexippus* (Lamas 2004), mitochondrial DNA sequences suggest that these groups are not genetically distinct (Brower and Jeansonne 2004) and at least one of the subspecies (*D. plexippus megalippe*) may mix in the Caribbean with migratory *D. plexippus plexippus*. Herein, we are concerned with the subspecies *Danaus plexippus plexippus* in Mexico, the United States and Canada.

3.1 Adults

The adult monarch is a relatively large butterfly, with a wingspan of approximately 9 to 11 cm. Its bright orange wings have black veins, and black edges that contain white spots along the margin. The underside of the wings is duller orange, so that when the wings are folded in rest, the butterflies appear camouflaged as they cluster or rest singly in trees or on other substrates. The species is sexually dimorphic; males are slightly larger than females and have a black spot on each hindwing consisting of androconial scales. Pheromone-producing androconial scales are used, in related species, to attract mates. However, most researchers agree that chemical communication plays a less significant role in monarch butterflies, compared with other species in the same genus. Females lack the androconial patch, have slightly more brown scales in the orange patches of their wings, and more black scales over the wing veins, making the veins appear wider.


1


3


2


4

Male and female adults

1 *Female on black-eyed susan*
2 *Female abdomen showing abdominal slit*
3 *Male on zinnias*
4 *Male abdomen showing claspers*

Viceroy
(Limenitis archippus)

Egg on Asclepias syriaca
(common milkweed)

Five larval instars and egg

There are color variants in adult monarchs, most notably a variation (nivosus) in which the orange is replaced with white (Stimson and Meyers 1984). This color variation is caused by a single recessive gene, and has been found throughout the world, including Australia, New Zealand, Indonesia and the United States. It is extremely rare everywhere but Hawaii, where it sometimes comprises up to 10% of the population (Stimson and Berman 1990, Vane-Wright 1986).

Monarch adults are sometimes confused with related butterfly species, including *D. gilippus* (the queen butterfly), *D. eresimus* (the soldier butterfly) and *D. erippus* (the South American monarch), and with *Limenitis archippus* (the North American viceroy butterfly).

Migratory North American monarchs undergo several generations per year. The summer generation adults live between two and five weeks. The late generation adults migrate, then overwinter at sites in central Mexico and California. These overwintering individuals live seven to nine months, without breeding and laying eggs until the following spring as they re-migrate toward their spring and summer breeding ranges.

3.2 Eggs

Monarch eggs are conical, with a flat base. They are approximately 1.2 millimeters (mm) tall by 0.9 mm in diameter at the widest point, and are a pale, yellow-cream color, with ridges running from the tip to the base. Monarchs only lay their eggs on milkweed plants. Adult females lay eggs singly, secreting a glue-like substance that adheres the egg to a milkweed plant. Wild females probably lay from 300 to 400 eggs over the course of their lifetime, although captive females can lay, on average, approximately 700 eggs in two to five weeks (Oberhauser 2004). The larvae emerge in three to five days, with shorter development times corresponding to warmer temperatures.

3.3 Larvae

Monarch larvae (caterpillars) are white with black and yellow stripes and have two pairs of black filaments, on larval segments 2 and 11. Larvae undergo five instars (intervals between molts) over a period of nine to 13 days. While the bright color patterns on monarch larvae probably represent aposematic, or warning, coloration, monarchs in the egg and larval stages nonetheless suffer high rates of predation from invertebrate predators. Several studies have documented mortality rates of over 90% during these stages (reviewed in Zalucki et al. 2002, Prysby 2004). It appears that the chemical defense gained from ingesting toxic milkweed cardenolides (see Host Plants: Milkweed section, below) is more effective against vertebrate predators, although Rayor (2004) documented a preference by wasp predators for larvae that had fed on milkweed species having lower cardenolide levels.

Once fifth instar larvae are fully grown, they leave their milkweed host plant to search for an elevated and usually well-hidden pupation site.

3.4 Pupae

Pupae

Monarch pupae (chrysalids) are about 3 centimeters (cm) long and are bright turquoise-green, with gold spots. These metallic-appearing spots are typical of the *Danainae*, and are caused by alternating dense and clear layers in the endocuticle (a layer in the exoskeleton). These layers reflect and transmit light differently, and cause constructive interference of light, making them look like shiny metal.

The pupa stage lasts nine to 15 days under normal summer conditions. This is the least-studied stage of monarchs, due to the difficulty in finding pupae in the wild. This difficulty suggests that monarch pupae are cryptically colored, as opposed to the aposematic (bright warning) coloration exhibited by adults. On the last day as a pupa, the orange, black, and white patterns of the adult wings become visible through the pupal covering.

4 HOST PLANTS: MILKWEED

Monarch larvae are obligate herbivores of milkweeds and are likely to feed on any of the approximately 115 species in the genus *Asclepias* in North America and the Caribbean (Malcolm et al. 1992, Malcolm 1994). This genus of perennial plants, with over 140 species world-wide, was also named, like the monarch, by Linnaeus. He named milkweeds after Asklepios, the Greek god of healing, because of their many folk-medicinal uses. Monarchs also feed on milkweed vines in the genera *Sarcostemma*, *Cynanchum* and *Matelea* (Ackery and Vane-Wright 1984). Until recently, these three genera and *Asclepias* were included in the family *Asclepiadaceae*, but the family is now treated as a subfamily in the dogbane family, *Apocynaceae*. In addition to being the larval food source for monarchs, their close relatives, and several other specialist insects, milkweeds are important nectar sources for many insects.

Milkweed is named for its milky sap, which contains alkaloids and other complex compounds, including cardenolides. In Spanish, milkweed is known as *venenillo* (small poison) and *algodoncillo* (small cotton), due to the toxic nature of the plant and the appearance of the seeds. The milky sap, or latex, confers both mechanical and chemical defenses against potential herbivores (Malcolm et al. 1992, Malcolm 1994), but monarch larvae show a range of feeding behaviors that circumvent these latex defenses (Dussourd and Eisner 1987, Dussourd 1993, Zalucki and Brower 1992, Zalucki and Malcolm 1999).

Cardenolides are a type of steroid-glycoside that include digitoxin; they induce nausea, vomiting, diarrhea, and cardiac arrhythmias in vertebrates. As larvae feed on milkweed, they sequester cardenolides for use as a chemical defense against natural enemies (Brower 1984). Cardenolide levels vary both within and between milkweed species and are inducible by damage or herbivore feeding (Malcolm and Zalucki 1996). While monarch feeding on many milkweed species has been documented, our knowledge of how monarch survival is affected by the female's choice of host plants is incomplete.

Asclepias curassavica
(tropical milkweed)

Asclepias syriaca
(common milkweed)

Close-up of common milkweed blossoms

Milkweed grows in a variety of disturbed and undisturbed environments, including farmlands, along roadsides and in ditches, open wetlands, dry sandy areas, short- and tall-grass prairie, agricultural areas, river banks, irrigation ditches, and arid valleys. Many species, especially *Asclepias incarnata* (swamp milkweed), *Asclepias curassavica*, (tropical milkweed, or bloodflower) and *Asclepias tuberosa* (butterfly weed), are often planted in gardens.

Livestock pastures can also represent significant milkweed habitat for monarchs. Some milkweeds are toxic to livestock (Malcolm 1991), especially if they are included in harvested livestock feed. However, the bitter taste of cardenolides in milkweeds may deter livestock sufficiently that milkweeds are not a serious problem when growing wild in pastures. Thus it is common to see extensive milkweed growth in pastures throughout North America, and these plants may be an important food resource for monarchs.

Woodson (1954) provides a good background on the distribution of milkweed species in the United States and Canada, but less is known about their distribution in Mexico. The most widely-used monarch host plant in the northern United States and Canada is the common milkweed, *Asclepias syriaca* (Malcolm et al. 1989), which thrives in disturbed areas and has probably been particularly successful following the development of agriculture in the grasslands and former forests in the central and northeastern United States and southeastern Canada (Malcolm et al. 1989, Vane-Wright 1993, Brower 1995). Because it thrives in disturbed habitats, natural plant succession affects common milkweed distribution and abundance. *Asclepias viridis, Asclepias asperula* and *Asclepias oenotheroides* are important host plants in the southern United States. *Asclepias currassavica* is probably the most important host species in Mexico, but Montesinos (2003) reports also finding eggs and larvae on *Asclepias glaucescens* in the state of Michoacán.

Milkweed pollination is accomplished in an unusual manner. The pollen is contained in structures called *pollinia* (pollen sacs), rather than occurring as free grains as is the case for pollen in the rest of the *Apocynaceae*. Pollinia attach to hairs or bristles on the feet or heads of visiting insects, and are carried to the receptive surfaces of other milkweeds. The most effective milkweed pollinators are large wasps, although bees, moths and butterflies can also carry the pollen from plant to plant. Of those milkweeds that have been studied, the majority are self-incompatible, which means that they must receive pollen from other milkweeds of the same species to produce viable seeds.

Asclepias syriaca and its close relative, *Asclepias* speciosa, have a peculiar root system that ramifies underground, and can cover thousands of meters. It is possible that a single plant (known as a genet) can form hundreds, and possibly even thousands of stems (known as ramets) that are genetically identical.

Underground root-like stems of an Asclepias syriaca *genet in Michigan. The vertical stakes are 0.5m apart and soil was washed away with water.*

5 THE MONARCH BUTTERFLY'S ANNUAL LIFE CYCLE

North American monarchs form two fairly distinct populations. The western migratory population breeds in the western United States and Canada, and winters near the California coast. The eastern migratory population breeds in the central and eastern United States and in southern Canada, and winters in central Mexico (in the eastern part of the state of Michoacán and western part of the state of México). The monarchs that spend the winter in the mountains of central Mexico or eucalyptus groves of coastal California are the final generation of a cycle that begins anew each year. Most of the butterflies in this final generation begin their lives as larvae in the northern United States or southern Canada, and then migrate up to thousands of kilometers to specific overwintering sites. After spending several months at these sites, they fly north and east, starting the cycle again.

Butterflies that are part of the eastern population lay eggs in northern Mexico and the southern United States. These eggs become the adults that re-colonize the northern part of the breeding range (Malcolm et al. 1987, 1993), and the population undergoes two more breeding generations. Only the final generation of the year migrates to Mexico in the fall. The behavior of the western population is similar, although the generation that overwinters probably re-colonizes most of the summer range, with subsequent generations increasing in numbers over the summer. Spring and summer adults live about a month, and those that migrate and overwinter live up to seven to nine months.

Although they live in temperate regions during the summer, monarch butterflies, like other Danainae, *are essentially a tropical species.*

5.1 Migration

Although they live in temperate regions during the summer, monarch butterflies, like other Danainae, are essentially a tropical species. Unlike other temperate insects, no life stage of the monarch butterfly can survive temperate-zone winters. Every autumn, North American monarchs undergo a southward migration to winter roosting sites, and re-colonize their breeding range the following spring. The monarch is the only butterfly to make such a long, two-way migration, with most of those in the east flying over 2500 kilometers (km) to reach their winter destination. Migratory individuals are typically in reproductive diapause, a state of suspended reproductive development that is controlled by neural and hormonal changes (Herman 1981) triggered by environmental changes, including decreasing day length, increasingly cooler nights, and, perhaps, host plant senescence (Goehring and Oberhauser 2002). Since the discovery of the wintering sites in Mexico by the scientific community in 1975 (Urquhart 1976), researchers have struggled to understand the cues that cause monarchs to begin their migration, the mechanisms they use to orient and find the overwintering sites and the patterns of fall and spring flights (Solensky 2004, Zhu et al. 2008).

Monarch migration appears to be a fairly flexible behavior that changes in response to new environments. For example, Australian monarchs sometimes exhibit seasonal movement, moving from inland to coastal areas in a north to northeasterly direction during the fall and winter (James 1993). Hawaiian, Caribbean, Mexican and South American populations do not migrate. Because the most spectacular monarch migrations occur in the eastern North American population, much of the research on monarch migration has focused on this population. These butterflies fly from their summer breeding range, which spans more than 100 million hectares (ha), to winter roosts that cover less than 20 ha, often to the same forest sites, year after year.

Nectar sources are vital to monarchs during their fall migration, when they need carbohydrates to fuel their flight and to convert to the lipid reserves or fat that supports them during the winter (Brower 1985, Masters et al. 1988, Gibo and McCurdy 1993, Brower et al. 2006). A variety of flowering plants are used during the fall migration; of particular note are goldenrods (*Solidago* spp.), asters (*Aster* spp.), and gayfeathers (*Liatris* spp.) in the north, and frostweed (*Verbesina virginica*) in Texas. Blooming clover, sunflower and alfalfa fields can also host thousands of monarchs (K. Oberhauser, E. Howard, personal observation).

While it has often been assumed that the eastern and western North American populations are strictly separated by the Rocky Mountains, recent evidence suggests that some western monarchs move south and southeast, entering the Mexican state of Sonora from Arizona (Pyle 2000, Brower and Pyle 2004). It is possible that some degree of genetic interchange occurs in Mexico and within the Rocky Mountains during the breeding season, preventing complete separation of the two populations.

Overwintering monarchs form dense clusters on the branches and trunks of trees, and large aggregations of butterflies in a discrete area are called a colony.

5.2 Overwintering

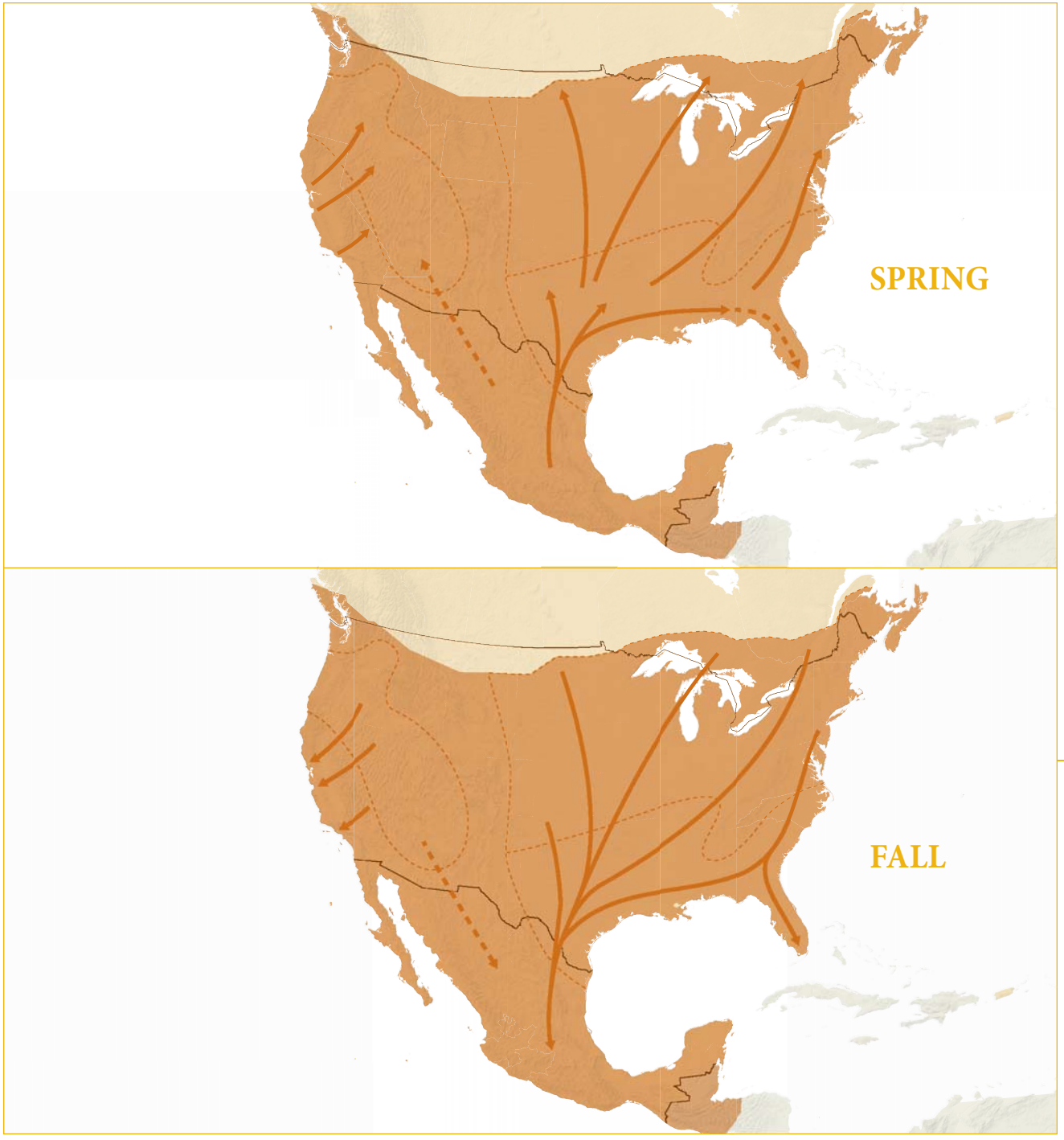
5.2.1 Mexico

The eastern monarchs spend the winter in a temperate mountain ecosystem in Mexico dominated by oyamel firs (*Abies religiosa*) (Brower 1995). Overwintering monarchs form dense clusters on the branches and trunks of trees, and large aggregations of butterflies in a discrete area are called a colony. Their colonies range in size from 0.5 to 5 ha, and occur on 12 different massifs (discreet mountainous masses) in the Transverse Neovolcanic Belt, a belt of volcanic mountain ranges and valleys extending across central Mexico (approximately 19° N and 100° W) (Calvert and Brower 1986, Slayback et al. 2007). The majority of the colonies are within the federally protected Monarch Butterfly Biosphere Reserve (MBBR), administered by the National Commission of Natural Protected Areas (Conanp).

The high altitude forests provide a cool microhabitat for monarchs, which results in a low metabolic rate and reduced activity for the butterflies, from mid-November to mid-March (Brower 1996). Overwintering colonies are spread over an area approximately 100 km x 100 km (Calvert and Brower 1986), but recent analyses show that the appropriate microclimatic conditions occur in approximately 562 km^2 of the entire 10,000 km^2–region (Slayback et al. 2007). Within the suitable area, individuals sometimes settle on the same stands of trees as their predecessors did in the previous winter and, in other years, they may settle up to 1.5 km away (Slayback et al. 2007).

Although no formal scientific studies have been published on the importance of access to water by overwintering monarchs, there are many indications that access to moisture is of key importance. Monarchs form colonies at the heads of the streams, and as the dry season advances and the stream sources drop down the arroyos (valleys), the monarch colonies move down, presumably to avoid desiccation (Calvert and Brower 1986). Additionally, massive flights out of the colonies to drink at natural water sources occur regularly and with increasing frequency as the dry season advances. Literally millions of monarchs fly out of their colonies and alight along moist stream banks and water seeps where they drink. The butterflies also drink moisture that condenses as frost on the open llanos (meadow) vegetation. The guides at the tourist facility at the El Rosario colony have taken advantage of this fact, piping water from springs and spraying it over vegetation which is then visited by thousands of monarchs, to the delight of visiting tourists. Lincoln Brower (personal communication) notes that southwestern winds that blow across the volcanic plain often result in adiabatic condensation of clouds (changing in temperature without heat

Migratory Routes of the Monarch Butterfly



Monarch butterfly habitat
Migration direction
Light migration
Population zones

Source: Maps based on research by Lincoln Brower, Sonia Altizer, Michelle Solensky and Karen Oberhauser, with reference to maps of Journey North and Texas Monarch Watch

loss to or gain from the surrounding air) as the winds are forced up over the Chincua mountain range. Oyamel fir needles are often covered with moisture, and during adiabatic events, in a phenomenon known as "fog drip," water drops fall from the trees onto the ground. This phenomenon is well known in the California redwood forests, where it accounts for a significant proportion of the entire ground water recharge.

5.2.2 California

Prior to European settlement, overwintering monarchs presumably used native forests along the California coast. Deforestation taking place in coastal California in the 19th century led to a decline in overwintering habitat for monarchs. Subsequently, pine forests were largely replaced by Eucalyptus trees, introduced in the 1850s for landscaping, as windbreaks, and for use as fuel (Lane 1993). Now, coastal California monarch wintering sites consist of wooded areas most often dominated by the non-native eucalyptus (*Eucalyptus* spp.), although monarchs also use the native Monterey pines (*Pinus radiata*), Monterey cypresses (*Cupressus macrocarpa*) and redwoods (*Sequoia sempervirens*) when these species are present. The sites are typically located in sheltered bays or farther inland, where they provide moderated microclimates and protection from strong winds. More than 300 different aggregation sites have been reported (Frey and Schaffner 2004, Leong et al. 2004), with high degrees of year-to-year fidelity to specific locations. As is true of the monarchs overwintering in Mexico, access to water, particularly early morning dew, appears to be important to winter survival.

5.2.3 Winter Breeding Populations

Small, non-migrating populations persist for most years in southern Florida (Knight et al. 1999, Altizer et al. 2000). It is likely that they are periodically extirpated, due to low temperatures, and receive an influx of migratory individuals from the eastern migratory population each fall (Knight et al. 1999). These individuals, as well as the monarchs of Cuba (Dockx 2007), probably do not represent a separate population. Resident populations have also been reported in Texas and other Gulf Coast states, and may be becoming more common (K. Oberhauser and R. Batalden personal observation). These populations are probably temporary, and may represent individuals from the migratory population that do not continue on to Mexico. Additional small, ephemeral populations are found during the winter along the southern Atlantic Coast and the Gulf Coast of the southern United States, but the source and breeding status of these populations are poorly understood.

Monarchs breed throughout the year in the Mexican states of Morelos, Guerrero, México, Oaxaca, Veracruz, San Luis Potosí, Chiapas, Michoacán, and Hidalgo (Montesinos 2003). Montesinos (2003) reports finding eggs and larvae on *Asclepias curassavica* in all of these locations, and on *Asclepias glaucescens* in Michoacán. The degree to which these local populations interbreed with the migratory butterflies is unknown.

Butterflies in forest

6 WORLD-WIDE DISTRIBUTION

In the Americas, monarchs range from southern Canada south into northern and western South America. Central American, South American, and Antillean monarchs do not migrate, although those in Costa Rica move from lowland deciduous forests in the dry season to the rainforest (Haber 1993). During the 19th century, monarchs colonized islands throughout much of the Pacific and Atlantic Oceans, and now have well-established populations in Australia; parts of Micronesia, Maderia and the Canary Islands; and parts of Spain and Portugal (Vane-Wright 1993). It is likely that most of this movement is due to humans, but the mechanisms for monarch colonization of new areas are not documented. There are also anecdotal sightings of monarchs in other parts of Europe, including the United Kingdom, but these have not led to established populations.

Mexico overwintering site

7 DISCOVERY OF THE OVERWINTERING SITES

The means by which monarchs survived winter was a source of speculation for well over a century, and the discovery of the overwintering sites resulted from a trinational effort. A thorough reconstruction of this speculation and the many researchers who attempted to understand the monarch's annual cycle is presented by Brower (1995). While monarchs were possibly seen migrating by one of Christopher Columbus's expeditions to eastern Mexico, the first official report of monarch migration was not until 1857, when D'Urban reported dark clouds of monarchs in the Mississippi Valley (Brower 1995). A complete understanding of the magnitude of the incredible migratory phenomenon was the result of an ingenious butterfly-tagging program started by Canadians Fred and Norah Urquhart in the 1930s. The Urquharts expanded this program by enlisting volunteer "research associates," in 1952. This army of volunteers, including school children, naturalists and adults, tagged thousands of butterflies over four decades. Over the years, documented tracking of individual butterflies suggested that monarchs from the northeastern and north-central parts of the United States and southeastern Canada overwintered somewhere in Mexico. In 1973, after reading an advertisement in a Mexican newspaper, Kenneth Brugger offered his help in finding the overwintering site. He and his wife, Catalina Aguado, searched for signs of monarchs, and on 2 January 1975, led by a local peasant, found millions of monarchs congregating in an oyamel fir forest in the mountains of eastern Michoacán (Urquhart 1976).

Scientists credit Mr. Brugger for discovering the oyamel forests in Mexico where hundreds of millions of monarch butterflies spend the winter. However, local residents already knew that millions of monarchs returned to their mountains every year, and had incorporated this phenomenon into their culture. The monarchs were known locally as *palomas* (doves), as well as *cosechadoras* (harvesters, since they arrive at the time of harvesting). Mazahuas and Otomies indigenous peoples also related the arrival of the butterflies to the "Day of the Dead" (*Día de muertos*),

believing that the butterflies were the souls of their ancestors. The Urquharts' tagging program and subsequent research provided local residents with the knowledge that the butterflies came from and returned to a huge and distant region, the entire eastern United States and southeastern Canada.

8 CURRENT STATUS AND CONDITION

8.1 Eastern Population

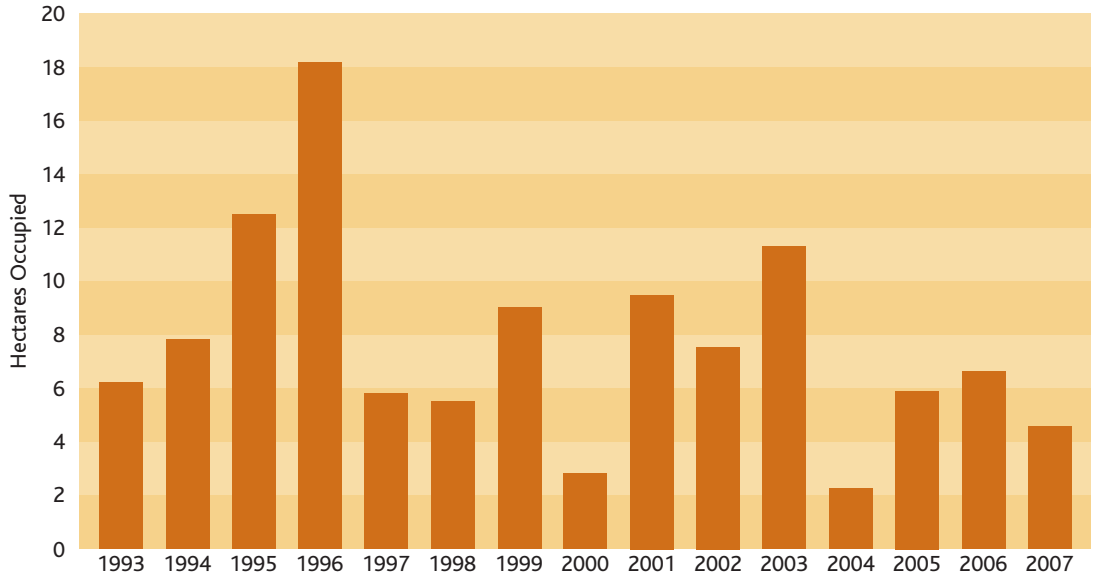
The eastern population is monitored in many locations, using many methods. Monitoring programs assess local densities of breeding monarchs throughout their breeding range, numbers of individual butterflies passing through migratory stop-over sites, and areas occupied on the winter range. Other programs assess the timing and location of fall and spring migratory movement. The fact that monarchs are spread over such a large area for most of their annual migratory cycle makes their population dynamics difficult to assess, and integrating information from so many different programs presents a scientific challenge that we are only beginning to address.

8.1.1 Winter Monitoring

WWF monitoring team using tape measure to measure colony size

The dense aggregations in known overwintering sites provide the only opportunity to measure the entire eastern migratory population at one time, and a variety of monitoring programs have provided data on the relative size of the population, numbers of colonies, and mortality from year to year. Since the early 1990s, Conanp personnel in the MBBR and staff of the World Wildlife Fund (WWF)–México have monitored the areas and locations occupied by monarchs throughout the wintering season, with the assistance of local residents (Garcia-Serrano et al. 2004, Rendón-Salinas et al. 2007). Beginning in 2004, these monitoring activities have included biweekly measurements, from November to March (Rendón-Salinas and Galindo-Leal 2005; Rendón-Salinas et al. 2006a, 2006b).

Different methods have been used to indicate how occupied area translates to monarch numbers, including mark-release-recapture methods and estimates of the numbers of monarchs occupying trees of different sizes (reviewed by Calvert 2004). Density estimates range from about 7 to 60 million monarchs per hectare, and Brower et al. (2004) showed that early estimates of 10 million monarchs per hectare probably grossly underestimated actual numbers. The wide range of estimates suggests that monarch densities are not consistent among colonies, years and seasons, but the area occupied by monarchs is used as a very rough estimate of population size. Such data are available for most years from 1976 to the present, although the degree to which all colonies were found and measured varies considerably.



Monarch overwintering population extrapolated from area occupied

Source: Area occupied by monarchs during winter in Mexico. Data from MBBR and WWF-Mexico (Eduardo Salinas-Rendon, Carlos Galindo-Leal, Eligio Garcia).

8.1.2 Breeding Population Monitoring

Two long-term monitoring programs with broad geographic ranges have focused on the breeding stage of the monarch annual cycle, the Monarch Larva Monitoring Project (MLMP) and the North American Butterfly Associations's (NABA) Fourth of July Butterfly Count (Oberhauser 2007). The MLMP (www.mlmp.org) is a citizen science project developed by researchers at the University of Minnesota that engages volunteer monitors in weekly surveys of immature monarchs on milkweed plants throughout the breeding range. Volunteers provide weekly estimates of monarch egg and larval densities in their monitoring sites. While this program covers the monarch breeding range fairly completely, densities are reported on a per plant basis. This method is easy for volunteers to carry out, but the translation of per-plant density into overall numbers suffers some of the same problems as using area occupied to indicate the size of the overwintering population.

Monarch Larva Monitoring Project Volunteer (Monarch Larva Monitoring Project)

Volunteers participating in the NABA annual Fourth of July Butterfly Count monitor summer populations of many adult butterflies, including monarchs (Swengel 1995). During this annual count, volunteers select an area 24 km in diameter and conduct a one-day census of all butterflies sighted within that circle. The counts are usually held within a few weeks of 4 July in the United States, 1 July in Canada and 16 September in Mexico. Like the MLMP, the Fourth of July Counts cover a broad geographic range. However, the count at any given location is conducted on a single day each summer, and may miss monarch population peaks.

8.1.3 Migration Monitoring

Several programs monitor the size, timing and location of autumn monarch migrations at specific locations. The longest-running project has been conducted in Cape May New Jersey since 1992 by Dick Walton and collaborators (Walton and Brower 1996, Walton et al. 2005). From 1 September to 31 October, monitors conduct from two to three on-the-road censuses per day, while driving 10 km/hr, recording the number of monarchs observed nectaring, flying or

resting. A study using similar methods has been conducted in the United States Fish and Wildlife Service's (USFWS) Chincoteague National Wildlife Refuge on Assateague Island, a barrier island on the Delmarva Peninsula in Virginia, beginning in 1997 (Gibbs et al. 2006). Another program monitoring the fall migration involves volunteers in the Peninsula Point Recreation Area in Michigan's Hiawatha National Forest, administered by the United States Forest Service (USFS) (Meitner et al. 2004). This project, started in 1996, is located on the northern shore of Lake Michigan at a migratory stopping point for monarchs. Volunteers conduct three counts every day throughout the time that monarchs are leaving Michigan, from the second week of August through the third week of September. In Canada, monarch migrations through Long Point National Wildlife Area and Point Pelee National Park, on the north shore of Lake Erie in Ontario, are also monitored each fall. Long Point data collected from 1995 through 2006 have been analyzed by Crewe et al. (2007).

In addition to these point-count methods, the timing of the spring migration of the eastern population has been monitored on a continental scale since 1997 by volunteers who report first sightings to Journey North, an online study of wildlife migration and seasonal change, and Monarch Watch, a research project based at the University of Kansas (Howard and Davis 2004). In a similar way, the temporal and spatial patterns of fall migration are monitored throughout the flyway through reports of overnight roost sites collected by the Journey South program (United States and Canada) and Correo Real program (Mexico). These studies help to identify specific locations and types of habitat that are essential during fall migration. Data from the Monarch Watch fall tagging program also identify migratory pathways, and have been used to delineate yearly geographic variation in the largest concentrations of migrating monarchs.

8.1.4 Eastern Population Trends

In an analysis of seven programs that have provided consistent data for over ten years, including estimates from breeding, migrating and wintering phases of the annual cycle, Oberhauser (2007 and unpublished) found that most programs reported relative abundance values below average from 2002 through 2006, although relative abundance values from 2005 and 2006 rebounded from those reported in 2002–2004. Detailed analyses of these data will help to inform additional data collection efforts to explain the reasons for observed patterns. However, the large year-to-year variation in monarch densities will make it difficult to detect long-term trends, and it is important that existing programs continue to collect monitoring data.

Winter data show peaks in 1990 and 1996 of about eighteen hectares in cumulative area occupied by monarchs, but less than ten hectares of occupied area in all but one winter (2003) over the past decade. An all-time low of 2.19 hectares was recorded in January 2005 (Rendón-Salinas and Galindo-Leal 2005, Cruz-Piña et al. 2006).

Crewe et al. (2007) noted a (statistically insignificant) decrease of about 3% in the number of migrating monarchs that pass through the Long Point National Wildlife Area monitoring site in Ontario over the 11 years of their study. They suggested that high variation among years contributed to the non-significant trend, and that more data are needed to determine whether the monarch butterfly population passing through Long Point will continue to decline, remain stable at its current below-average level, or continue to show periodic recoveries.

8.2 Western Population

Monarch population sizes at wintering sites in California are estimated annually within two weeks of Thanksgiving, and in many years, there are data available throughout the season. Long-term data on monarch abundance at California wintering sites exist in the California Department of Fish and Game's Natural Diversity Data Base (NDDB). The NDDB contains information on 332 separate wintering sites, approximately 60% of which are privately owned, and 40% of which are publicly owned, mostly in state parks.

In-depth analyses of these counts at one extensively monitored site (Frey et al. 2004, Frey and Schaffner 2004) reveal a five-year decline ending in 2003, with a low of approximately 10,000 overwintering butterflies in 2002–2003. During 2004, monarch butterfly numbers were significantly higher than those in 2003, with over 70,000 monarchs. These values were 45,000 butterflies in 2005–2006 and 60,000 in 2006–2007 (Ventana Wildlife Society 2007).

A decrease in insecticide applications will benefit a wide variety of non-pest insects, including monarchs.

9 CURRENT FACTORS CAUSING LOSS OR DECLINE

9.1 Breeding Habitat Loss and Degradation

A 2000 study of the use of agricultural habitats by monarchs suggested that up to 70% of monarchs that migrated to Mexico may have fed on milkweed in agro-ecosystems (Oberhauser et al. 2001). As agricultural practices have changed since the 2000 study was conducted, monarch use of agricultural habitat is currently likely to be less widespread. Most soybeans and a large portion of the corn currently grown in the United States are genetically modified to allow post-emergence applications of glyphosate (Roundup) (James 2001, USDA 2007), which results in fields with fewer milkweed and other weeds. While *Asclepias syriaca* can survive the tilling that was formerly used to control weeds in most soybean and corn fields, it is unable to endure repeated application of glyphosate. Additionally, suburbanization of agricultural land results in extensive habitat loss; some estimates suggest the loss of 2400 or more hectares of open space (both agricultural land and natural areas) per day to development (an annual loss of 876,000 hectares/year) (NRCS 2001, American Farmland Trust 2007).

Corn that is genetically modified to contain a Bt toxin (from the bacterium *Bacillus thuringiensis*) can result in decreased insecticide use, since the corn itself produces a protein that is toxic to a major pest, the European corn borer. A decrease in insecticide applications will benefit a wide variety of non-pest insects, including monarchs. Bt-producing corn was studied as a potential risk to monarchs, since toxic pollen from the corn may be blown onto milkweed plants and consumed by monarch larvae (Losey et al. 1999, Hansen Jesse and Obrycki 2000). While recent studies indicate that pollen and anthers from Bt-corn affect monarch larva survival and development (Dively et al. 2004, Anderson et al. 2004), overall conclusions are that the effects of current Bt-corn varieties on

Roadside milkweed

monarch populations range from "not significant" to "negligible" (Sears et al. 2001, Dively et al. 2004, Anderson et al. 2005). Additionally, the lack of milkweed in and near cornfields due to widespread use of herbicide-tolerant crops has further decreased the risk from Bt-corn.

Roadsides once constituted a small, but significant, portion of monarch habitat. Due to herbicide application and mowing, these habitats have mainly changed to grasslands containing few flowering plants, and thus provide poorer-quality wildlife habitat. Additionally, milkweed is considered a noxious species in some areas, resulting in eradication efforts.

In some areas across North America, milkweed plants are also being severely damaged by ozone pollution. Common milkweed is particularly sensitive to ozone damage, which is manifested by sharply defined, small dot-like lesions, called stipples, on the upper surfaces of the leaves (Bennett and Stalte 1985). In cases of severe ozone damage, the leaves may exhibit large dark areas on the upper leaf surface as the markings blend together. The impact of ozone damage on monarch larvae is not known.

Other anthropogenic factors, such as elevated carbon dioxide, may also affect milkweeds. Thus, human activities may be changing the distribution and abundance of milkweeds in ways that are as yet not understood.

Most of the focus on breeding habitat is in the United States and Canada, since monarchs that migrate to the overwintering sites in Mexico and California come from these locations. However, there are small local monarch populations in Mexico. The milkweed used by these local populations is subject to herbicide applications, especially in areas where cattle graze. Additionally, the riparian habitat in which milkweed grows is threatened by deforestation or land change (Eneida Montesinos, personal communication).

9.2 Wintering Habitat Loss and Degradation

9.2.1 Mexico

Several researchers have documented loss of Mexican overwintering habitat. Brower et al. (2002) used aerial photographs from 1971, 1984 and 1999 to document increasing rates of forest degradation (in and near the area protected by the 1986 decree) over the two time intervals between the photographs (annual rates of 1.7% from 1971 to 1984, and 2.4% from 1984 to 1999). The latter rate was slightly higher in the area protected by the 1986 decree. Considering only the mountainous relief of a similar study area, Ramírez et al. (2003) found an annual disturbance rate of 1.3% and annual land use change of 0.1%. Both analyses covered only three of the five sanctuaries protected. Ramírez et al. (2006) used satellite images from 1986 to 2006 to document an accumulated loss and disturbance of 10,500 hectares of forested land from the MBBR (as defined by the 2000 decree), equivalent to one-fifth of the entire area currently protected.

Since 2001, WWF-Mexico and the Mexican Nature Conservation Fund (FMCN) have annually monitored forest loss in the core and buffer areas of the MBBR, and have reported losses of over 560 hectares in a single year (from 2005 to 2006) (Ramírez and Zubieta 2005, WWF 2004, 2006). Illegal logging activities have been responsible for most of the deforestation documented, but subsistence-farming activities are also a concern (WWF 2004). Although the MBBR has official protected status, the land is divided into more than 100 private properties

(70% under communal regimes). Thus forest conservation and forest disturbance are related to property boundaries rather than to official protection limits, and show a high concentration of disturbance in about a dozen properties (Ramírez et al. 2006).

Annual monitoring results are reported to the governors of the states of Michoacán and México, and the Mexican Ministry of Environment and Natural Resources (Semarnat). Under strong pressure from President Felipe Calderon, the Mexican government has shut down illegal sawmills and charged people with crimes associated with illegal logging. The 2006–2007 forest cover assessment indicated a decrease in the rate of forest loss and deterioration in the core area of the MBBR, which could be the result of the current Mexican presidential policy of "zero tolerance to illegal logging." Future assessments will provide a test of this policy.

There is increasing evidence that diversion of water for human use could result in severe degradation of the overwintering sites. Successive years have resulted in the installation of increasing numbers of plastic pipes that divert water out of the overwintering forests for human and domestic animal use. For example, in the Ojo de Agua ravine on the south face of Cerro Pelón, water has been diverted to the extent that the streambed is dry for more than a kilometer. Monarchs fly down that ravine for more than two kilometers to obtain water farther downstream (L. Brower, personal communication). Increasing distances to water will presumably result in increased consumption of the lipids that keep the butterflies alive through the winter.

Illegal logging in Reserve

Potential biological causes of habitat degradation include the dwarf mistletoe (*Arceuthobium abietis religiosae*) and insects, particularly bark beetles, although the long-term impacts of infestations with either of these are poorly understood. Some researchers have estimated that approximately 5,000 hectares of oyamel fir (*Abies religiosa*) have different levels of mistletoe infection, and suggest that management strategies to manage these outbreaks need to be addressed (Hoth 1993).

Forest fires in the MBBR cause both habitat loss and direct impacts on monarchs if they occur during the overwintering period. Smoke disturbs the roosting butterflies, making them fly off of their roosting sites. Fires are most common in the MBBR buffer zone and near towns, where agricultural practices include burning to clear land for crops and grazing. Recent data show surface areas of 616 and 342 hectares burned in 2003 and 2005, respectively, with a low of 76 hectares in 2007. There were 27 fires in 2007, 11 and 16 in the states of México and Michoacán, respectively (F. Martínez, personal communication), and local community members are involved in many aspects of fire prevention and combat.

Finally, high numbers of tourists and degradation of the overwintering environment due to poorly-regulated visits may be harming monarchs (Brenner and Hubert 2006, Carlos Galindo-Leal, personal communication). For the past thirty years, tourism to the overwintering sites in Mexico has been increasing. At present, there are between 100,000 and 150,000 visitors every year, most of them concentrated in the Sierra El Campanario Sanctuary (El Rosario Ejido), during the weekends of December through March. In spite of thirty years of experience, tourism continues to be poorly organized. Ejidos with tourism activity lack business plans and do not reinvest income on maintenance or capacity building activities. At present, there is no formal assessment of the impacts of tourism, but there are several indications that tourists are having negative impacts.

Currently, Conanp and the Department of Tourism are taking steps aimed at mitigating and preventing impacts of tourism on the sanctuaries, through infrastructure development, local capacity-building, public awareness, and posting of signs.

Through a variety of crowd control techniques, local guides protect the butterflies in areas that receive high numbers of visitors but the process of getting the tourists to the sites—often, in the Sierra Chincua Sanctuary, by means of horseback—leads to trail degradation and erosion, and extremely dusty conditions that can lead to blocked spiracles (air passages) and butterfly suffocation (K. Oberhauser, personal observation). Food and handicraft shops in El Rosario and Chincua take up more and more area and produce more garbage. Increased firewood-harvesting to support small restaurants may be harming endemic junipers and other native plants. Tourists and horses are dispersing invasive plants, particularly the weed *Acaena elongate* (family *Rosaceae*), known in Mexico as *pegarropa* (which means adheres to cloth) due to the velcro-like quality of the seeds, and possibly disturbing the butterflies with noise and increased carbon dioxide levels. Brenner and Hubert (2006) suggest that there is a serious problem of coordination of tourism activities. Neither policies oriented to different target tourist groups nor a comprehensive visitor management plan have been developed, resulting in services and products that are the same low quality for everyone and that do not take into consideration the expectations and financial means of different ecotourism segments (Brenner and Hubert 2006).

There has been extensive loss of wintering habitat in California, with a decline from 1990 to 1998 of over 12% in wintering habitats available to monarchs.

9.2.2 California

There has been extensive loss of wintering habitat in California, with a decline from 1990 to 1998 of over 12% in the number of wintering habitats available to monarchs (Meade 1999, Frey and Schaffner 2004). Factors that have resulted in the loss of appropriate habitat include tree growth that results in increased shading, and tree loss due to factors such as senescence, diseases, and commercial and municipal development (Meade 1999, Leong et al. 2004). Monarch habitat has also been destroyed in California by monarch-focused recreational activities. For example, a famous overwintering site at Pacific Grove was destroyed when a motel was built among the butterfly trees to accommodate visitors to the site (Lane 1993).

9.3 Disease and Parasites

Monarchs are affected by a variety of infectious diseases caused by viruses, bacteria, fungi, protozoans, nematodes and mites. They are also heavily preyed upon by a number of predators and parasitoids.

9.3.1 Parasitoids

Parasitoids are insects that deposit eggs in or on other insects. The larvae of these species eat their hosts from the inside, and generally emerge from the carcass of a larva, pupa or adult. Parasitoids that consume monarch larvae include both flies and wasps. Tachinid fly larvae feed on monarch caterpillars, usually killing their host just before pupation. From one to several fly maggots emerge from the host, and drop to the ground on long, gelatinous tendrils. In some localized populations, most monarch larvae are parasitized by tachinid flies, but parasitism rates are generally from 5 to 20% (Oberhauser et al. 2007). Various parasitoid wasp species also parasitize monarch larvae, but less is known about their importance, probably because wasps tend to parasitize pre-pupal larvae, and are thus less likely to be found by researchers. Braconid wasp parasitism may result in as many 32 adult wasps from a single monarch carcass.

9.3.2 Parasites

Spine-shouldered stink bug with monarch larva

Monarchs are infected by a nuclear polyhedrosis virus and Pseudomonas bacteria. A protozoan parasite, *Ophryocystis elektroscirrha*, is found in both wild and captive populations, and a microsporidian Nosema species has been identified in captive monarchs (University of Georgia 2007); both of these infections can have debilitating effects on monarchs. Horsehair worms, in the phylum *Nematomorpha*, have been observed in monarch larvae (Prysby and Oberhauser unpublished). *O. elektroscirrha* is the only well-studied monarch parasite. The inactive spore of this protozoan disease is mixed among the scales on the integument (exoskeleton) of monarch adults, and spread from mother to offspring when larvae ingest spores deposited onto the eggs or surrounding milkweed. This parasite can reduce larval survival, butterfly mass, and life span (Altizer and Oberhauser 1999). Populations that do not migrate, such as those in southern Florida and Hawaii, have the highest parasite infections, with about 70% heavily infected individuals. Only about 30% in western North America and 8% in the eastern migratory population are heavily infected (Altizer et al. 2001).

9.4 Climate Change

Monarchs overwinter in specific climatic regions in the montane oyamel fir forests located in Mexico. Oberhauser and Peterson (2003) used ecological niche models to identify a narrow range of temperature and precipitation that allowed monarchs to survive the winter. Conditions predicted by climate change models suggest that the current overwintering sites will not be suitable for monarchs in 2055. Hadley Climate Center models predict increased precipitation during the winter in the Mexican wintering sites, but little change in temperature. Using conditions forecast for 2055, Oberhauser and Peterson (2003) predicted increased precipitation during cold weather, such as the conditions that killed up to 70–80% of the two largest overwintering populations in 2002 (Brower et al. 2004). While 50% of monarchs can survive temperatures of -8˚C by supercooling if they are dry, 50% of wet individuals are frozen at temperatures of -4.4˚C (Anderson and Brower 1993, 1996).

Batalden et al. (2007) also used ecological niche modeling to study the summer breeding range of monarchs and how it may be affected by climate change. Monarchs follow warm, moist conditions as they move northward in the spring, but are able to utilize a wide area, without directional flight, throughout most of the summer. Climate change model predictions suggest that monarchs' ecological niche, at least as defined by temperature and precipitation, will move northward, necessitating movement by all summer generations. The degree to which monarchs will be able to utilize newly-available conditions to the north depends on whether they can change their migratory patterns, and on the ability of milkweed to colonize areas in which it does not currently grow.

9.5 Pesticide Use

The use of herbicides was discussed above. In addition to the loss of habitat caused by herbicides that remove monarch host plants and nectar sources, monarchs can be killed outright by insecticides used to control pest insects. Insecticides may be important sources of mortality in agricultural areas, in urban and suburban areas where adult mosquito control programs are utilized (Oberhauser et al. 2006), and near forests that are being sprayed with Bt to control forest pests, particularly gypsy moths. While all of these insect control methods have the potential to kill monarchs, the degree to which they affect overall population numbers is unknown.

10 LEGAL STATUS, MANAGEMENT AND ACTION

Concern about the long-term viability of monarchs in North America has resulted in several legal protection efforts. Much of this concern is centered on monarch habitat needs, and the rate of loss of habitat used by monarchs. The difficulty in accurately measuring monarch populations, their complicated migratory life cycle, and year-to-year variation in monarch density make it difficult to link monarch numbers to large-scale habitat availability. Thus, there is still speculation about the short-term impacts of habitat loss on monarchs. However, we do know that monarch habitat is being lost during each of its three life history stages (breeding, migrating and overwintering). The extraordinarily dense concentrations in the Mexican overwintering sites make threats there of particular concern.

A number of continent-wide monarch conservation initiatives have been endorsed by cooperative activities of the governments or government agencies of Canada, Mexico and the United States.

10.1 International

As a result of perceived threats to the monarch, the winter roosts in Mexico and California were designated as threatened phenomena by the International Union for Conservation of Nature and Natural Resources (IUCN) in the IUCN Invertebrate Red Data Book in 1983 (Wells et al. 1983, Malcolm 1993). This was the first designation for a biological phenomenon, as opposed to a species, in the history of international conservation. It recognizes the fact that the migratory phenomenon, which involves millions of monarchs migrating to distant overwintering sites each year, is imperiled, even though the species as a whole is not in danger of extinction. Mexico's Monarch Butterfly Biosphere Reserve was inscribed in the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Network of Biosphere Reserves in 2006. The Advisory Committee for Biosphere Reserves recommended that Mexican authorities increase cooperation with Canadian and United States authorities responsible for key sites along monarch migratory routes. No specific international protection is conferred by either the IUCN or UNESCO designation.

A number of continent-wide monarch conservation initiatives have been endorsed by cooperative activities of the governments or government agencies of Canada, Mexico and the United States. The Commission for Environmental Cooperation (CEC), in partnership with the Trilateral Committee for Wildlife and Ecosystem Conservation and Management and other agencies, has supported several efforts to protect monarchs. In 1997, the CEC and US Fish and Wildlife Service (USFWS) convened a stakeholders' meeting in Morelia, Michoacán, to develop a long-term strategy for monarch conservation (Hoth et al. 1999), and a USFWS-supported meeting in Lawrence, Kansas, in 2001 resulted in a summary of important research and conservation objectives (Oberhauser and Solensky 2002).

Since 1995, the USFWS Wildlife Without Borders–Mexico grants program has partnered with Mexican authorities and nongovernmental organizations to protect and restore the wintering habitat of the monarch butterfly. Between 1995 and 2006, USFWS awarded almost $800,000 in grants for monarch projects. About 94 percent of the funds were for projects to develop the capacity of the local communities of the MBBR to sustainably manage their natural resources. USFWS partners with Mexican authorities and Alternare, A.C., to support a training program to develop the natural resource management capabilities of local communities, and has funded programs to provide training in reforestation techniques for peasant farmers living in the MBBR.

Since 1993, the USFS–International Programs has been working with MBBR managers and partners in the region to build management capacity, provide guidance to communities for resource management, and conserve natural resources in the core zone of the MBBR. Staff from the Willamette National Forest and other units have provided training and consultations on forest inventory, global positioning system (GPS)/geographic information system (GIS) utilization, and design and maintenance of trails. Through a partnership with the Monarch Model Forest, partners developed proposals to assist with recreation management and ecotourism, landscape ecology, small-scale wood product development and marketing, and community incentive programs.

In March 2006, the Trilateral Committee for Wildlife and Ecosystem Conservation and Management (Trilateral Committee) initiated a project to establish a network of sister protected areas (SPAs) to collaborate on monarch conservation projects focused on habitat preservation and restoration, research, monitoring, environmental education, and public outreach. Thirteen protected areas administered by the USFWS, US National Park Service (USNPS), Canadian Wildlife Service (CWS), Parks Canada Agency (PCA), and Mexico's National Commission of Natural Protected Areas (Conanp) were identified as part of the initial network (see map).

The initiative to develop the North American Monarch Conservation Plan (NAMCP) was launched at the December 2006 Monarch Flyway Conservation Workshop sponsored by the USFS-International Programs, US Agency for International Development (USAID), Texas Parks and Wildlife Department (TPWD), the Wildlife Trust, and the City of McAllen, Texas. The NAMCP initiative was endorsed by the Trilateral Committee in May 2007, and in June 2007, at the initiative of the Mexican Chair of the BCWG, the CEC Council, through Resolution 07-09, directed the CEC Secretariat to support the NAMCP development effort. The CEC, Trilateral Committee, and USFS-International programs are also supporting efforts to develop a trilingual Monarch Butterfly Monitoring Handbook of standardized monitoring protocols linked to existing monitoring programs for use by land managers, citizen scientists, NGOs, and educators across North America.

The North American Pollinator Protection Campaign (NAPPC) is an alliance of pollinator researchers, conservation and environmental groups, private industry, and state and federal agencies in all three countries (http://www.nappc.org). NAPPC works to organize local, national, and international projects involving pollinator research, education and awareness, conservation and restoration, special partnership initiatives, and policies and practices. The main goal of the campaign is to show a positive impact on population health of pollinating animals, such as monarchs, within five years. There is a specific NAPPC task force focused on monarch monitoring and conservation.

Monarch Butterfly Sister Protected Area Network

1 *Monarch Butterfly Biosphere Reserve (states of Michoacán and México) (Conanp)*
2 *Iztaccíhuatl Popocatépetl Zoquiapan Nacional Park (states of México, Puebla, and Morelos) (Conanp)*
3 *Cumbres de Monterrey National Park (Nuevo León) (Conanp)*
4 *Maderas del Carmen Wildlife Protected Area (Coahuila) (Conanp)*
5 *Balcones Canyonlands National Wildlife Refuge (Texas) (USFWS)*
6 *St. Marks National Wildlife Refuge (Florida) (USFWS)*
7 *Quivira National Wildlife Refuge (Kansas) (USFWS)*
8 *Flint Hills (Kansas) (USFWS)*
9 *Marais des Cygnes National Wildlife Refuge (Kansas) (USFWS)*
10 *Neal Smith National Wildlife Refuge (Iowa) (USFWS)*
11 *Cuyahoga Valley National Park (Ohio) (USNPS)*
12 *Point Pelee National Park (Ontario) (PCA)*
13 *Long Point National Wildlife Area (Ontario) (CWS)*

10.2 Canada

The Species at Risk Act (SARA), passed by the Canadian government in 2003, established a legislated process for the assessment, listing and recovery of species at risk (Environment Canada 2007). In addition to its legal list of species at risk, SARA includes general prohibitions and provisions for enforcement. The Act provides protection for all listed endangered, threatened and extirpated species and protects the critical habitat of these species where

they occur on federal lands. Under SARA, the Canadian government develops management plans that set conservation goals and objectives, identify threats to species, and indicate the main areas of activities to be undertaken to address those threats. The monarch is listed as a species of special concern under SARA because of a combination of biological characteristics and identified threats, especially risks to the overwintering sites in Mexico.

The Canada National Parks Act also protects the monarch at Point Pelee National Park in Ontario. In 1995, Canada and Mexico signed a declaration to create an International Network of Monarch Butterfly Reserves. The two nations pledged to jointly expand this network. Three areas in Southern Ontario were designated as Monarch Butterfly Reserves under the declaration: Point Pelee National Park, Long Point National Wildlife Area and Prince Edward Point National Wildlife Area. All three of these areas were protected before the declaration.

In 1997, the Legislature of the Province of Ontario passed the Fish and Wildlife Conservation Act. This Act gave "special status" to a number of invertebrate species, including the monarch butterfly. The Act requires that anyone in Ontario rearing, capturing, tagging, or conducting research on monarchs apply for special permits to conduct such activities.

10.3 United States

There is currently no special legal status at the federal level for monarch butterflies or their habitat in the United States.

In California, current legal protections involve a patchwork of city ordinances, coastal zone management plans and state law. In 1987, the California legislature passed Assembly Bill #1671, to recognize the monarch's migration and winter aggregation as a natural resource and to encourage the protection of its winter habitat. A year later, California voters approved a bond issue allocating $2,000,000 to purchase critical overwintering habitat (Snow and Allen 1993). As a result, some winter roosts in state, county or town parks receive protection. A small number of Californian cities and counties have enacted ordinances that prohibit activities that disturb monarchs and their winter roost trees. Of the ordinances currently in place, many apply these prohibitions only when monarchs are present.

A number of universities, nongovernmental agencies and organizations in the United States directly and indirectly support monarch conservation. For example, the Monarch Watch program (University of Kansas) supports the creation of Monarch Waystations to provide monarch nectaring and breeding habitat along the migratory path of monarchs. In the fall of 2007, over 1800 waystations, ranging in size from 100 to over 1000 m^2, had been registered. Other organizations, such as Journey North, the Monarch Butterfly Sanctuary Foundation, the Michoacán Reforestation Fund, the Monarch Program, and Monarchs in the Classroom (University of Minnesota) raise funds to support monarchs directly, and increase awareness of monarchs through a variety of educational programs. The Xerces Society for Invertebrate Conservation, working with the Ventana Wilderness Society, and California Polytechnic State University are managing an effort to census overwintering monarch populations in Thanksgiving counts. The Xerces Society is also assessing the legislation and/or ordinances of the State of California, and municipalities as they relate to monarch overwintering sites (see also Brower et al. 1993).

A number of universities, nongovernmental agencies and organizations in the United States directly and indirectly support monarch conservation.

The Texas Parks and Wildlife Department (TPWD), through the Texas Monarch Watch program, supports monarch monitoring workshops and provides information packets for volunteers involved in monitoring. TPWD also contracts with scientists to monitor transects on highway rights-of-way. In addition, units of the Texas system of protected areas hope to adopt the handbook of standardized monitoring protocols being developed in collaboration with CEC for use by the Sister Protected Area Network to provide greater geographic coverage along the monarch flyway. This could serve as a model for other state resource agencies along the flyway.

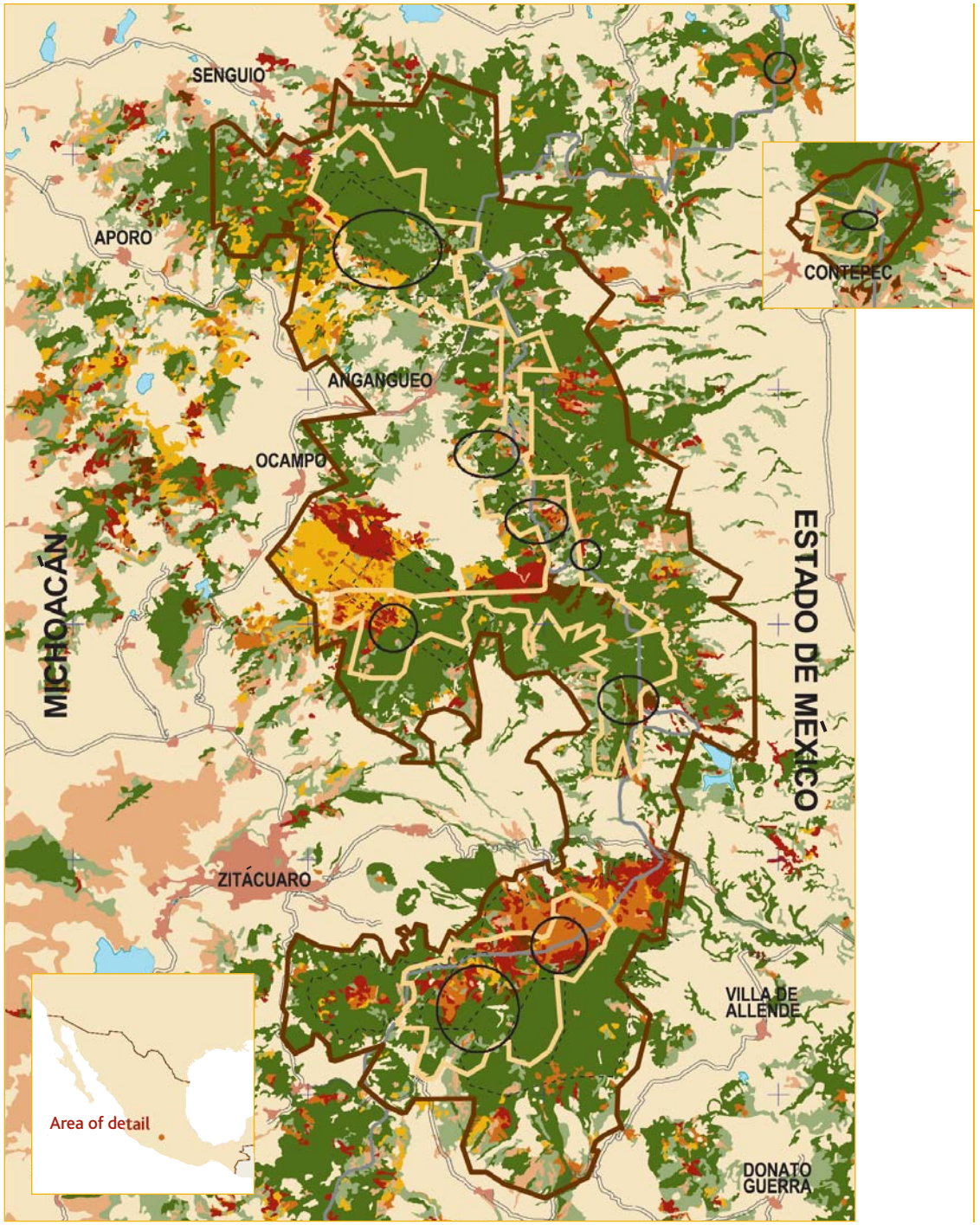
10.4 Mexico

Three federal decrees have been enacted to protect monarch habitat in Mexico. The first (1980 decree) protected the monarch overwintering areas without specifying the locations to be conserved and restricted extractive activities in the forests only during the overwintering season (November to March). The second (1986 decree) defined for protection 16,110 hectares in five discrete areas along the border of the states of México and Michoacán: Cerro Altamirano, Sierra Chincua, Sierra El Campanario, Cerros Chivatí-Huacal, and Cerro Pelón. Together these five areas were called the Special Monarch Butterfly Biosphere Reserve (SMBBR). Each area had a core and buffer zones, with a total of 4,491 ha in core zones and 11,619 ha in buffer zones. On 10 November 2000, by Presidential decree, the Monarch Butterfly Biosphere Reserve (MBBR) was established (2000 decree), increasing the size of the former SMBBR to 56,259 ha (13,552 ha of core area and 42,707 ha of buffer). The new reserve included the creation of the Monarch Butterfly Conservation Fund (administered by FMCN and WWF-Mexico), which provides economic incentives to prevent logging by local communities who own the core area and whose forest harvesting permits were withdrawn (Missrie 2004, Galindo-Leal and Rendón Salinas 2005, Missrie and Nelson 2007).

The monarch butterfly is listed as "under special protection" in the Species at Risk standard, by the Mexican government.

The monarch butterfly is listed as "under special protection" in the Species at Risk standard (NOM-059-Semarnat-2001), by the Mexican government. This means that it is considered a species or population that could be threatened by factors that negatively affects its viability, and that its recovery and conservation should be promoted wherever it is found.

Smaller colonies outside of the MBBR have varying degrees of protected federal status and are administered by Conanp. The Iztaccíhuatl-Popocatépetl National Park and Los Azufres Natural Resources Protected Area both regularly host small overwintering monarch colonies, and these areas are protected. The Mil Cumbres colony in the Cerro Garnica area is partially included in the Cerro Garnica National Park, but in recent years the colony has established about one kilometer from the northern boundary of the national park, and is thus not under any protection category. Another colony forms in Piedra Herrada near Valle de Bravo (in the state of México). This land was protected in a 1941 decree by President Avila Camacho as a natural protected area (NPA), and a 2005 revision of the decree resulted in protection of 143, 848 ha in the watersheds of Valle de Bravo, Malacatepec, Xalostoc and Temascaltepec. Through the Regional Sustainable Development Program (Conanp 2007), money was assigned to the NPA to be used in the Parador Ecoturistico Piedra Hearrada, a monarch overwintering site that offers tourist guide services. Some of the funds will be used to construct a cultural center near this site. The state of México declared a water sanctuary at Corral del Piedra (3622 ha), which also includes the monarch sanctuary of Piedra Herrada. Butterfly colonies in Cerro del Amparo and Palomas (both in the Temascaltepec municipality, state of México) are included in the Nevado de Toluca National Park. Protective actions specifically directed at monarchs have not been mandated in any of these areas, however.



Loss of forest cover in the Monarch Butterfly Biosphere Reserve and surroundings, 1986 to 2006

Loss period
- 1986-1993
- 1993-2000
- 2000-2003
- 2003-2006

Reserve limits
- Core zone, 2000
- Buffer zone, 2000
- Protected area, 1986
- Hibernation areas, 1986–2006

Land cover
- Dense forest
- Disturbed forest
- Shrubs
- Crops and grassland
- City areas
- Water

- State limits
- Main roads

Source: Ramírez Ramírez, M. Isabel, Ruth Miranda Guerrero, Raúl Zubieta Hernández (2007). Vegetación y Cubiertas del Suelo, 2006 (1:75000). Serie Cartográfica Monarca, Volumen I, Segunda Edición. MBSF-CIGA-UNAM-SEMARNAT-UNESCO. <http://www.ine.gob.mx/publicaciones>.

In 2004, the federal government, represented by Semarnat through Conanp, organized the first Monarch Butterfly Regional Forum, with the collaboration of the state governments of México and Michoacán, the MBBR, and WWF-México.

Several Mexican nongovernmental organizations support monarch conservation. For example, WWF-Mexico has been involved in monarch butterfly conservation, conducting activities that include colony monitoring, forest management, community restoration, eco-tourism, and environmental education programs. La Cruz Habitat Protection Project supports the planting of pine and oyamel fir trees in the area of monarch overwintering habitat. Alternare, A.C., supports local communities in and near the MBBR by promoting a variety of sustainable practices, including farming, building construction and reforestation. Similar activities are conducted in the state of Mexico by *Fundación Nacional para la Conservación del Hábitat Boscoso de la Mariposa Monarca* (Funacomm), which participated in the annual Texas Parks and Wildlife Expo event in 2007 to seek markets for the communities' crafts. The monarch program of the conservation organization Biocenosis focuses on promoting conservation of threatened species and habitats, general ecosystem conservation and management, and social monitoring. *Hombre y Alas de Conservación* (Halcon) and *Gestión Ambiental y Proyectos para el Desarrollo Sustentable Monarca* (Gapdes), NGOs based in Zitacuaro, support local communities in the MBBR through projects that include land use plans, forest management programs, sustainable development and environmental restoration.

In 2001, a Multidisciplinary Technical Scientific Workshop was organized by Profepa to develop a coordinated plan to systematize and integrate existing technical information and conservation efforts to clarify the causes of monarch mortality in overwintering sites. The group includes personnel from the MBBR, WWF-Mexico, IPN and the National Autonomous University of Mexico (*Universidad Nacional Autónoma de México*—UNAM) to identify risks to monarchs caused by both human activities or natural phenomena, and preventive measures to address these risks. The Forestry Commissions in the states of Michoacán and México also support conservation programs and actions, with technical assistance and subsidies, in coordination with several other government organizations.

In 2004, the federal government, represented by Semarnat through Conanp, organized the first Monarch Butterfly Regional Forum, with the collaboration of the state governments of México and Michoacán, the MBBR, and WWF-México. This annual event fosters coordination and collaboration among many stakeholders, identifies conservation and research priorities, promotes institutional transparency, and builds awareness about current challenges and opportunities for problem solving. The governors of the states of México and Michoacán and Semarnat officials have participated in every forum.

Conanp developed the National Strategy for Sustainable Tourism in Protected Areas in 2007. In the MBBR, the strategy focuses on controlling and reducing harmful impacts of tourism through planning, monitoring and regulatory activities; promoting sustainable development of tourism activities by supporting infrastructure, such as more appropriate foot paths; and improving the knowledge base of individuals involved with tourism. Additionally, Conanp is working to promote year-round tourist activities that focus on the ecology and landscapes of the MBBR. Recently, the WWF-Telcel Alliance began working with Conanp and the ejido of El Rosario to develop land use and tourism business plans, and improve basic infrastructure to support more sustainable tourism. They are working to improve bathrooms for tourists to avoid discharges of sewage water in the upper watershed; have set up 65 educational, informational and crowd management signs; and worked to improve the commercial infrastructure (restaurant and shop corridor).

11 PUBLIC AND COMMERCIAL PERCEPTIONS AND ATTITUDES

In the United States, the monarch has been designated as the state insect of Alabama, Idaho, Illinois, and Texas, and the state butterfly of Minnesota, Vermont, and West Virginia. The California Legislature declared 5 February as California Western Monarch Day in an effort to educate the public about the importance of these spectacular butterflies. The monarch was chosen as the insect emblem of Quebec in 1998 by a popular vote. It was nominated in 1989 as the national insect of the US. In Mexico, it is the representative insect of the state of Michoacán, and a popular representation of Mexico nature.

Children study monarchs in school, citizen scientist volunteers throughout North American track their migration and breeding, conservationists are concerned about impacts of human activities on monarchs, and citizens, government agencies and conservation organizations try to alleviate these impacts. Scientists study monarch mating behavior, interactions with milkweed and predators, responses to environmental change, and migration.

Part of the fascination with monarchs results from its spectacular migration, during which a single individual can traverse Canada, the US and Mexico. The concept that an organism with a mass about equal to that of a paperclip can fly thousands of kilometers from summer breeding grounds to overwintering sites in Mexico is mind-boggling, as are the aggregations of millions of butterflies, perhaps surpassed in number only by krill in the Arctic Ocean. In addition, because monarchs are so easy to raise and observe in captivity, many adults remember discovering a monarch larva as a child, and watching it transform into a butterfly.

The popularity of monarch butterflies makes them the focus of conservation concern; while human activities affect all organisms with which we share the earth, monarchs engender more than their share of public concern. The attraction to monarchs, and the resultant conservation and scientific interest have enriched human knowledge of the natural world and our resolve to preserve it.

Few species have more popular appeal than the monarch.

12 TRINATIONAL CONSERVATION: GOALS, OBJECTIVES AND TARGET ACTIONS

Monarch conservation will require trilateral action involving individuals, organizations and institutions. Here, we present objectives and actions that are designed to address the following overarching goal: to conserve the habitat required by monarchs during their annual cycle of breeding, migrating and overwintering. These objectives and actions represent our best understanding of aspects of monarch biology that are relevant to conservation and summarized in this document. Habitat conservation should include both protection of existing habitat, and restoration of habitat that has been degraded by human activities. Because monarchs co-exist with human populations, conservation activities must also address the social, economic and educational needs of humans living in and near monarch habitat. Additionally, because monarchs utilize a broad range of habitats that cover large geographic areas during their migratory cycle, it is imperative that conservation actions are based on a flyway approach, rather than directed exclusively towards a specific stage of the annual cycle. However, the small size and immediate human threats to the overwintering sites in Mexico and California make conservation in these areas of immediate critical concern.

To address the overarching goal of monarch habitat conservation, proposed action items target four main areas: 1) Threats prevention, control and mitigation; 2) Innovative enabling approaches; 3) Research, monitoring, evaluation and reporting; and 4) Education, outreach and capacity building. Within each area, specific conservation objectives and actions are proposed. The broad range of monarch populations and their complicated biology, summarized in this document, require continued research on the impacts of specific actions on monarch conservation. Thus, many of the conservation objectives address ways in which we can increase our understanding of monarch biology, specifically monitoring interactions with their living and non-living environment. Additionally, the objectives address monitoring how conservation actions affect the social and economic well-being of humans, as well as how these actions affect monarch populations.

12.1 Specific Objectives of the Monarch Conservation Plan

1. THREATS PREVENTION, CONTROL AND MITIGATION

A. Overwintering

- Decrease or eliminate deforestation due to logging and habitat conversion
- Sustain benefits from tourism without harming monarch populations or habitat
- Determine causes of decreasing water availability and mitigate impacts on monarchs
- Determine impacts of plant and insect parasites on forests in monarch overwintering areas

B. Flyway

- Address the threats of habitat loss and degradation in the flyway

C. Breeding Areas

- Address the threats of the loss, fragmentation, and modification of breeding habitat
- Limit impact of habitat management practices on monarchs, flowering plants and milkweed

D. Across Annual Range

- Investigate the effects of global climate change on monarch survival
- Assess the impacts of parasites and pathogens on monarchs and their host plants

2. INNOVATIVE ENABLING APPROACHES

- Promote environmentally sustainable income sources for individuals and institutions whose current livelihood results in degraded monarch habitat
- Support trilateral activities that promote environmental cooperation and support

3. RESEARCH, MONITORING, EVALUATION AND REPORTING

- Monitor monarch population distribution, abundance, and habitat quality, and utilize the monitoring data to understand monarch population drivers
- Determine socioeconomic factors that influence the distribution and abundance of monarch butterflies
- Evaluate and assess the effects of conservation actions on monarch distribution and abundance

4. EDUCATION, OUTREACH, AND CAPACITY BUILDING

- Expand communication and information sharing that supports monarch conservation
- Enhance capacity building, training and networking programs

12.2 Table of Specific Actions

1. THREATS PREVENTION, CONTROL AND MITIGATION
A. Overwintering

THREAT	ACTION	PRIORITY	TIME FRAME
1. Threats due to deforestation from large-scale, organized illegal logging; small-scale, illegal subsistence logging; legal logging; and habitat conversion Objective: Decrease or eliminate deforestation due to logging and habitat conversion	Assess the effects of land use changes in and near the MBBR	①①①①	→
	In Mexico, provide long-term capacity building projects to support increased surveillance and enforcement programs by government, NGO and community groups.	①①①①	→
	In the US, purchase and legally protect overwintering sites in California.	①①①①	→
	In Mexico, provide technical assistance and support through specific prevention and mitigation actions, such as transportation system redesign, logging road closures, etc.	①①①①	3 yrs
	Develop and reinforce sustainable practices in communities and expand the number of communities involved in these projects.	①①①①	→
	Review effectiveness of economic incentives to not cut the forest in the MBBR.	①①①①	1 yr
	Identify and promote market trade of non-timber products that can be produced within the MBBR buffer zone and surrounding areas.	①①①	3 yrs
	Promote commercial forest plantings in the buffer zone and surrounding area.	①①	→
	Monitor monarchs' use of core vs. buffer areas to determine if current protection is adequate.	①①①	3 yrs
	Promote and strengthen ecological restoration programs in conservation zones, and productive reforestation in managed zones.	①①①	→
2. Threats due to poorly-regulated tourism Objective: Benefit from tourism without harming monarch populations or habitat	Assess tourist impacts on forest habitat and disturbance to overwintering colonies.	①①①	5 yrs
	Develop and implement a plan for sustainable ecotourism	①①①	5 yrs
3. Threats due to decreasing water availability Objective: Determine causes of decreasing water availability and mitigate impacts on monarchs	Identify causes of decreasing water access and monitor water availability for overwintering monarchs.	①①①①	1 yr
	Restore water access.	①①①①	→
4. Threats due to biological factors Objective: Determine the impacts of plant and insect parasites on forests in monarch overwintering areas	Determine impacts of dwarf mistletoe on *Abies religiosa* and implement a control program.	①①①①	→
	Determine impacts of bark beetles and other insects on *Abies religiosa* and implement a control program.	①①	→

Priority ■ low: ① ■ medium: ①① ■ high: ①①① ■ critical: ①①①①
Time frame ■ Year (s): **yr, yrs** ■ Continuous: →

1. THREATS PREVENTION, CONTROL AND MITIGATION (continued)

B. Flyway

THREAT	ACTION	PRIORITY	TIME FRAME
1. Threat: Habitat loss and degradation in monarch flyway Objective: Address the threats of habitat loss and degradation in the flyway	Identify habitat types and locations that are essential for the migration (roosting sites and nectaring habitats).	①①①	3 yrs
	Assess effects of land use changes on monarch migration.	①①①	→
	Develop and disseminate guidelines to conserve, enhance and restore migration habitat.	①①	→
C. Breeding areas			
1. Threat: Habitat loss and degradation in monarch breeding areas Objective: Address the threats of the loss, fragmentation, and modification of breeding habitat	Determine if, when and where milkweed is a limiting resource and develop plans to plant regionally appropriate species.	①①①①	3 yrs
	Strengthen monarch butterfly habitat protection on public and private land.	①①①①	→
	Assess effects of land use changes on monarchs and milkweed (e.g., conversion of land to corn and wheat for ethanol, or to homes).	①①①①	3 yrs
	Develop guidelines for farm buffers for nectar sources.	①①①	3 yrs
	Develop road, powerline and railroad right-of-way habitat protection programs; promote protection in facilities such as golf courses or parks.	①①①	→
2. Threat: Habitat management practice Objective: Limit impact of habitat management practices on monarchs, flowering plants and milkweed	Study and limit impact of biocides (herbicides, insecticides) on monarch populations and their habitat.	①①①	3 yrs
	Develop highway and other roadside mowing regimens compatible with monarch breeding.	①①①	3 yrs
	Develop recommendations to encourage consideration of milkweed as a beneficial plant, not a noxious weed.	①	1 yr
	Control dog-strangling vine and other invasive plants that directly affect monarchs or milkweed.	①①	→
D. Across Annual Cycle			
1. Threat: Global Change Objective: Investigate the effects of global change on monarchs' survival	Identify direct and indirect impacts of global change affecting monarch populations (warming and other changes in weather patterns, pollution, increased UV exposure, increased CO_2, invasive species).	①①①①	→
2. Threat: Parasites and pathogens that affect monarchs Objective: Assess the impact of parasites and pathogens on monarchs and their host plants	Determine the role of commercial production and distribution of monarchs on disease prevalence. Consider a breeder inspection program.	①①	3 yr

2. INNOVATIVE ENABLING APPROACHES

OBJECTIVE	ACTION	PRIORITY	TIME FRAME
Promote environmentally sustainable income sources for individuals and institutions whose current livelihood results in degraded monarch habitat	Establish specific standards with local criteria for timber and non-timber products, including agricultural monarch-friendly products, throughout flyway.	①①	→
	Develop environmentally friendly fair trade programs for products and services (e.g., handicrafts, ecotourism).	①	→
	Payments for environmental services (carbon sequestration, hydrological services and landscape conservation).	①①①①	→
Support trilateral activities that promote environmental cooperation and support	Explore legal, social, and environmental feasibility of promoting trinational agreements for conservation easements.	①①	3 yrs
	Expand the Sister Protected Area Network (possibly to Amistad National Recreation Area and state parks in Texas, Sierra Gorda in Querétaro, Los Azufres and Valle de Bravo Natural Resource Protected Areas in Michoacán).	①①①	→
	Support a bi- or trilingual staff person who will coordinate and monitor monarch conservation activities, possibly to be housed at TPWD in Austin, Texas.	①①①	→

Priority ■ low: ① ■ medium: ①① ■ high: ①①① ■ critical: ①①①①
Time frame ■ Year (s): **yr, yrs** ■ Continuous: →

3. RESEARCH, MONITORING, EVALUATION AND REPORTING

OBJECTIVE	ACTION	PRIORITY	TIME FRAME
Monitor monarch population distribution, abundance, and habitat quality, and utilize the monitoring data to understand monarch population drivers	Develop shared monitoring toolkit, with protocols linked to existing programs that address breeding, migrating, and overwintering.	①①①①	1 yr
	Distribute monitoring toolkit, and coordinate data collection.	①①①①	3 yrs
	Create a trinational agreement to exchange data among researchers and stakeholders, perhaps by instituting a tri-country data bank.	①①①	3 yrs
	Develop a diagnosis of population drivers.	①①①	3 yrs
	Develop easily implementable, physiological assays of monarch performance such as haemolymph, lipid and water content assays of stress indicators.	①	3 yrs
	Determine the influence of topography, seasonal wind patterns and other landscape features on monarch movement.	①①	3 yrs
Determine socioeconomic factors that influence the distribution and abundance of monarch butterflies	Identify socioeconomic factors that can be targeted for monarch mitigation actions.	①①①① (Mexico) ①① (US and Canada)	3 yrs
	Identify costs and benefits, and feasibility (stakeholder acceptance) of mitigation actions for monarch conservation.	①①①① (Mexico) ①① (US and Canada)	3 yrs
Evaluate and assess the effects of conservation actions on monarch distribution and abundance	Maintain a record of conservation actions.	①①①	→
	Collect and analyze existing data and use them to determine whether mitigation actions have been successful.	①①①①	→
	Develop adaptive management procedures to encourage factors that result in positive changes and discourage those that result in negative changes.	①①①①	→
	Develop standardized indicators to evaluate the effectiveness of economic incentives to conserve monarch habitats.	①	→

4. EDUCATION, OUTREACH, AND CAPACITY BUILDING

OBJECTIVE	ACTION	PRIORITY	TIME FRAME
Expand communication and information-sharing that support monarch conservation	Develop Trilateral Plan for Monarch Butterfly Flyway outreach, taking into account available and needed materials.	!!	1 yr
	Develop, distribute and assess educational toolkit (including sensitivity to habitat values and management) to teachers, trainers, consumers.	!!	1 yr
	Use electronic and print media for increasing awareness, distributed via an easy-to-use and interactive website.	!!!	→
	Relate monarch migratory phenomena to climate-change awareness	!	3 yrs
	Create a factsheet and other communication materials on the Monarch Butterfly Flyway status and needs and distribute to decision makers and communities.	!!!	1 yr
	Develop and distibute consumer educational material (pollination services and monarch friendly products).	!!	3 yrs
Enhance capacity building, training and networking programs	Develop field training program for all levels of decision makers.	!!	3 yrs
	Develop and conduct training programs for guides at overwintering sites and migratory staging areas.	!!	1 yr
	Develop and conduct training programs for natural resource professionals, on using monitoring toolkit.	!!	1 yr
	Promote a trinational declaration to establish NAMCP actions as priorities for funding.	!!	1 yr

Priority ■ low: ! ■ medium: !! ■ high: !!! ■ critical: !!!!
Time frame ■ Year (s): **yr, yrs** ■ Continuous: →

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14 APPENDIX: LIST OF ACRONYMS

BCWG	Biodiversity Conservation Working Group, CEC
CEC	Commission for Environmental Cooperation
Cofom	*Comisión Forestal de Michoacán* (Forestry Commission of Michoacán)
Conafor	*Comisión Nacional Forestal* (National Forestry Commission)
Conanp	*Comisión Nacional de Áreas Naturales Protegidas* (National Commission for the Protection of Natural Areas; part of Semarnat)
CWS	Canadian Wildlife Service
FMCN	*Fondo Mexicano para la Conservación de la Naturaleza* (Mexican Fund for the Conservation of Nature)
IPN	*Instituto Politecnico Nacional* (National Polytechnic Institute)
IUCN	International Union for Conservation of Nature and Natural Resources (also known as the World Conservation Union)
MBBR	Monarch Butterfly Biosphere Reserve
NAPPC	North American Pollinator Protection Campaign
NDDB	Natural Diversity Data Base, California Department of Fish and Game
NGO	Nongovernmental organization (general term for many not-for-profit organizations)
PCA	Parks Canada Agency
Probosque	*Protectora de Bosques del Estado de México* (Protector of Woodlands of the State of México).
Profepa	*Procuraduría Federal de Protección al Ambiente* (Federal Law Office for Environmental Protection, Semarnat)
SARA	Species at Risk Act (Canada)
Semarnat	*Secretaría de Medio Ambiente y Recursos Naturales* (Ministry of the Environment and Natural Resources)
TPWD	Texas Parks and Wildlife Department
UNAM	*Universidad Nacional Autónoma de México* (National Autonomous University of Mexico)
USAID	United States Agency for International Development
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USNPS	United States National Park Service
WWF	World Wildlife Fund

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This North American Monarch Conservation Plan offers a list of key trinational collaborative conservation actions, priorities and targets to be considered for adoption by the three countries. The actions identified address the following main objectives: (1) decrease or eliminate deforestation in the overwintering habitat; (2) address threats of habitat loss and degradation in the flyway; (3) address threats of loss, fragmentation and modification of breeding habitat; (4) develop innovative enabling approaches that promote sustainable livelihoods for the local population; and (5) monitor monarchs throughout the flyway. The adoption of measures to address these objectives will help conserve the monarch and its habitats for future generations.

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Este plan de América del Norte para la conservación de la mariposa monarca ofrece una lista de las principales acciones, prioridades y objetivos de conservación conjuntos que los tres países deben considerar para su adopción. Las acciones identificadas abordan los siguientes objetivos principales: 1) reducir o eliminar la deforestación en el hábitat de invernación; 2) atender las amenazas de pérdida y degradación de hábitats en la ruta migratoria; 3) atender las amenazas de pérdida, fragmentación y modificación del hábitat de reproducción; 4) desarrollar enfoques e instrumentos innovadores para fomentar modos de vida sustentables entre la población local, y 5) monitorear a las monarca a lo largo de su ruta migratoria. La adopción de medidas a fin de cumplir con estos objetivos ayudará a conservar a la monarca y sus hábitats para futuras generaciones.

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Ce plan nord-américain de conservation du monarque propose une série de mesures, de priorités et d'objectifs clés en matière de conservation qui pourraient faire l'objet d'une action concertée des trois pays. Les mesures énoncées visent les principaux objectifs suivants : 1) réduire ou éliminer le déboisement dans les aires d'hivernage; 2) lutter contre les menaces de perte et de dégradation des habitats le long de la voie migratoire; 3) lutter contre les menaces de perte, fragmentation et modification des habitats de reproduction; 4) élaborer des approches habilitantes innovatrices qui favoriseront des modes de subsistance durables pour les populations locales; 5) assurer une surveillance du monarque dans l'ensemble de la voie migratoire. L'adoption de mesures permettant d'atteindre ces objectifs contribuera à la préservation du monarque et de ses habitats pour les générations futures.

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