

# Monarch Butterfly

WWF WILDLIFE AND CLIMATE CHANGE SERIES



*This assessment is one in a series resulting from a WWF study that assesses the vulnerability of numerous species to the effects of climate change. For each species, we also recommend climate-adaptive management strategies.*

**MONARCH BUTTERFLIES** (*Danaus plexippus*) range throughout the world, but this assessment focuses on North American populations.

Monarchs have a high dispersal ability across a large geographic range. This, combined with their short generation time and high reproductive rate, suggests that monarchs may have a high capacity to adapt to longer term changes in climate.

However, a number of traits make them vulnerable to a changing climate. Like most butterflies, monarchs are highly sensitive to weather and climate: They depend on environmental cues (temperature in particular) to trigger reproduction, migration, and hibernation. Their dependence on milkweed alone as a host plant is a further vulnerability, particularly as milkweed abundance is declining throughout the monarch range. They also face a decline in their overwinter habitat, and the effects of an increasing frequency of extreme weather events such as drought and severe storms, and extremes in hot and cold temperatures.

Priorities for climate-informed monarch conservation should include restoring and increasing the extent of habitat with appropriate milkweed species and nectar sources. The public at large can contribute to this effort by planting backyard habitat. Increased monitoring of populations is also important, and citizen science efforts can contribute to this. It is also essential to maintain and restore overwinter habitat, reduce the use of herbicides and pesticides, and address issues related to land-use change.



Monarch butterfly range

## DETERMINING SPECIES VULNERABILITY

*The study identified the key vulnerabilities of a species based on four factors:*

**SENSITIVITY:** the inability of the species to persist, as is, under changing climatic conditions. To assess sensitivity, we looked at IUCN Red List status, geographic range, population size, temperature tolerance, reliance on environmental cues (for reproduction, migration, hibernation), symbiotic interactions, diet, abundance of food sources, freshwater requirements, habitat specialization, and susceptibility to disease.

**ADAPTIVE CAPACITY:** the ability of the species to respond to changes in climate. To assess adaptive capacity, we looked at dispersal ability, generation time, reproductive rate, and genetic variation.

**EXPOSURE:** the extent of climatic change and variation that the species encounters and is projected to encounter.

**OTHER THREATS:** any other relevant threats, such as habitat destruction, poaching, human-wildlife conflict and pollution, as well as the human responses to climate change that exacerbate these threats.

# CLIMATE VULNERABILITY OF THE MONARCH BUTTERFLY

Vulnerability Levels: **H** = High **M** = Medium **L** = Low **U** = Unknown

## SENSITIVITY

### **L** IUCN Red List Status

**Near threatened.** The eastern monarch migration, however, has been classified as an endangered phenomenon.<sup>1</sup>

### **L** Geographic Range

**Large.** The largest population is in North America, but populations of varying size occur in many other parts of the world.<sup>2</sup> The focus of this assessment is on North America, where there are three recognized populations. Two of these are migratory, and are found east and west of the Rocky Mountains. The eastern population travels up to 3,000 miles in a year to overwinter in Central Mexico.<sup>3</sup> The western population travels a shorter distance to overwinter on the California coast.<sup>3,4</sup> One smaller, nonmigratory population is found in southern Florida.<sup>5</sup> Over the past 20 years, monarchs may have lost more than 165 million acres of habitat, including nearly a third of their summer breeding grounds.<sup>6</sup>

### **M** Population Size

**Medium.** The area of forest occupied by overwintering butterflies is used as an indirect indicator of abundance.<sup>4</sup> At the end of 2014, the eastern population occupied an overwinter habitat of 2.79 acres, representing the second-smallest area measured since monitoring began in 1993.<sup>7</sup> Current western monarch population estimates represent a 50% decline from the long-term average.<sup>8</sup>

### **M** Temperature Tolerance

**Medium.** For monarch caterpillars, temperatures above 29°C may retard growth,<sup>9</sup> and extended exposure to temperatures above 36°C can cause significant mortality<sup>10</sup>; the upper thermal limit appears to be 42°C.<sup>11</sup> Long hot dry spells can reduce adult butterfly lifespan and the number of eggs females lay.<sup>12</sup> Below-freezing temperatures can be lethal to overwintering adults, particularly when combined with moisture.<sup>13</sup> Physiological acclimation may however help in coping with thermal extremes.<sup>11</sup> Temperature influences annual population growth of monarchs and is crucial in determining range limits for butterflies in general.<sup>14,15</sup>

### **H** Does the species rely on environmental cues for reproduction?

**Yes.** Temperature influences reproductive development in adult male and female butterflies, with an optimal temperature of 28°C for both sexes.<sup>16</sup> The rate of development across all life stages is temperature dependent.<sup>9</sup> In many butterfly species, climatic conditions affect body temperature, which in turn is crucial for finding mates, increasing fecundity, and laying eggs.<sup>17</sup>

### **H** Does the species rely on environmental cues for migration?

**Yes.** Both temperature and precipitation influence migration phenology.<sup>14</sup> If the weather is unfavorable, migrants accumulate in “staging areas” for several days.<sup>18</sup> Monarchs overwintering in Mexico require prolonged exposure to cold overwintering temperatures in order to trigger the northward migration.<sup>19</sup>

### **H** Does the species rely on environmental cues for hibernation?

**Yes.** Hibernation is triggered by fluctuating fall temperatures, decreasing daylight, and aging milkweed.<sup>20</sup>

### **H** Does the species have any strong or symbiotic relationships with other species?

**Yes.** Monarch butterflies lay their eggs on milkweed, and the caterpillars need milkweed to grow and develop.<sup>3</sup>

### **H** Diet

**Specialist.** Caterpillars feed on milkweed only. There are over 100 species<sup>3</sup> of milkweed; 72 of them are native to the USA and Canada, with the highest species diversity found in Texas and Arizona.<sup>21</sup>

### **M** Abundance of Food Source

**Medium.** Milkweed abundance in the eastern and western USA is decreasing.<sup>3</sup> Milkweed quality for caterpillars diminishes at higher temperatures.<sup>22</sup>

### **M** Freshwater Requirements

**Medium.** Precipitation influences the annual population growth of monarchs.<sup>14</sup> Very dry conditions keep eggs from hatching,<sup>23</sup> and affect the availability and quality of milkweed and nectar sources.<sup>11,24</sup> However, many milkweed species are drought-tolerant once established.<sup>21</sup>

### **M** Habitat Specialization

**Specialist.** Monarchs require a mix of nectar flowers and native milkweed throughout their flyway.<sup>3</sup> Mexico’s high-elevation oyamel fir forest provides an ideal microclimate for overwintering butterflies,<sup>11</sup> as do forest groves along the California coast.

### **M** Susceptibility to Disease

**Medium.** Monarchs can be exposed to diseases caused by bacteria, viruses, and fungi,<sup>24</sup> as well as affected by parasitoids (tachinid flies, braconid wasps).<sup>11</sup> Changing temperature and precipitation could affect parasitoid abundance.<sup>11</sup> Individuals staying in the southern USA rather than overwintering in Mexico are increasingly exposed to the protozoan parasite *Ophryocystis elektroscirrha*, particularly from year-round tropical milkweed (the parasite’s host).<sup>25</sup> Parasite prevalence and load are lower in migratory populations.<sup>26</sup>

## ADAPTIVE CAPACITY

### **L** Dispersal Ability

**High.** The rapid expansion of monarch populations around the world suggests a very high dispersal ability and indicates there may be extensive gene flow between populations.<sup>27</sup> The eastern migratory population migrates up to 3,000 miles in the fall to overwintering sites in Mexico.<sup>28</sup>

### **L** Generation Time

**Short.** The eastern migratory population typically has 3-5 generations in a year, depending on temperature.<sup>29</sup> The overwintering generation lives for approximately 8-9 months, while the other generations live for approximately one month each.<sup>3</sup>

### **L** Reproductive Rate

**High.** On average, a female lays 300-400 eggs over her lifetime,<sup>24</sup> though mortality rates are high.

### **M** Genetic Variation

**Medium.** Studies suggest that there is gene flow between eastern and western populations, and that levels of genetic diversity within these populations are fairly high.<sup>27</sup>

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## EXPOSURE

### **M** What degree of climate variability is the species currently exposed to?

**Medium.** Currently exposed to a variety of extreme weather and climatic events, including floods, strong winds, droughts, fires, severe rains, heat waves, and freezing temperatures.<sup>4</sup> A few examples follow: A severe storm killed an estimated 2.5 million butterflies in January 1981.<sup>30</sup> Drought and fires in Texas have led to a lack of nectar for butterflies headed south.<sup>11</sup> Wet winters have left soggy butterflies in Mexico exposed to cold snaps<sup>31</sup> (a severe storm in 2002 killed 80% of the overwintering population).<sup>24</sup> In 2012, near-record heat sped up the northward migration, skewed migratory patterns, and limited reproduction; in 2013, the opposite happened when cold weather delayed the northward migration.

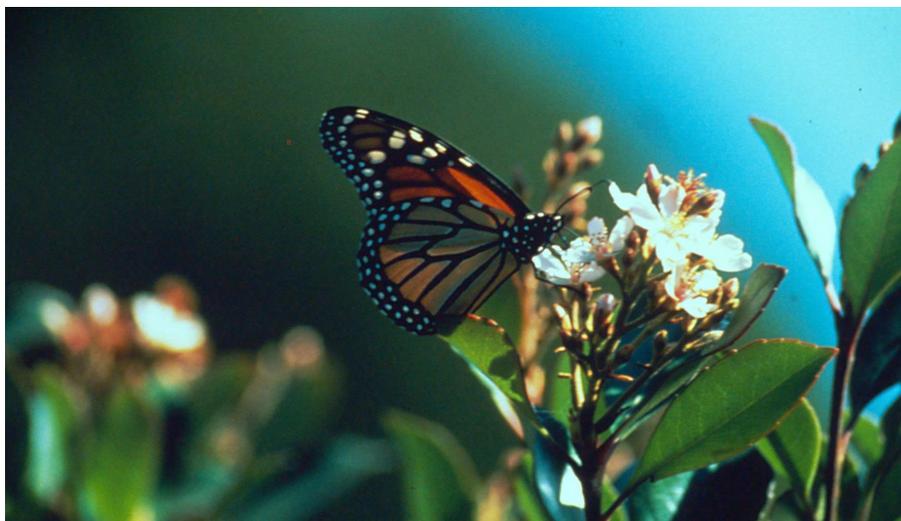
### **M** What level of change in temperature and precipitation is projected across the species' range?

**Medium.** North America is projected to get warmer throughout. The most warming is projected to take place at higher latitudes of the USA and Canada, as well as eastern Canada. The least warming is projected in parts of southern Mexico, the US Pacific Coast, and the southeastern US. Also projected are more frequent extreme heat events, more intense droughts, and increased precipitation variability. It is likely that the higher latitudes in North America will experience an increase in precipitation, while much of the southern half of North America will get drier.<sup>32</sup>

## OTHER THREATS

### **H** Other Threats

**High.** Habitat conversion and changes in land management practices, particularly in the corn belt region of the US.<sup>3</sup> A surge in the use of glyphosate herbicide on crops (particularly corn and soybean), which has caused severe milkweed decline in the US Midwest.<sup>6</sup> A decline in nectar plants. Deforestation and degradation of forests through illegal logging in Mexico.<sup>4</sup>



## RECOMMENDED CLIMATE-ADAPTIVE MANAGEMENT STRATEGIES

Based on the vulnerability assessment, we recommend these climate-adaptive management strategies for monarch butterflies:

1. Restore and increase the extent of habitat to include stepping stones, movement corridors, and climate refugia; improve management and restoration of habitat to facilitate resilience.
2. Increase monitoring of population range shifts, changes in phenology, changes in population abundance, changes in behavior, and the correlation of any of these with changes in weather and climate. This can be done both through traditional science, as well as through informed citizen science reporting.
3. Reduce pressures from other threats:
  - Ensure that milkweed is available throughout the monarch range, including in backyard habitat provided by the public at large. To avoid maladaptation, take care to plant the correct milkweed species at the correct time of year. Large areas of plantings will always be better than small areas, so more than backyard habitats will be needed.
  - Maintain and restore a dense, undisturbed forest for overwintering butterflies in Mexico and California.<sup>11</sup>
  - Ensure that nectar sources are thriving throughout the monarch range, including in backyard habitat provided by the public at large.
  - Reduce the use of herbicides and pesticides in monarch habitat.<sup>3</sup>
  - Address the negative impacts of land-use change.

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For this and other species assessments, visit [worldwildlife.org/wildlife-and-climate](http://worldwildlife.org/wildlife-and-climate)

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