U.S. FISH AND WILDLIFE SERVICE

SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

SCIENTIFIC NAME: *Danaus plexippus*

COMMON NAME: Monarch butterfly

LEAD REGION: IR3

DATE INFORMATION CURRENT AS OF: 09/17/2020

STATUS/ACTION

___ Species assessment - determined either we do not have sufficient information on threats or the information on the threats does not support a proposal to list the species and, therefore, it was not elevated to Candidate status

___ Listed species petitioned for uplisting for which we have made a warranted-but-precluded finding for uplisting (this is part of the annual resubmitted petition finding)

___ Candidate that received funding for a proposed listing determination; assessment not updated

_X_ New candidate

___ Continuing candidate

___ Listing priority number change

Former LPN: ___

New LPN: ___

___ Candidate removal: Former LPN: ___

___ A – Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.

___U – Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.

___ F – Range is no longer a U.S. territory.

___ I – Insufficient information exists on taxonomy, or biological vulnerability and threats, to support listing.

___ M – Taxon mistakenly included in past notice of review.

___ N – Taxon does not meet the Act's definition of "species."

___ X – Taxon believed to be extinct.

Date when the species first became a Candidate (as currently defined): NA

Petition Information:

___ Non-petitioned

_X_ Petitioned; Date petition received: August 26, 2014

90-day substantial finding FR publication date: December 31, 2014

12-month warranted but precluded finding FR publication date: NA

FOR PETITIONED CANDIDATE SPECIES:

a. Is listing warranted (if yes, see summary of threats below)? Yes

b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? NA

c. Why is listing precluded? Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, preclude the proposed and final listing rules for this species. We continue to monitor populations and will change its status or implement an emergency listing if necessary. The "Progress on Revising the Lists" section of the current CNOR (*http://endangered.fws.gov/*) provides information on listing actions taken during the last 12 months.

PREVIOUS FEDERAL ACTIONS

On August 26, 2014, we received a petition from the Center for Biological Diversity, Center for Food Safety, Xerces Society for Invertebrate Conservation, and Dr. Lincoln Brower, requesting that we list the monarch butterfly (*Danaus plexippus plexippus*) as a threatened species under the Act. On December 31, 2014, we published a 90-day finding that the petition presented substantial scientific or commercial information, indicating that listing the monarch butterfly may be warranted (79 FR 78775).

ANIMAL/PLANT GROUP AND FAMILY: Insects, Nymphalidae (Brush-footed Butterflies)

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE

United States: Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky,

Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming

United States territories: American Samoa, Guam, Johnston Atoll, U.S. Virgin Islands

Other countries or island groups: Anguilla, Antigua and Barbuda, Aruba, Commonwealth of Australia, Azores, Bahamas, Barbados, Belize, Bermuda, Bonaire, British Virgin Islands, Nation of Brunei, Canada, Canary Islands, Cayman Islands, Colombia, Cook Islands, Costa Rica, Cuba, Curacao, Dominica, Dominican Republic, Ecuador, El Salvador, Republic of Fiji, French Guiana, French Polynesia, Gibraltar, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Republic of Indonesia, Jamaica, Republic of Kiribati, Madeira, Malaysia, Marquesas Islands, Republic of the Marshall Islands, Martinique, Republic of Mauritius, Mexico, Federated States of Micronesia, Montserrat, Morocco, Republic of Nauru, Nicaragua, New Caledonia, New Zealand, Norfolk Island, Commonwealth of Northern Mariana Islands (CNMI), Republic of Palau, Independent State of Papua New Guinea, Panama, Peru, Republic of the Philippines, Portugal, Puerto Rico, Réunion, Saba, Saint Barthélemy, Saint Kitts and Nevis, Saint Lucia, Saint Martin, Saint Pierre and Miquelon, Saint Vincent and the Grenadines, Samoa, Sint Eustatius, Sint Maarten, Spain, Society Islands, Solomon Islands, Suriname, Democratic Republic of Timor-Leste, Tokelau, Kingdom of Tonga, Trinidad and Tobago, Turks and Caicos Islands, Tuvalu, Vanuatu, Venezuela, Territory of the Wallis and Futuna Islands

CURRENT STATES/COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE

United States: Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming

United States territories: American Samoa, Guam, Johnston Atoll, U.S. Virgin Islands

Other countries or island groups: Anguilla, Antigua and Barbuda, Aruba, Commonwealth of Australia, Azores, Bahamas, Barbados, Belize, Bermuda, Bonaire, British Virgin Islands, Nation of Brunei, Canada, Canary Islands, Cayman Islands, Colombia, Cook Islands, Costa Rica, Cuba, Curacao, Dominica, Dominican Republic, Ecuador, El Salvador, Republic of Fiji, French Guiana, French Polynesia, Gibraltar, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Republic of Indonesia, Jamaica, Republic of Kiribati, Madeira, Malaysia, Marquesas Islands, Republic of the Marshall Islands, Martinique, Republic of Mauritius, Mexico, Federated States of Micronesia, Montserrat, Morocco, Republic of Nauru, Nicaragua, New Caledonia, New Zealand, Norfolk Island, Commonwealth of Northern Mariana Islands (CNMI), Republic of Palau, Independent State of Papua New Guinea, Panama, Peru, Republic of the Philippines, Portugal, Puerto Rico, Réunion, Saba, Saint Barthélemy, Saint Kitts and Nevis, Saint Lucia,

Saint Martin, Saint Pierre and Miquelon, Saint Vincent and the Grenadines, Samoa, Sint Eustatius, Sint Maarten, Spain, Society Islands, Solomon Islands, Suriname, Democratic Republic of Timor-Leste, Tokelau, Kingdom of Tonga, Trinidad and Tobago, Turks and Caicos Islands, Tuvalu, Vanuatu, Venezuela, Territory of the Wallis and Futuna Islands

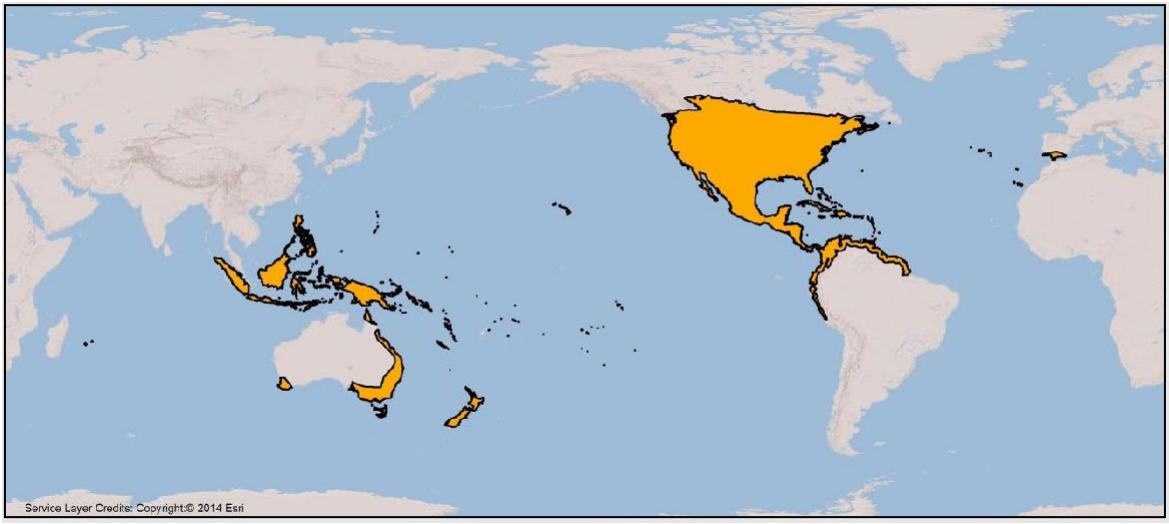

Figure 1. *Global range (shown in orange) of monarch.*

LAND OWNERSHIP

The monarch is wide-ranging across multiple continents. It occurs on both public and private lands; however, we are unable to provide a percentage of occupancy on any specific land-type.

LEAD REGION CONTACT: Barbara Hosler, Interior Region 3, (517) 351-6326, barbara_hosler@fws.gov

LEAD FIELD OFFICE CONTACT: NA

BIOLOGICAL INFORMATION

The Monarch *(Danaus plexippus)* Species Status Assessment Report, Version 2.0 is a summary of the information assembled and reviewed by the U.S. Fish and Wildlife Service (Service) and incorporates the best scientific and commercial information available for the species. Excerpts from the SSA Report are provided in the sections below. For more detailed information, please refer to the SSA report (Service 2020, entire).

Species Description

Adult monarch butterflies are large and conspicuous, with bright orange wings surrounded by a black border and covered with black veins. The black border has a double row of white spots, present on the upper side and lower side of forewings and hindwings (Bouseman and Sternburg 2001, p. 222). Adult monarchs are sexually dimorphic, with males having narrower wing venation and scent patches (CEC 2008, p.11; Figure 2). The bright coloring of a monarch serves as a warning to predators that eating them can be toxic (referred to as aposematism).

Figure 2. *Male monarch on milkweed. Note the arrow pointing to one of the two black dots on the hind wings. These are not present on female monarchs. Photo by Tim Koerner, U.S. Fish and Wildlife Service.*

Taxonomy

The petition that the Service received in 2014 was for listing a subspecies of the monarch butterfly (*Danaus plexippus plexippus*) (Center for Biological Diversity et al. 2014, p. 4). The petition also requested a determination of whether any new North American subspecies of *Danaus plexippus* should be listed. After careful examination of the literature and consultation with experts, there is no clearly agreed upon definition of potential subspecies of *Danaus plexippus* or where the geographic borders between these subspecies might exist. Given these findings, we examined the entire range of *Danaus plexippus*. For more information on taxonomy, see Appendix 1 of the SSA report.

Habitat/Life History

During the breeding season, monarchs lay their eggs on their obligate milkweed host plant (primarily *Asclepias* spp.). Larvae (caterpillars) feed on milkweed and sequester toxic cardenolides as a defense against predators (Parsons 1965, p. 299). The larvae then pupate into chrysalids before emerging as adult butterflies. There are multiple generations of monarchs produced during the annual breeding season, with most adult butterflies living approximately two to five weeks; overwintering adults enter into reproductive diapause (suspended reproduction) and live six to nine months (Cockrell et al. 1993, pp. 245-246; Herman and Tatar 2001, p. 2509; Figure 3).

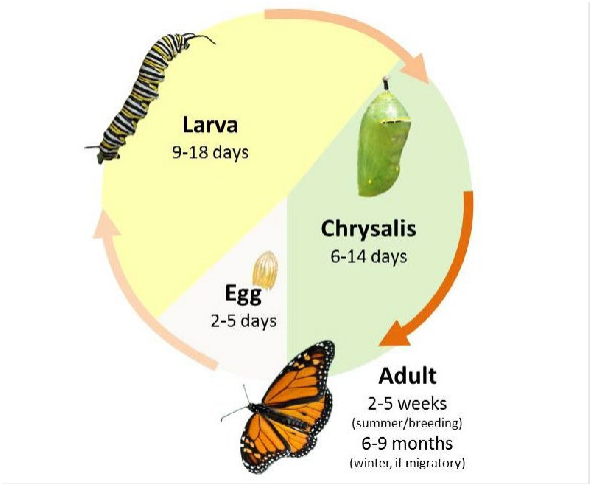

Figure 3. *Monarch life cycle. Development times calculated from Zalucki (1982), based on temperatures ranging from 22°-32°C. Adult life span based on Herman and Tatar (2001).*

The monarch life cycle varies by geographic location. Individual monarchs in temperate climates, such as eastern and western North America, undergo long-distance migration, where the migratory generation of adults goes through a reproductive diapause and lives for an extended period of time (Herman and Tatar 2001, p. 2509). Monarchs outside of the eastern and western North American populations breed year-round, repeatedly following the above-referenced life cycle throughout the year, and do not exhibit the long-distance migratory behavior.

In the fall, in both eastern and western North America, monarchs begin migrating to their respective overwintering sites. This migration can take monarchs distances of over 3,000 kilometers (km) (1,864 miles) (Urquhart and Urquhart 1978, p. 1760) and last for over two months (Brower 1996, p. 93). Migratory individuals in eastern North America predominantly fly south or southwest to mountainous overwintering grounds in central Mexico, and migratory individuals in western North America generally fly shorter distances south and west to overwintering groves along the California coast into northern Baja California (Solensky 2004, p. 79). Data from monarchs tagged in the southwestern states in the fall suggest that those in Nevada migrate to California, those in New Mexico migrate to Mexico, and those in Arizona migrate to either Mexico or California (Southwest Monarch Study Inc. 2018).

In early spring (February-March), surviving monarchs break diapause and mate at the overwintering sites before dispersing (Leong et al. 1995, p. 46, van Hook 1996, pp. 16-17). The same individuals that undertook the initial southward migration begin flying back through the breeding grounds and their offspring start the cycle of generational migration over again (Malcolm et al. 1993, p. 262).

In eastern North America, monarchs travel north in the spring, from Mexico to Canada, over two to three successive generations, breeding along the way (Flockhart et al. 2013, p. 4-5). Individual monarchs disperse as far north as they can physiologically tolerate based on climatic conditions and available vegetation; the most specific predictors of the northern distribution of individual monarchs are monthly mean temperature and precipitation (Flockhart et al. 2013, p. 4; Flockhart

et al. 2017, p. 2568). The number of generations of monarchs produced in a given year can vary between three and five and is dependent upon environmental conditions (Brower 1996, p. 100).

While a majority of the eastern monarchs shift to the more northern reaches of their range, western monarchs continue to occupy and breed in warmer climates throughout the summer, while also expanding to include the farther reaches of their range. In the spring in western North America, monarchs migrate north and east over multiple generations from coastal California toward the Rockies and to the Pacific Northwest (Urquhart and Urquhart 1977, p. 1585; Nagano et al. 1993, p. 157). In the southwestern states, migrating monarchs tend to occur more frequently near water sources such as rivers, creeks, roadside ditches, and irrigated gardens (Morris et al. 2015, p. 100).

Adult monarch butterflies during breeding and migration require a diversity of blooming nectar resources, which they feed on throughout their migration routes and breeding grounds (spring through fall). Monarchs also need milkweed (for both egg-laying and larval feeding) embedded within this diverse nectaring habitat. The correct phenology, or timing, of both monarchs and nectar plants and milkweed is important for monarch survival. The position of these resources on the landscape is important as well. In western North America, nectar and milkweed resources are often associated with riparian corridors, and milkweed may function as the principal nectar source for monarchs in more arid regions (Dingle et al. 2005, p. 494; Pelton et al. 2018, p. 18; Waterbury and Potter 2018, p. 38; Dilts et al. 2018, p. 8). Additionally, many monarchs use a variety of roosting trees along the fall migration route.

Individuals in non-migratory populations need nectar and milkweed resources year-round. Host plants used by monarchs in these locations include *Asclepias* spp., *Gomphocarpus* spp., and *Calotropis* spp., all of which are either milkweed or closely related genera (Blakley and Dingle 1978, p. 134; Buden and Miller 2003, p. 4).

Migratory individuals of eastern and western North America require a very specific microclimate at overwintering sites. The eastern population of monarchs overwinter in Mexico, where this microclimate is provided by forests primarily composed of oyamel fir trees (*Abies religiosa*), on which the monarchs form dense clusters (Williams and Brower 2015, pp. 109-110). The sites used for overwintering occur in mountainous areas west of Mexico City located between elevations of 2,900 and 3,300 meters (m) (9,514-10,827 feet) (Slayback and Brower 2007, p. 147). The temperature must remain cool enough to prevent excessive lipid depletion (Alonso-Mejía et al. 1997, p. 935), while at the same time staying warm enough to prevent freezing (Anderson and Brower 1996, pp. 111-113). Exposure to these cooler temperatures also helps monarchs orient northward in the spring (Guerra and Reppert 2013, pp. 421-422). The oyamel fir forest provides essential protection from the elements, including rain, snow, wind, hail, and excessive solar radiation (Williams and Brower 2015, p. 109). Many sites also provide a source of hydration via nectar plants or a water source (Brower et al. 1977, pp. 237-238). Most of the observed overwintering sites are located within the Monarch Butterfly Biosphere Reserve, which covers over 56,000 ha (138,379 acres) (Vidal and Rendón-Salinas 2014, p. 169; Ramírez et al. 2015, p. 158).

Migratory monarchs in the western population primarily overwinter in groves along the coast of California and Baja California (Jepsen and Black 2015, p. 149). The location and structure of

these sites provide the specific microclimate (although different from the Mexico overwintering microclimate) needed for survival in the western overwintering areas. There are approximately 400 groves that have been occupied, but only a portion of these sites is occupied in any given year. These sites, typically close to the coast, span approximately 1,225 km (761 miles) of coastline (COSEWIC 2010, p. 10). These groves are populated by a variety of tree species, including blue gum eucalyptus (*Eucalyptus globulus*), Monterey pine (*Pinus radiata*), and Monterey cypress (*Hesperocyparis macrocarpa*) (Griffiths and Villablanca 2015, pp. 41, 46-47), all of which act as roost trees. These groves provide indirect sunlight for the overwintering monarchs, sources of moisture for hydration, defense against freezing temperatures, and protection against strong winds (Tuskes and Brower 1978, p.149; Leong 1990, pp. 908-910, Leong 1999, p. 213). The close proximity to the coast [average distance of 2.37 km (1.47 miles)] also provides a mild winter climate (Leong et al. 2004, p. 180).

Historical Range/Distribution

There are no reliable records of monarchs outside of continental North America or the Caribbean before 1840 (Vane-Wright 1993, p. 180). However, by 1883, the monarch was reported as one of the most common butterflies in many Pacific Islands (Walker 1914, p. 187). It is generally accepted that both monarchs and milkweed dispersed from North America via human assistance, potentially aided through wind dispersal events (Brower 1995, p. 354). For the purposes of our analysis, we assume that monarchs in locations outside of North America have become naturalized, and thus, these records, along with the North American occurrences, comprise the historical range of the species (Figure 1).

Current Range/Distribution

We found monarch occurrence records in 90 countries, islands, or island groups. We delineated these occurrences into 31 different populations (Table 1). Table 1 also shows how these 31 populations are distributed among eight areas considered to represent significant diversity from each other; these areas are referred to as adaptive capacity units (ACUs) (see Species Needs below for description of the ACUs and how they were delineated).

Table 1. *The 31 delineated monarch populations, with their associated ACUs and the countries and islands that comprise each population.*

ACU	Population	Countries/Islands within Population
Australia, New Zealand, and Indo-Pacific Islands	Australia	Commonwealth of Australia
	Cook Island	Cook Islands
	French Polynesia	French Polynesia
	Greater Indonesia	Nation of Brunei, Republic of Indonesia, Malaysia, Democratic Republic of Timor-Leste
	Guam & CNMI	Guam, Commonwealth of Northern Mariana Islands (CNMI)
	Johnston Atoll	Johnston Atoll
	Kiribati	Republic of Kiribati
	Marquesas Islands	Marquesas Islands
	Marshall Islands	Republic of the Marshall Islands
	Mascarene Islands	Republic of Mauritius, Réunion

ACU	Population	Countries/Islands within Population
	Micronesia	Federated States of Micronesia
	Nauru	Republic of Nauru
	New Zealand	New Zealand
	Norfolk Island	Norfolk Island
	Palau	Republic of Palau
	Papua New Guinea	Independent State of Papua New Guinea
	Philippines	Republic of the Philippines
	Samoa	American Samoa, Samoa
	South Pacific Islands	Republic of Fiji, New Caledonia, Society Islands, Solomon Islands, Vanuatu
	Tokelau	Tokelau
	Tonga	Kingdom of Tonga
	Tuvalu	Tuvalu
	Wallis & Futuna	Territory of the Wallis and Futuna Islands
Central America & the Caribbean	Caribbean	Anguilla, Antigua and Barbuda, Bahamas, Barbados, Bermuda, Bonaire, British Virgin Islands, Cayman Islands, Cuba, Dominica, Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Montserrat, Puerto Rico, Saba, Saint Barthélemy, Sint Eustatius, Saint Kitts and Nevis, Saint Lucia, Saint Martin, Saint Vincent and the Grenadines, Sint Maarten, Turks and Caicos Islands, U.S. Virgin Islands
	Central America	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Mexico
S. Florida	Florida	United States (FL)
Hawaii	Hawaii	United States (HI)
Iberian Peninsula	Iberian Peninsula	Azores, Canary Islands, Gibraltar, Madeira, Morocco, Portugal, Spain
South America & Aruba	South America and Aruba	Aruba, Colombia, Curacao, Ecuador, French Guiana, Guyana, Peru, Suriname, Trinidad and Tobago, Venezuela
E. North America	Eastern North America	Canada, Mexico, Saint Pierre and Miquelon, United States (East)
W. North America	Western North America	Canada, United States (West), Mexico

<u>Population Estimates/Status</u>

Worldwide

Of the 31 populations currently known, at least one monarch individual has been observed in 27 of the populations since 2000, and these are considered extant. Monarch presence within the remaining four has not been confirmed since 2000, so these are unknown but are presumed extant. The current health of these populations is unknown, as there is insufficient information available, with the exception of eastern and western North American populations as detailed

below. While the Australia, New Zealand, and Indo-Pacific Islands ACU appears the largest in spatial extent, the eastern North American population has the most individuals (even accounting for large variation in estimates; Figure 4).

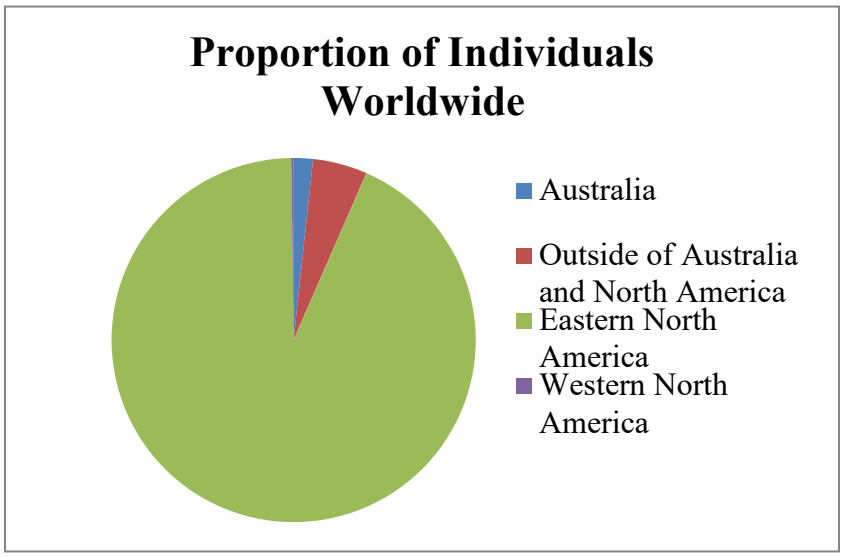

Figure 4. *Estimated relative proportion of individual monarchs by geographical area. The numbers are based on the following: eastern North America (77,141,600; based on average of last 5 years overwintering estimates, assuming a 21.1 million monarch/ha density), western North America (168,365; based on average of past five years of overwintering counts); Australia (1,424,790; based on estimates from M. Zalucki, The University of Queensland (Australia), 2017, pers. comm.); and outside of Australia and North America (4,000,000; based on 3-5 million monarch estimate; M. Zalucki 2017, pers. comm.).*

Eastern North American Population

The eastern North American monarch population has been systematically censused annually since 1994 (Figure 5; Vidal and Rendón-Salinas 2014, pp. 167-168). The population size in Mexico is reported in area occupied, measured in hectares (ha), rather than numbers of butterflies. Although varying year-to-year, monarchs consistently numbered in the hundreds of millions throughout the 1990s and early 2000s (assuming a 21.1 million monarch/hectare density; Thogmartin et al. 2017a, p. 1). There are additional survey data suggesting that monarch populations were as high or higher in the two decades prior to standardized monarch monitoring at the Mexican overwintering sites (Vidal and Rendón-Salinas 2014, p. 172, Calvert and Brower 1986, pp. 167-169).

Figure 5. *Area occupied (in hectares) by eastern North American monarch butterflies at overwintering sites in Mexico (actual hectare measurement displayed above each bar). Year displayed is the beginning year for the winter (e.g., 2017 represents the number for the winter of 2017-2018). Data from Monarch Watch (2020).*

Western North American Population

The western North American population has been censused annually since 1997, providing an estimate of annual population size (Figure 6). In the years before the annual census, surveys, using similar protocols, were conducted on a smaller number of sites. Records from those surveys were used to calculate the approximate size of the western population back to 1981 (Schultz et al. 2017, p. 2). Those estimates indicate that there were at least 4,500,000 butterflies in the 1980s (Schultz et al. 2017, p. 3).

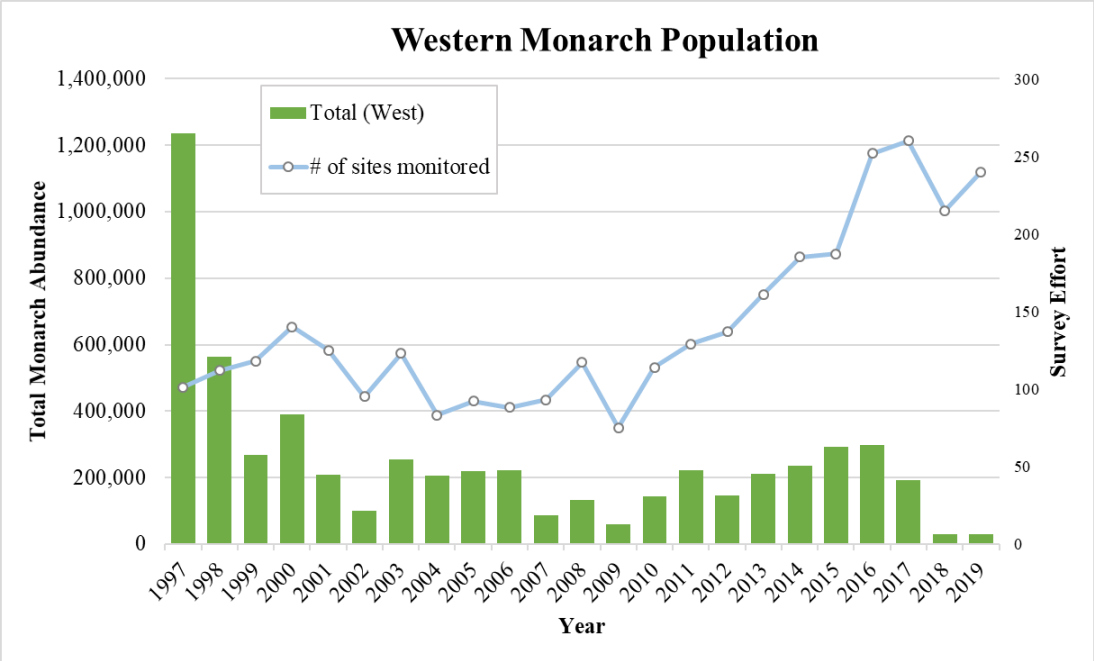

Figure 6. *Thanksgiving counts showing the number of western North American monarch butterflies observed at overwintering sites (green bars). Blue line shows the number of sites monitored (survey effort) for a given year. Data from The Xerces Society for Invertebrate Conservation 2020, entire.*

SPECIES NEEDS

Population-level Needs

Monarchs, like many insects, are sensitive to environmental conditions (temperature and precipitation) and can experience large swings in population numbers year-to-year in response to these conditions (Rendón-Salinas et al. 2015, p. 3; Schultz et al. 2017, pp. 3-4). During favorable conditions, monarch survival and reproductive rates are high and population numbers increase; conversely, when environmental conditions are unfavorable, survival and reproductive rates are low and population numbers can plummet. Thus, to successfully recruit over generations and years, they must be capable of withstanding large swings in population sizes (*N*). Specifically, they need a robust population growth rate (lambda, or λ). Given that environmental fluctuations vary spatially, robust growth rates likely vary across populations.

To support a strong growth rate, monarch populations require large population sizes and sufficient quantity and quality of habitat to accommodate all life stages and large population sizes. Large population sizes also help maintain genetic health and facilitate thermoregulation during the winter, which is important for good physical health. It may also be important for mate finding and aposematism (S. Malcolm 2018, pers. comm.). Both migratory and breeding habitat need to be distributed throughout the landscape to ensure connectivity, allowing monarchs within a population to reach all portions of their range and to maximize lifetime fecundity (Zalucki and Lammers 2010, p. 84; Miller et al. 2012, p. 2).

Species-level Needs

The ecological requisites at the species level include having a sufficient number and distribution of healthy populations to ensure it can withstand annual variation in its environment (resiliency), catastrophes (redundancy), and novel biological and physical changes in its environment (representation). We describe the monarch's requirements for resiliency, redundancy, and representation below.

Resiliency

Monarch resiliency requires maintaining healthy populations across spatially heterogeneous conditions. Healthy monarch populations are better able to withstand and recover from environmental variability and stochastic perturbations (e.g., storms, dry years) than those populations that are less demographically, genetically, or physically healthy. The greater the number of healthy populations, the more likely it is that the monarch will withstand perturbations and natural variation, and hence, have greater resiliency. Additionally, given the monarch's sensitivity to environmental conditions (experiencing large swings in population numbers year-to-year; Rendón-Salinas et al. 2015, p. 3), monarchs occupying a diversity of environmental conditions and being widely distributed helps guard against populations being exposed to adverse conditions concurrently, and thus, fluctuating in synchrony. Asynchronous dynamics within and among populations minimizes the chances of concurrent losses, and thus, provides species' resiliency. Lastly, maintaining the natural patterns and levels of connectivity between populations also contributes to monarch resiliency by facilitating population-level heterozygosity via gene flow and demographic rescue following population decline or extirpation due to stochastic events.

Redundancy

Monarch redundancy is best achieved by having multiple, widely distributed populations of monarchs relative to the spatial occurrence of catastrophic events. In addition to guarding against a single or series of catastrophic events that extirpate monarch populations, redundancy is important to protect against reducing the species' adaptive capacity. Having multiple monarch populations occupying areas of unique diversity will guard against losses of adaptive capacity due to population losses or declines.

Representation

The monarch's ability to withstand novel changes is influenced by its adaptive capacity, which is primarily a function of the species' ability to colonize new areas and its breadth of variation in biological traits and genetic diversity (both neutral and adaptive genetic variation). In addition, maintaining large populations across an array of environments as well as the natural networks of genetic connections among populations are important components of preserving a species' adaptive capacity. We delineated eight geographical units, referred to as adaptive capacity units (ACUs). The North American ACUs are described below. Refer to the SSA report for descriptions of the other five ACUs.

1. *Eastern North America*: Eastern North American monarchs are identified as an ACU because they exhibit long-distance migratory behavior, occupy unique ecological conditions, and serve (along with the western North American ACU) as the ancestral origin for the species

worldwide (Pierce et al. 2014a, p. 4; Zhan et al. 2014, p. 318). They also contribute unique phenotypic variation in wing morphology and disease/parasite infection resistance, in addition to unique genetic variation (Tenger-Trolander et al. 2019, p. 14673). Furthermore, compared to monarchs in the western North American ACU and the southern Florida ACU, eastern North American monarchs have lower rates of infection by the protozoan parasite *Ophryocystis elektroscirrha* (*OE*) (less than 10%; Altizer et al. 2000, p. 131), which may be due in part to the eastern monarch's long-distance migration (Bartel et al. 2011, p. 348).

2. *Western North America*: Western North American monarchs form a separate ACU because, along with the eastern North American ACU, they serve as the ancestral origin for the species worldwide (Pierce et al. 2014a, p. 4; Zhan et al. 2014, p. 318) and exhibit long-distance migratory behavior. In addition, they contribute unique variation in ecology, reproductive behavior, wing morphology, flight performance, and disease/parasite resistance.
3. *Southern Florida*: Southern Florida monarchs form a separate ACU because they contribute unique variation primarily in genetics (Knight and Brower 2009, p. 821; Zhan et al. 2014, p. 318; Pierce et al. 2014a, p. 4) and phenotypic characteristics of non-migratory behavior, year-round breeding, a different strain of *OE*, and the ability to survive high *OE* loads (Altizer 2001, p. 622; Sternberg et al. 2013, pp. E239-E241; Altizer and de Roode 2015, p. 91).

SUMMARY OF BIOLOGICAL INFORMATION

Monarchs in eastern and western North America represent the ancestral origin for the species worldwide. They exhibit long-distance migration and overwinter as adults at forested locations in Mexico and California. These overwintering sites provide protection from the elements (for example, rain, wind, hail, and excessive radiation) and moderate temperatures, as well as nectar and clean water sources located nearby. Adult monarchs feed on nectar from a wide variety of flowers. Reproduction is dependent on the presence of milkweed, the sole food source for larvae. Monarch butterflies are found in 90 total countries, islands, or island groups. Monarch butterflies have become naturalized in most of these locations outside of North America since 1840. The populations outside of eastern and western North America (including southern Florida) do not exhibit long-distance migratory behavior.

THREATS

We define "threat" as any action or condition that is known to or is reasonably likely to negatively affect individuals of a species. This includes those actions or conditions that have a direct impact on individuals, as well as those that affect individuals through alteration of their habitat or required resources. The mere identification of "threats" is not sufficient to compel a finding that listing is warranted. Describing the negative effects of the action or condition (i.e., "threats") in light of the exposure, timing, and scale at the individual, population, and species levels provides a clear basis upon which to make our determination. In determining whether a species meets the definition of an "endangered species" or a "threatened species," we have considered the factors under section 4(a)(1) and assessed the cumulative effect that the threats identified within the factors—as ameliorated or exacerbated by any existing regulatory mechanisms or conservation efforts—will have on the species now and in the foreseeable future.

We have little to no information on positive or negative influences acting upon those populations outside of the eastern and western North American populations. There is limited information on predation, parasitism, and disease outside of eastern and western North American populations. Given this limited information, we were unable to ascertain to what extent predation, parasitism, and disease impact the monarch populations outside of the eastern and western North American populations. Similarly, while data suggest global use of insecticides is increasing, we are unable to estimate the degree of overlap with monarch populations and thus derive a credible projection of impact on the monarch populations outside of the eastern and western North American populations.

The primary drivers affecting the health of the two North American migratory populations are changes in breeding, migratory, and overwintering habitat (due to conversion of grasslands to agriculture, urban development, widespread use of herbicides, logging/thinning at overwintering sites in Mexico, unsuitable management of overwintering groves in California, and drought), continued exposure to insecticides, and effects of climate change. These key influences are discussed below.

Availability, Distribution, and Quality of Milkweed

The availability of milkweed is essential to monarch reproduction and survival. Reductions in milkweed are cited as a key driver in monarch declines (Brower et al. 2012, p. 97; Pleasants and Oberhauser 2013, p.7; Inamine et al. 2016, p. 1081; Thogmartin et al. 2017b, p.12; Waterbury and Potter 2018, pp. 42-44; Saunders et al. 2019, p. 8612).

A majority of the milkweed loss has occurred in agricultural lands, where intensive herbicide usage for weed control has resulted in widespread milkweed eradication. More than 860 million milkweed stems were lost in the Midwest between 1999 and 2014, a decline of almost 40% (Pleasants 2017, p. 7). Currently, approximately 89% and 94% of corn and soybean crop acreages, respectively, are planted as glyphosate (herbicide)-tolerant crops (USDA 2018). Glyphosate use in western agricultural lands has also increased dramatically since the 1990s, especially within the Central Valley of California, Snake River Plain of Idaho, and the Columbia River Basin, which spans the border between Washington and Oregon (USGS NAWQA 2017; Waterbury and Potter 2018, p. 42). As weed species develop increasing resistance to glyphosate, other herbicide (e.g., dicamba)-tolerant crops are developed, which can lead to a corresponding increase in use of those herbicides. Accordingly, herbicide impacts to milkweed and nectar plants will continue to impact monarch resources.

Milkweed is also lost on the landscape through development and conversion of grasslands (Lark et al. 2015, pp. 3-4). Between 2008 and 2012, a total of 5.7 million acres of grassland were converted to new cropland, including up to 3 million acres of Conservation Reserve Program (CRP) land (Lark et al. 2015, p. 5). Loss of agricultural milkweeds in the Midwest has resulted in an estimated 81% decline in monarch production, in part because monarch egg densities were higher on milkweed in agricultural fields (3.89 times more eggs than on non-agricultural milkweed; Pleasants and Oberhauser 2013, pp. 5-6). This particularly impacts the eastern monarch population because more Mexico overwintering monarchs originate from the Midwest crop belt region than any other region (with estimates ranging from 38% to over 85% of all overwintering monarchs originating from the Midwest; Wassenaar and Hobson 1998, pp. 15438-

15439; Flockhart et al. 2017, p. 4). Accordingly, herbicide impacts to milkweed and nectar plants will continue to impact monarch resources available in agricultural lands.

Availability, Distribution, and Quality of Breeding Range Nectar Resources

Reductions in nectar resources are also cited as a potential key driver in monarch declines (Thogmartin et al. 2017b, p.12). Losses of nectar resources are due to the same stressors identified above for milkweed resources.

Availability, Distribution, and Quality of Migration Nectar Resources

Losses of nectar sources during migration have also been particularly implicated as a potential key driver in monarch declines (Inamine et al. 2016, p. 1081; Thogmartin et al. 2017b, p.12; Saunders et al. 2019, p. 8612). Losses of nectar resources are due to the same stressors identified above for milkweed resources. Additionally, with a warming climate, drought impacts may become more important, especially in the western population and in the migratory bottleneck through Mexico and into Texas for the eastern population (see Climate Change discussion below).

Availability and Quality of Overwintering Habitat

Both western and eastern monarchs rely on the microclimate provided by the trees at their overwintering sites (Leong et al. 2004, entire; Williams and Brower 2015, entire). Loss of trees occurs at overwintering sites in Mexico primarily through small- and large-scale logging, storms, and an increasingly unsuitable climate (see Climate Change discussion below). Most overwintering sites used by eastern monarchs occur within the Monarch Butterfly Biosphere Reserve (Reserve), a 56,259-ha (139,019 acres) protected area. Within this area, there is a logging ban within the 13,551-ha (33,485 acres) core zone (Ramírez et al. 2015, p. 158). However, recent logging has occurred both legally (including salvage logging allowed after storms) and illegally at multiple colonies (Vidal et al. 2014, pp. 180-185; Brower et al. 2016, entire).

Logging was estimated by Vidal and colleagues (2014, p. 180) in the core zone of the Reserve from 2002 through 2012. Within this period, 2,179 ha (5,384 acres) of core zone were deforested [less than 10% canopy cover remained; 1,254 ha (3,099 acres)] or degraded [a decrease in canopy cover; 925 ha (2,286 acres)]. Most of these losses were attributed to illegal logging [2,057 ha (5,083 acres)], with the remaining 122 ha (301 acres) lost due to floods, drought, strong winds, and fire. Current estimates of forest loss throughout the Reserve vary from 0-2.4% per year (Ramírez et al. 2015, p. 163). While anti-logging and reforestation efforts are underway (López García 2011, p. 631), logging is still ongoing within the Reserve (Brower et al. 2016, entire). Although clearcutting of forests destroys habitat directly, thinning of the forest also changes the microclimate needed by overwintering monarchs, making them more susceptible to winter mortality (Brower et al. 2011, p. 43).

Western monarch overwintering habitat along the Pacific Coast has been subject to loss through various forms of development, particularly urban development (Sakai and Calvert 1991, p. 149; Frey and Schaffner 2004, p. 172). Habitat alteration, both natural and anthropogenic, can also alter the microclimate of the western overwintering sites, leading to less suitable habitat conditions (Jepsen et al. 2015, p. 17). There are many other stressors that can work alone or in

tandem on the western overwintering sites, including disease and pests that impact the trees used for overwintering, as well as senescence and improper grove management. Fire is also a threat, both indirectly through habitat loss and directly to overwintering monarchs (Pelton et al. 2016, pp. 28, 32). Drought in the West can further exacerbate the stressors on the western overwintering sites (see Climate Change discussion below).

Insecticide Exposure

Insecticides are pesticides with chemical properties that are designed to kill insects, and most are non-specific and broad-spectrum in nature. That is, insects exposed to these insecticides are susceptible to mortality and/or sub-lethal effects. Furthermore, the larvae of many Lepidopterans are considered major pest species, and insecticides are tested specifically on this taxon to ensure that they will effectively kill individuals at labeled application rates. Monarchs may also be exposed to insecticides in areas beyond the insecticide application points due to drift (Olaya-Arenas and Kaplan 2019, p. 1; Halsch et al. 2020, p. 3).

Insecticide impacts to monarchs are primarily influenced by the extent to which monarchs are exposed to insecticides throughout their range. Although insecticide use is most often associated with agricultural production (e.g., between 2005 and 2012, 60% of insecticide applied occurred on agricultural lands; USEPA 2017, p.11), any habitat where monarchs are found may be subject to insecticide use. Insecticides can be used for insect pest control anywhere there is a pest outbreak or for general pest prevention. Homeowners may treat yards and gardens to protect plants from pests or purchase plants from nurseries that sell plants pre-treated or grown from seeds treated with insecticides (often from the neonicotinoid class of pesticides) as ornamentals. Natural areas, such as forests and parks, may be treated to control for insects that defoliate, bore into wood, or otherwise damage trees. Outbreaks of pests, such as gypsy moths, Mormon crickets, or grasshoppers, may trigger insecticide treatments over larger areas to control populations. Use of insecticides in vector control, especially pyrethroids and organophosphates, may be significant in areas of the country where mosquitoes pose a public health threat or reach nuisance levels. The use of insecticides in the U.S. is ubiquitous; in 2012 for example, expenditures on insecticides topped $5 billion in the United States, with 64 million pounds used for agriculture, home and garden, and other purposes (USEPA 2017).

The most widely used classes of insecticide include organophosphates, pyrethroids, and neonicotinoids. Neonicotinoids entered the market in the mid- to late-1990s, and because of their high insecticidal activity at low application rates, they are now the most used class of insecticides in the world (Braak et al. 2018, p. 507). By 2008, for example, neonicotinoid insecticides accounted for 80% of global seed treatment sales (Jeschke et al. 2011, p. 2898), and by 2011, more than 79% of the corn acreage and 34% to 44% of soybean acreage in the U.S. were planted with neonicotinoid-treated seeds (Douglas and Tooker 2015, p. 5092). Neonicotinoid insecticides are absorbed into plants and distributed throughout their tissues to their stems, leaves, roots, fruits, and flowers. They kill and injure insects by attacking their central nervous system.

Studies looking specifically at dose-response of monarchs to neonicotinoids, organophosphates and pyrethroids have demonstrated monarch toxicity at label application rates and field concentration levels (e.g., Krischik et al. 2015, entire; James 2019, entire; Krishnan et al. 2020, entire; Bargar et al. 2020, entire). Moreover, the magnitude of risk posed by insecticides may be

underestimated, as research usually examines the effects of the active ingredient alone, while many of the formulated products contain more than one active insecticide (e.g., Swagger contains bifenthrin and imidacloprid; Krishnan et al. 2020, p. 17, but see Oberhauser et al. 2009, entire). The additional risk posed from compounds added to improve the kill rate (referred to as synergists) are often not assessed. The use of synergists is not uncommon. For example, fungicides (often used as a synergist) were most commonly detected on milkweed samples (e.g., 98% of the milkweed sampled in one year contained the fungicide, Propiconazole) and, in many of these cases, co-occurred with insecticides like deltamethrin and thiamethoxam (Olaya-Arenas and Kaplan 2019, p. 13). See Insecticide Supplemental Materials for the Monarch SSA report for further discussion of the risk of pesticides to the monarch, including data, references, and supporting information.

Climate Change Effects

Climate change can affect monarchs both directly and indirectly (Nail and Oberhauser 2015, entire) on both the overwintering and breeding grounds. Increasing storm frequency in the Mexican overwintering colonies can lead to catastrophic (up to 80%) mortality through the freezing temperatures that accompany these storms (Anderson and Brower 1996, p. 112; Brower et al. 2004, entire). Severe storms may become more frequent with precipitation predicted to increase during the winter when monarchs are present in Mexico (Oberhauser and Peterson 2003, p. 14067).

Monarchs need a very specific microclimate at their overwintering sites not just to avoid storm mortality, but also to avoid early fat depletion. Additionally, changing precipitation patterns and temperatures may influence the microclimate needed by overwintering monarchs (Williams and Brower 2015, p. 116). Current modeling of the monarch's fundamental niche predicts the loss of 38.6% to 69.8% of current suitable habitat within the Monarch Butterfly Biosphere Reserve (Zagorski 2016, p. 17). In western North America, climate change is predicted to cause a significant change in the distribution of overwintering monarchs in coastal California and will result in an inland and upslope displacement of suitable overwintering conditions by the year 2050 (Fisher et al. 2018, p. 10). The probability of occurrence of suitable overwintering conditions becomes roughly proportional to elevation.

Climate change impacts, particularly increasing temperatures, may impact monarch fecundity (reproductive rate) (Oberhauser 1997, pp. 168-169), mating success (Solensky and Oberhauser 2009, p. 6), and survival during migration and while overwintering (Masters et al. 1988, entire; Alonso-Mejía et al. 1997, entire). Laboratory studies indicate optimal temperatures for monarch range from 27–29°C (80.6–84.2 °F) with sublethal effects beginning around 30–36°C (86–96.8°F) range and an upper lethal thermal limit of 42°C (107.6°F) (Zalucki 1982, p. 243; York and Oberhauser 2002, p. 294; Zalucki and Rochester 2004, p. 225; Nail et al. 2015, p. 101). Nighttime temperatures of 34°C (93.2°F) during periods with daytime temperatures of 38°C (100.4°F) result in lower survival, showing that respites from elevated temperatures are important in allowing monarchs to survive temperature stress (Nail et al. 2015, p. 104). Temperatures consistently above 33–35°C (91.4–95°F) are unsuitable for monarchs and may account for their general absence from southern U.S. states after spring (Malcolm et al. 1987, p. 78; Zalucki and Rochester 1999, pp. 155-157). High temperatures and drought conditions may be particularly impactful during the crucial spring migration (Chip Taylor 2020, pers. comm.).

In addition to the impact of climate change on overwintering monarchs directly, the Mexico overwintering sites are predicted to be less suitable for oyamel fir trees, the predominant monarch roosting tree. The overwintering sites are predicted to become increasingly warm throughout the year, potentially making 50% or more of the sites unsuitable for oyamel fir trees in 2030 (Sáenz-Romero et al. 2012, p. 102; Ramírez et al. 2015, p. 167). Widespread drought is similarly likely to impact trees in the western overwintering areas both directly and indirectly due to increased susceptibility to pests (Paine and Millar 2002, p. 148).

A warming climate may influence breeding habitat by altering suitable locations for both monarchs (Batalden et al. 2007, pp. 1369-1370) and their milkweed host plant (Lemoine 2015, entire). Nectar resources during migration may be reduced under climate conditions (decreased precipitation) projected for south-central Texas (Saunders et al. 2019, p. 8612). Drought may also influence the amount and availability of nectar needed for migrating butterflies (Brower et al. 2015, entire; Stevens and Frey 2010, p. 740; Espeset et al. 2016; p. 826). The coastal non-migratory population may also be impacted by loss of habitat through rising sea levels due to climate change (Tampa Bay Climate Science Advisory Panel 2015, entire). While drought and increased temperatures may reduce monarch habitat in some areas, the climatically suitable niche for monarchs may increase, potentially increasing their summer breeding grounds if both monarchs and milkweed are able to adapt (Lemoine 2015, pp. 10-17).

Climate change may additionally impact monarchs in ways that are more difficult to measure. This may include phenological mismatch (e.g., timing of milkweed and nectar sources not aligning with monarch migration; Thogmartin et al. 2017b, p. 13) or range mismatch with associated species. For example, a change in environmental suitability could cause a range shift for monarch natural enemies, increasing or decreasing their overlap with the monarch's range (McCoshum et al. 2016, p. 229-233). Furthermore, recent research suggests that carbon dioxide may impact the medicinal properties of some milkweed species, potentially leading to increased *OE* parasite virulence and decreased monarch tolerance of *OE* infections (Decker et al. 2018, p. 7).

CUMULATIVE EFFECTS

Using the best available science about the primary drivers affecting the health of the two North American migratory populations, we estimated the probability of the population abundance reaching the point at which extinction is inevitable (pE) for each population given their current abundance and growth rate, as well as under projected future conditions. The range in the estimates represents the best and worst plausible future state conditions of the primary drivers, including conservation efforts. We also evaluated the species' vulnerability to catastrophic events (e.g., extreme storms at the overwintering habitat), which are not captured in the pE estimates. Additionally, we assessed the effects of high daily temperatures under different climate change scenarios; these risks are also not fully captured in the pE estimates. We synthesized all of these factors to assess the monarch's viability. Because the SSA framework considers not just the presence of the factors, but also to what degree they collectively influence risk to the entire species, our assessment integrates the cumulative effects of the factors on the monarch's viability and replaces a standalone cumulative effects analysis.

CONSERVATION MEASURES PLANNED OR IMPLEMENTED

While many factors have been implicated in the decline in monarch populations, the loss of milkweed and nectar resources (i.e., breeding and migratory habitat) has been targeted as the threat that can be most easily addressed through conservation efforts. Protection, restoration, enhancement and creation of habitat is a central aspect of recent monarch conservation strategies, thus highlighting the importance of restoring and enhancing milkweed and nectar resources (Oberhauser et al. 2017a, p. 6-8; Pleasants 2017, p. 43; Thogmartin et al. 2017b, p. 2-3; MAFWA 2018, p. 52; Pelton et al. 2019, p. 4-5, WAFWA 2019, p. 41). Improved management at overwintering sites in California has also been targeted to improve the status of western North American monarch butterflies (Pelton et al. 2019, p. 4; WAFWA 2019, pp. 37-40). We are not aware of conservation actions for the populations outside of eastern and western North America, but conservation measures for the eastern and western North American populations are described below.

Major overarching landscape-level conservation plans and efforts include the Mid-America Monarch Conservation Strategy developed by the Midwest Association of Fish and Wildlife Agencies (MAFWA) and the Western Monarch Butterfly Conservation Plan developed by the Western Association of Fish and Wildlife Agencies (WAFWA). The Mid-America Monarch Conservation Strategy established a goal of adding 1.3 billion stems of milkweed on the landscape by 2038 (MAFWA 2018, p. 42). The 1.3 billion stem goal is an estimated goal for adding enough breeding and migratory habitat to support 6 hectares (14.8 acres) of overwintering population for the eastern North American population, per Thogmartin et al. (2017c, pp. 2-3). Twenty-nine states—including Arkansas, Connecticut, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Dakota, Texas, Vermont, Virginia, West Virginia, and Wisconsin—have agreed to participate in the effort to reach the 1.3 billion stem goal, which will also need contributions from multiple sectors of society. Sectors of society are a combination of land cover and ownership factors and include private land owners, agricultural and non-governmental organizations, rights-of-way organizations, and federal, state and local governments.

The Western Monarch Butterfly Conservation Plan currently encompasses the states of Arizona, California, Idaho, Nevada, Oregon, Utah, and Washington, which comprise the core of the western monarch range (WAFWA 2019, p. 3). The plan includes short-term goals of: 1) protecting and managing 50% of all currently known and active monarch overwintering sites, including 90% of the most important overwintering sites by 2029; and 2) providing a minimum of 50,000 additional acres of monarch-friendly habitat in California's Central Valley and adjacent foothills by 2029. It also includes overwintering and breeding habitat conservation strategies, education and outreach strategies, and research and monitoring needs.

In early 2020, the Nationwide Candidate Conservation Agreement for Monarch Butterfly on Energy and Transportation Lands (CCAA/CCA) was finalized and will contribute to meeting MAFWA Strategy and WAFWA Plan goals. Under this agreement, energy and transportation entities will provide habitat for the species along energy and transportation rights-of-way corridors across the country. Participants will carry out conservation measures to reduce or remove threats to the species and create and maintain habitat annually. In exchange for

implementing voluntary conservation efforts and meeting specific requirements and criteria, those businesses and organizations enrolled in the CCAA will receive assurance from the Service that they will not have to implement additional conservation measures should the species be listed. The goal of the CCAA is enrollment of up to 26 million acres of land in the agreement, providing over 300 million additional stems of milkweed (Cardno, Inc. 2020, p. 3).

Many conservation efforts implemented under Federal, Tribal, State, or other programs, such as the Farm Service Agency's Conservation Reserve Program, the Natural Resource Conservation Service's Environmental Quality Incentives Program, Agricultural Conservation Easement Program and Conservation Stewardship Program, and the Service's Partners For Fish and Wildlife Program, are expected to contribute to the overarching habitat and population goals of the MAFWA Strategy and WAFWA Plan. Smaller conservation efforts, such as pollinator gardens, implemented by local governments, non-governmental organizations (NGOs), private businesses, and interested individuals will also play an important role in reaching habitat and population goals established in the MAFWA Strategy and WAFWA Plan. Several land managers who oversee overwintering sites in California have developed and implemented grove management strategies (e.g., Ardenwood Historical Farm, Lighthouse Field) or have added monarch groves in their general management plans (e.g., Vandenberg Air Force Base). Others are in the process of developing grove management plans for which funding has already been established (e.g., Ellwood Mesa Complex). At this time, grove management plans have been implemented by at least three overwintering sites and are currently being developed for at least seven more. An additional 37 overwintering sites are on public land that has a general management plan that specifically includes protections for monarch groves (IELP and Xerces Society 2012, entire). Management and restoration of these sites may include activities such as replacing dead trees, modifying canopy structure, planting fall- and winter-blooming shrubs as nectar sources, and addressing monarch predation issues (Jepsen et al. 2017, entire).

The Service developed the Monarch Conservation Database (MCD) to capture information about monarch conservation plans and efforts to inform the listing decision. As of June 1, 2020, there are 48,812 complete monarch conservation effort records in the MCD that have a status of completed, implemented, or planned since 2014, and 113 monarch conservation plans. These efforts constitute a total of 5,635,992 acres of land area in the continental United States and Hawaii (5,534,451 acres and 97,949 acres in the eastern and western populations, respectively) enhanced or created for monarchs, with the most common conservation effort being direct planting of milkweed and other nectar resources. (Note that these values includes all completed, implemented, and not yet completed efforts; completed and implemented efforts to-date total 4,542,323 acres nationally.) Initial estimates of the amount of acreage needed to reach the 1.3 billion stem goal within the MAFWA Strategy planning area were around 20 million acres.

CURRENT CONDITION

Eastern North American Population

Based on the past annual censuses, the eastern North American population has been generally declining over the last 26 years (Figure 5). Although the numbers at the overwintering sites have declined, we did not find a corresponding change in the spatial extent of the population during the breeding season. Given its current population size and population growth rate, the pE over

the next 60 years is 61% (48%-69%; CI 50%) (Figure 7). The pE does not account for risks from catastrophic events (discussed below under Future Conditions).

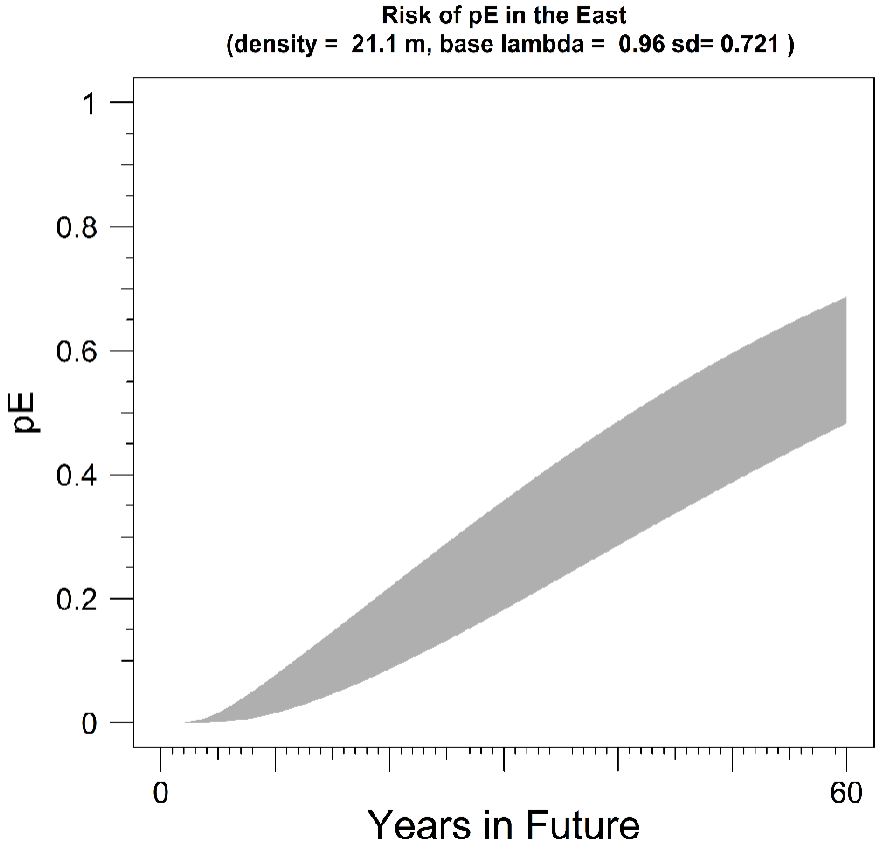

Figure 7. *pE for the eastern North American monarch population over time, represented by 50% confidence interval (gray space). Probability based on current trend in growth.*

Western North American Population

Based on the past annual censuses, the western North American population has been generally declining over the last 23 years, despite an increasing number of sites being surveyed (Figure 6). Under current conditions, the risk of extinction over time is predicted to increase sharply, with the pE over 60 years reaching 99% (98%-99%, CI 50%) (Figure 8). The pE does not account for risks from catastrophic events (discussed below under Future Conditions).

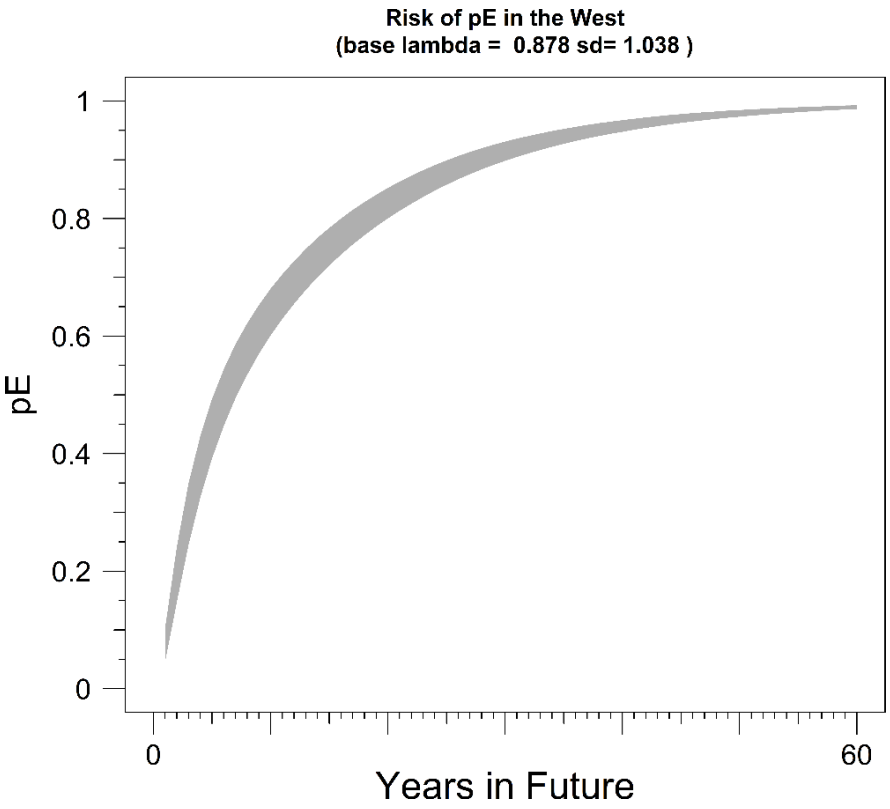

Figure 8. *pE for the western North American monarch population over time, represented by 50% confidence interval (gray space). Probability based on current trend in growth.*

FUTURE CONDITION

Future Scenarios and Catastrophic Events

North American Migratory Populations

To assess the future condition of monarch populations, we organized the key factors driving monarch population dynamics into five categories: 1) milkweed availability, 2) nectar availability, 3) migration nectar availability, 4) climate change effects, and 5) insecticide exposure. We then forecasted how each of these five influences is expected to change (i.e., its expected future state condition). We described the expected changes as the percent change from current state conditions. Lastly, we combined the most optimistic and pessimistic expected state conditions of each influence to form composite plausible best and plausible worst scenarios, respectively.

We also evaluated several potential events to determine if they were of sufficient magnitude and severity to cause a population collapse (i.e., a catastrophic event). We determined that extreme storm events and widespread drought have sufficient potential to pose a catastrophic risk to the eastern population and widespread drought and co-occurrence of poor environmental conditions

and low population abundance have sufficient potential to pose a catastrophic risk to the western population.

Worldwide

Due to a lack of information on current influences, we were unable to forecast future scenarios for the populations outside of eastern and western North America. However, we identified two potential catastrophic events, both of which are effects of climate change: sea-level rise and lethal high temperatures.

Future Conditions

Eastern North American Population

Under both best and worst case scenarios, the population continues to decline ($\lambda < 1$). The greatest impact on the population occurs during the first 20 years for both scenarios; lambda increases by 1.5% from 0.960 to 0.975 under the best case scenario and declines by -4.5% from 0.960 to 0.917 under the worst case scenario. As expected under a declining trajectory, the pE increases over time (Figure 9). At year 30, pE ranges from 24% to 46%.

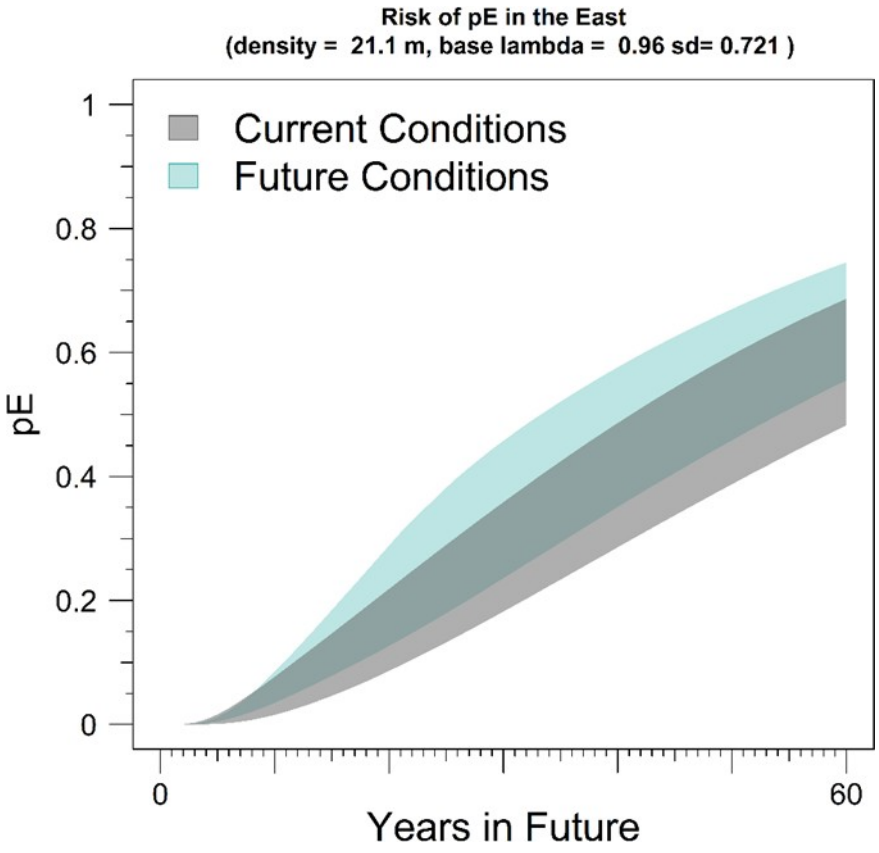

Figure 9. *pE for the eastern North American monarch population over time, given both current (gray band) and projected changes in state conditions (blue band). By year 60, pE ranges from 56% to 74% under the best and worst case future scenarios, respectively.*

We were unable to incorporate direct effects from increasing temperatures and catastrophic risks into the population models, so we qualitatively discuss the implications of these factors on the future condition of the population. We evaluated the changes in the spatial extent and number of days with projected temperatures above thermal thresholds during critical time periods in monarch migration (see Appendix 2 of the SSA report for further details). We assessed these changes under two future Representative Concentration Pathways (RCP), developed by the International Panel on Climate Change (IPCC 2001)—RCP 4.5 and RCP 8.5. Under the RCP 4.5 scenario, both the spatial extent and the average number of days above 38°C (100.4°F) (sublethal and moderate survival reductions) are projected to decrease in the northcentral subregion but markedly increase in the south (94% and 331%, for area and number of days, respectively) and northeast subregions in April and May. The spatial extent and average number of days above the lethal threshold [42°C (107.6°F)] are projected to increase dramatically for the south (6,630% and 8,147%, respectively) during the same period. Given these results, monarch reproductive success and survival rates of the first generation of monarchs coming off of the wintering grounds are likely to decline although the extent of which these rates will decline is unknown.

Similarly, given the projections of monarch health described above, the eastern population will be increasingly vulnerable to catastrophic losses due to extreme storm events at the overwintering grounds and widespread droughts during the breeding season and along the migratory route. Although we cannot quantify this increased risk, the longer the eastern population remains at low population abundance, the more likely it is that catastrophic losses will occur and the greater the extinction risk for the eastern population.

Western North American Population

Under both scenarios, the population continues to decline ($\lambda < 1$). Under the best case scenario, greatest positive effect occurs in years 21-50 when lambda slightly increases by 0.3% from 0.878 to 0.881; under the worst case scenario, the population is most affected during the first 20 years when lambda decreases -5.8% from 0.878 to 0.828. As would be expected with a declining growth, the pE increases over time (Figure 7.5). At year 10, pE ranges from 66 to 71% and reaches 92% to 95% in 30 years.

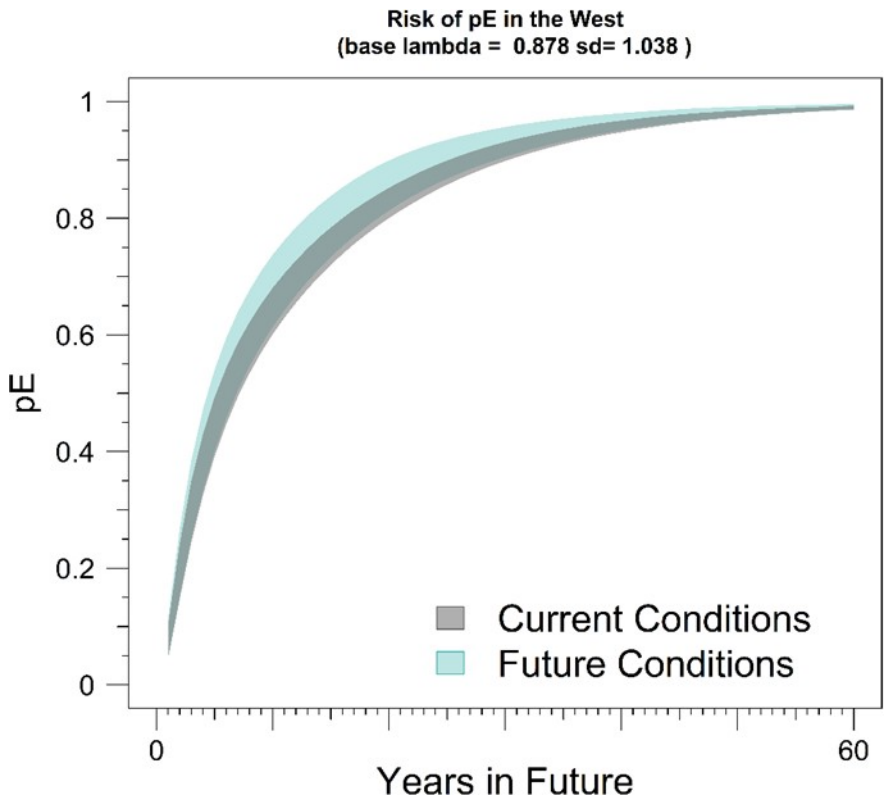

Figure 10. *pE for the western North American monarch population over time, given both current (gray band) and projected changes in state conditions (blue band). By year 60, pE reaches 99% under the best and worst case future scenarios.*

Under the RCP 4.5 scenario, the spatial extent of the area over which the average number of degree days above 38°C (100.4°F) and above 42°C (107.6°F) is projected to decrease (-23% and -11%, respectively), while increases are projected for the average numbers of days above 38°C (100.4°F) (38%) and above 42°C (107.6°F) (11%). Given these results, monarch reproductive success and survival rates are likely to decline although the extent of which these rates will decline is unknown.

Similarly, given the projections of monarch health described above, the western population is vulnerable to catastrophic losses due to both widespread drought events and the co-occurrence of poor environmental conditions and low population abundance. The risk of extinction due to these events increases the longer the population remains at the current low abundances.

Worldwide Populations

We qualitatively assessed the impact due to predicted climate change effects. Fifteen of the 29 populations are classified as being "at risk" due to sea-level rise or increasing temperatures.

SUMMARY OF THREATS

Based on the past annual censuses, the eastern and western North American migratory populations have been generally declining over the last 20+ years. The primary drivers affecting

the health of these two North American populations are loss and degradation of habitat (from conversion of grasslands to agriculture, widespread use of herbicides, logging/thinning at overwintering sites in Mexico, senescence and incompatible management of overwintering sites in California, urban development, and drought), continued exposure to insecticides, and effects of climate change. Conservation efforts are addressing some threats from loss of milkweed and nectar resources and management at overwintering sites. We have little to no information on positive or negative influences currently acting upon the populations outside of the eastern and western North American populations although we identified sea-level rise and lethal high temperatures, resulting from climate change, as potentially catastrophic events that could affect those populations outside of eastern and western North America.

FINDING

Section 4 of the Act (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth the procedures for determining whether a species meets the definition of "endangered species" or "threatened species." The Act defines an "endangered species" as a species that is "in danger of extinction throughout all or a significant portion of its range," and a "threatened species" as a species that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The Act requires that we determine whether a species meets the definition of "endangered species" or "threatened species" because of any of the following factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) Overutilization for commercial, recreational, scientific, or educational purposes; (C) Disease or predation; (D) The inadequacy of existing regulatory mechanisms; or (E) Other natural or manmade factors affecting its continued existence.

After evaluating threats to the species and assessing the cumulative effect of the threats under the section 4(a)(1) factors, we determined that the primary threats affecting the monarch and its habitat are loss and degradation of habitat from conversion of grasslands to agriculture, widespread use of herbicides, logging/thinning at overwintering sites in Mexico, senescence and incompatible management of overwintering sites in California, urban development, and drought (Factor A), exposure to insecticides (Factor E), and effects of climate change (Factor E). We found no evidence that monarch is currently impacted at the population-level by overutilization for commercial, recreational, scientific, or educational purposes (Factor B) or predation or disease (Factor C), nor did we find information to suggest that the species will be impacted by these factors in the future. We also considered the impact of existing regulatory mechanisms (Factor D) and conservation measures on the magnitude of existing threats.

Based on the past annual censuses, the eastern and western North American migratory populations have been generally declining over the last 20 years. The monarch butterfly is also known from 29 populations that are outside of the 2 migratory North American populations. At least one monarch butterfly has been observed in 25 of these populations since 2000, and these are considered extant. Monarch butterfly presence within the remaining four populations has not been confirmed since 2000, but they are presumed extant. We know little about population sizes or trends of most of the populations outside of the eastern and western North American populations (except for Australia, which has an estimate of just over 1 million monarch butterflies). We do not have information related to the threats acting on the populations outside of eastern and western North America; however, we determined that 15 of the 29 populations,

including the Australian population, are classified as being "at risk" due to sea-level rise or increasing temperatures, resulting from climate change.

The North American migratory populations are the largest relative to the other rangewide populations, accounting for more than 90% of the worldwide number of monarch butterflies. For the two North American migratory populations, we estimated the probability of the population abundance reaching the point at which extinction is inevitable (pE) for each population. In its current condition, the eastern North American population has a low extinction risk (pE <10%) over the next 10 years. The western North American population has a much higher risk of extirpation due to current threats, with a pE of 60-68% over the next 10 years. Looking across the range of future conditions that we can reasonably determine, the pE for the eastern population is projected to range from 24% to 46% in 30 years, and the pE for the western population is projected to be 92% to 95% in 30 years. These pE estimates incorporate the primary factors that influence the populations' resiliency, including availability of milkweed and nectar resources (losses as well as gains from conservation efforts), loss/degradation of overwintering habitat, insecticides, and effects of climate change. Additionally, at the current and projected population numbers, both the eastern and western populations become more vulnerable to catastrophic events (for example, extreme storms at the overwintering habitat). Also, under different climate change scenarios, the number of days and the area in which monarch butterflies will be exposed to unsuitably high temperatures will increase markedly. The potential loss of the North American migratory populations from these identified threats would substantially reduce the species' resiliency, representation, and redundancy.

On the basis of the best scientific and commercial information available, we find that the petitioned action to list the monarch butterfly under the Act is warranted. We will make a determination on the status of the species as threatened or endangered when we complete a proposed listing determination. When we complete a proposed listing determination, we will examine whether the species may be endangered or threatened throughout all of its range or whether the species may be endangered or threatened in a significant portion of its range. However, an immediate proposal of a regulation implementing this action is precluded by higher priority listing actions and final listing determinations.

RECOMMENDED CONSERVATION MEASURES

- Intensify monarch breeding and migratory habitat restoration or enhancement efforts at a landscape scale across all sectors, as outlined in the MAFWA and WAFWA conservation plans and the monarch rights-of-way CCAA, by planting milkweed and nectar plants that are geographically native.
- Protect and manage overwintering sites in California, as described in the WAFWA conservation plan.
- Avoid or limit pesticide use.
- Follow best management practices to avoid or limit exposure of all monarch life stages to insecticides.

LISTING PRIORITY

THREAT			
Magnitude	Immediacy	Taxonomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/population	3
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/population	6
Moderate to Low	**Imminent**	Monotypic genus	7
		Species	**8***
		Subspecies/population	9
	Non-imminent	Monotypic genus	10
		Species	11
		Subspecies/population	12

Rationale for listing priority number

We are assigning the monarch a listing priority number of 8, as explained below.

Magnitude

The monarch faces threats from loss and degradation of breeding and migration habitat due to conversion of grasslands to agriculture, widespread use of herbicides, and drought; loss and degradation of overwintering habitat from logging/thinning at overwintering sites in Mexico, and senescence and incompatible management of overwintering sites as well as urban development in California. The magnitude of these habitat-based threats is higher in the western North American population than in the eastern North American population; however, the eastern population is much larger—in both population size and spatial extent—than the western population. Conservation efforts are underway and planned to address the loss and degradation of breeding and migration habitat in eastern and western North America and protection and management of overwintering sites in California, thereby substantially reducing the magnitude of those threats. The species is also vulnerable to exposure to insecticides. The effects of climate change are long-term threats that can affect monarchs directly and reduce the extent and

suitability of habitat on both the overwintering and breeding grounds. In addition, the eastern and western North American populations will become more vulnerable to catastrophic events (e.g., extreme storms, widespread drought). Overall, the magnitude of these threats to the monarch is moderate.

Imminence

Threats to the monarch from loss and degradation of habitat are ongoing although conservation efforts are underway. Exposure to insecticides is currently affecting the species, and the effects of climate change are projected in the foreseeable future. Therefore, we regard these threats as imminent.

Have you promptly reviewed all of the information received regarding the species for the purpose of determining whether emergency listing is needed? Yes

Is Emergency Listing Warranted? No

Ongoing conservation measures, including implementation of the MAFWA and WAFWA conservation plans as well as the monarch rights-of-way CCAA, have a high likelihood of increasing the amount of suitable breeding and migration habitat for monarchs in North America.

DESCRIPTION OF MONITORING

The eastern North American monarch population is systematically monitored annually on their overwintering areas in Mexico by World Wildlife Fund-Mexico. The western North American population is censused annually at overwintering sites in California; the western monitoring efforts are coordinated by the Xerces Society.

COORDINATION WITH STATES

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:

Arkansas, California, Delaware, Georgia, Idaho, Illinois, Indiana, Iowa, Kentucky, Maine, Maryland, Minnesota, Missouri, Montana, Nebraska, Nevada, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Dakota, Texas, Utah, Vermont, Virginia, Washington, West Virginia, and Wisconsin

Indicate which State(s) did not provide any information or comments:

Alabama, Arizona, Colorado, Connecticut, Florida, Hawaii, Kansas, Louisiana, Massachusetts, Michigan, Mississippi, New Hampshire, New Jersey, New Mexico, New York, Oregon, South Carolina, Tennessee, and Wyoming

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APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: _____

Regional Director, Fish and Wildlife Service Date 9/24/2020

Concur: AURELIA SKIPWITH Digitally signed by AURELIA SKIPWITH Date: 2020.12.08 14:30:23 -05'00'

Director, Fish and Wildlife Service Date

Do not concur: _____

Director, Fish and Wildlife Service Date

Director's Remarks: