BEFORE THE SECRETARY OF THE INTERIOR

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PETITION TO PROTECT THE MONARCH BUTTERFLY (*DANAUS PLEXIPPUS PLEXIPPUS*) UNDER THE ENDANGERED SPECIES ACT

Notice of Petition

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PETITIONERS

The Center for Biological Diversity ("Center") is a nonprofit, public interest environmental organization dedicated to the protection of imperiled species and the habitat and climate they need to survive through science, policy, law, and creative media. The Center is supported by more than 775,000 members and activists throughout the country. The Center works to secure a future for all species, great or small, hovering on the brink of extinction.

The **Center for Food Safety** ("CFS") is a nonprofit public interest organization established in 1997 whose mission centers on protecting public health and the environment by curbing the adverse impacts of industrial agriculture and food production systems on public health, the environment, and animal welfare, and by instead promoting sustainable forms of agriculture. As particularly relevant here, CFS is the leading nonprofit working on the adverse impacts of genetically engineered crops and neonicotinoid pesticides. CFS and its over half-a-million members are concerned about the impacts of industrial agriculture on biodiversity generally, and on monarch butterflies specifically. CFS and its members have strong interests in the conservation of monarch butterflies that are impacted, directly and indirectly, by harmful agricultural practices. As part of its mission and member interests, CFS's multifaceted pollinator protection program actively works to reduce the adverse effects of toxic pesticides on important insect and pollinator species, such as monarch butterflies and honey bees. This program utilizes scientific, policy, educational, legislative, regulatory, and grassroots campaigns to spearhead action from government agencies, policymakers, and the public, to protect food security and the environment by requiring robust analyses of these pesticides' adverse impacts, and suspending or curbing their use as needed.

The Xerces Society is a nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. For forty years, the Society has been at the forefront of invertebrate protection worldwide, harnessing the knowledge of scientists and the enthusiasm of citizens to implement conservation programs.

Dr. Lincoln Brower first began studying monarch butterfly biology in 1954 when he was a graduate student at Yale University. He currently is Distinguished Service Professor of Zoology Emeritus at the University of Florida and Research Professor of Biology at Sweet Briar College. His research includes conservation of endangered biological phenomena and ecosystems, the overwintering and migration biology of the monarch butterfly, chemical defense, mimicry, and scientific film making. He has authored and coauthored more than 200 scientific papers on the monarch butterfly. Since 1977 he has been deeply involved with conservation of the monarch's overwintering and breeding habitats.

Submitted this 26th day of August, 2014

Pursuant to Section 4(b) of the Endangered Species Act ("ESA"), 16 U.S.C. § 1533(b); Section 553(e) of the Administrative Procedure Act, 5 U.S.C. § 553(e); and 50 C.F.R. § 424.14(a), the Center for Biological Diversity and Center for Food Safety as co-lead petitioners joined by the Xerces Society for Invertebrate Conservation and Dr. Lincoln Brower hereby petition the Secretary of the Interior, through the United States Fish and Wildlife Service ("FWS," "Service"), to protect the monarch butterfly (*Danaus plexippus plexippus)* as a threatened species.

FWS has jurisdiction over this petition. This petition sets in motion a specific process, placing definite response requirements on the Service. Specifically, the Service must issue an initial finding as to whether the petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. § 1533(b)(3)(A). FWS must make this initial finding "[t]o the maximum extent practicable, within 90 days after receiving the petition." *Id*. Petitioners also request that critical habitat be designated for the monarch butterfly concurrently with the species being listed, pursuant to 16 U.S.C. § 1533(a)(3)(A) and 50 C.F.R. § 424.12.

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EXECUTIVE SUMMARY

The monarch is an iconic large orange and black butterfly that is one of the most familiar butterflies in North America. During summer monarchs can be found throughout the United States and southern Canada in most places where milkweeds (*Asclepias* spp.), their host plants, are available. Each year monarchs undertake a spectacular multi-generational migration of thousands of miles to and from overwintering and breeding areas. Most monarchs east of the Rocky Mountains migrate from southern Canada and the northern United States to the mountains of interior Mexico to overwinter. Most monarchs west of the Continental Divide migrate to coastal California.

Monarchs east and west of the Rocky Mountains now face significant threats to their survival in both their summer and winter ranges, and their numbers have declined precipitously in recent years. Overall the North American monarch population has declined by more than 90 percent in the past two decades based on comparisons of the most recent population size estimates to the 20-year average. Numbers of monarchs east of the Rockies have declined by more than 90 percent since 1995; at most recent count, in winter 2013-2014, monarchs east of the Rockies dropped to the lowest number yet recorded, continuing the progression toward declining numbers seen over the last decade. Similarly, numbers of monarchs west of the Rockies have declined by more than 50 percent since 1997. The significant threats facing the monarch are high in magnitude and ongoing.

In recognition of the dire status of this symbolic animal, in June 2014 the White House issued a Presidential Memorandum creating a federal strategy to promote the health of honey bees and other pollinators including the monarch. Although this is an important acknowledgement of the large-scale issues that are threatening the monarch, much more tangible action is needed to protect the butterfly and its habitat. Specifically, protecting this iconic species under the Endangered Species Act is a step that should be immediately taken to safeguard and recover the monarch.

The Endangered Species Act (ESA) allows species to be listed as “threatened” when they are at risk of becoming endangered in a significant portion of their range. The ESA defines an endangered species as “any species which is in danger of extinction throughout all or a significant portion of its range” and a threatened species as “any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” As applied here, the language of the statute, its legislative history and congressional intent, and the relevant judicial precedent interpreting and applying the statute all make clear that a species need not be at risk of worldwide extinction to qualify for ESA protection. Rather, in enacting the “significant portion of range” provision, Congress intended to provide a means to protect species before they are on the brink of extinction, which is of paramount importance to species conservation.

The best available scientific information indicates that the monarch butterfly is threatened in a significant portion of its range. The North American monarch population is significant because without it, the redundancy, resiliency, and representation of the species would be so impaired that the monarch would have an increased vulnerability to extinction. The migratory butterflies in eastern and western North America represent the vast majority of all monarchs in the world.

Though monarchs are found in relatively small, peripheral, and introduced populations in tropical and subtropical locations outside of North America (see Appendix A), these non-migrating populations cannot conserve the genetic diversity and spatial distribution of the species, are limited in population growth potential such that they cannot substitute for the abundance of the continental North American population, and are themselves vulnerable to extirpation.

Numerous species have been protected under the ESA that have large ranges and relatively abundant population sizes but that have experienced population decline and that face significant threats to their continued existence. A few examples of such species include the gray bat (*Myotis grisescens),* Indiana bat (*Myotis sodalis),* fat pocketbook mussel (*Potamilus capax),* piping plover (*Charadrius melodus),* Chinook salmon (*Oncorhynchus (=Salmo) tshawytscha)*, and small whorled pogonia flower (*Isotria medeoloides*). A species is not required to have declined to the level of range-wide endangerment in order to qualify for protection under the ESA.

The ESA states that a species shall be determined to be endangered or threatened based on any one of five factors (16 U.S.C. § 1533 (a)(1)): 1) the present or threatened destruction, modification, or curtailment of its habitat or range; 2) overutilization for commercial, recreational, scientific, or educational purposes; 3) disease or predation; 4) the inadequacy of exisiting regulatory mechanisms; and 5) other natural or manmade factors affecting its contined existence. The monarch is threatened by all five of these factors and thus warrants protection under the Act:

Factor One: Modification or Curtailment of Habitat or Range

Monarch habitat has been drastically reduced and degraded throughout the butterfly's summer and winter ranges and threats are ongoing. Monarch habitat is threatened by, among other things, pesticide use from genetically engineered, pesticide-resistant crop systems that kill milkweeds and nectar sources, as well as by development, logging, and climate change.

A primary threat to the monarch is the drastic loss of milkweed caused by increased and later-season use of the herbicide glyphosate in conjunction with widespread planting of genetically-engineered, herbicide-resistant corn and soybeans in the Corn Belt region of the United States and to planting of genetically-engineered cotton in California. In the Midwest, nearly ubiquitous adoption of, glyphosate-resistant "Roundup Ready" corn and soybeans has caused a precipitous decline of common milkweed, and thus of monarchs, which lay their eggs only on milkweeds. The majority of the world's monarchs originate in the Corn Belt region of the United States where milkweed loss has been severe, and the threat that this habitat loss poses to the resiliency, redundancy, and representation of the monarch cannot be overstated.

Monsanto introduced Roundup Ready soybeans in 1996 and Roundup Ready corn in 1998. Genetically-engineered herbicide-resistant varieties (nearly all Roundup Ready) now comprise 94 percent of soybeans and 89 percent of all corn grown in the United States. Glyphosate is not only being applied to vastly more acres than ever before, it is being applied more intensively to the acres that are treated with it. Between 1995, the year before Roundup Ready soybeans were introduced, and 2013, total glyphosate use on corn and soybeans rose from 10 million to 204 million pounds per year, a 20-fold increase. Roundup Ready crops have also shifted the application period later into the growing season when milkweed is more susceptible to glyphosate.

Additional monarch habitat is being lost due to the rapid conversion of grasslands and other milkweed-containing land types to corn and soybean fields to produce biofuels. Most remaining monarch habitat in the Midwest is on Conservation Reserve Program (CRP) lands. This habitat is threatened by ongoing conversion of these lands to corn and soybean production, a change driven by federal biofuels policy. Nationally, CRP acreage has shrunk by 11.2 million acres (30 percent) since 2007, with more than half of this decline occurring in the Midwest, which has lost 6.2 million CRP acres. This land-use change has resulted in the widespread elimination of milkweed from these habitats due to glyphosate use.

Glyphosate used in conjunction with Roundup Ready crops has nearly eliminated milkweed from cropland throughout the monarch's vital Midwest breeding range. It is estimated that in Iowa, for example, cropland lost 98.7 percent of its milkweed from 1999 to 2012. In just the 13 years from 1999 to 2012, it is estimated there was a 64 percent decline in overall milkweed in the Midwest, most of which was from croplands. Because cropland milkweed produces nearly four times as many monarchs as plants in other settings, milkweed loss in corn and soybean fields has had a disproportionate impact on monarch numbers. It is estimated that in 2012, the Midwest produced 88 percent fewer monarchs than it did in 1999.

Monarch habitat is further threatened by the imminent introduction of new herbicide-resistant crops that are genetically engineered to now be resistant to multiple herbicides including for the first time 2,4-D and dicamba, which will be used in addition to glyphosate. Herbicides frequently drift beyond the boundaries of crop fields to affect wild plants growing nearby. These new genetically engineered crops will lead to sharply increased herbicide use, continued elimination of common milkweed from cropland, and reduction via herbicide drift of flowering plants that provide monarch adults with nectar, thereby threatening monarch nectaring habitat. Remnant monarch habitat outside of croplands is also being lost and degraded.

Monarch breeding, nectaring, and wintering habitats have also been lost to development, and this threat is ongoing. Between 1982 and 2010, 43 million acres of land in the United States were newly developed, representing a 58 percent increase in developed land over a roughly 30-year period. Of note, more than 37 percent of developed land in the United States was developed during the last 28 years. East of the Rockies, it has been very roughly estimated that approximately 167 million acres of monarch habitat, an area about the size of Texas, may have been lost since the mid-1990s due to agricultural changes and development including nearly one-third of the monarch's total summer breeding range.

Monarch breeding habitat west of the Continental Divide is being lost due to urban and rural development, aggressive roadside management, herbicides, intensification of agriculture, and long-term drought. Glyphosate is also heavily used in the western portion of the monarch's range, and may be degrading habitat there as well.

The monarch is also threatened in its winter range. Monarch wintering habitat in California is threatened by development and natural senescence. Monarch wintering habitat in Mexico is threatened by logging, forest diseases, and climate change. Though large-scale illegal logging in the Mexican winter range has largely been curtailed, the economy of the monarch butterfly region faces serious economic challenges which catalyze small-scale illegal logging as a short-term option to cope with poverty.

Finally, climate change poses a dire threat to monarch habitat. Several scientists have predicted that the monarch's overwintering habitat in Mexico may be rendered unsuitable by global climate change, and that much of the monarch's summer range may also become unsuitable due to increasing temperatures.

Factor Two: Disease and Predation

Disease and predation are significant sources of mortality for monarchs. In light of recent population declines and the major threats facing monarch habitat, either predation or disease or both could rise to population-level threats putting the monarch butterfly at risk of extinction. Numerous pathogens infect monarchs including viruses, bacteria, and protozoan parasites. The parasite *Ophryocystis elektroscirrha* (OE) is the most studied of monarch parasites and is of particular concern. Monarchs that are infected with these protozoa do not fly as well or live as long as uninfected butterflies. OE disproportionally affects female butterflies and may be responsible for the declining percentage of females in the population, which has long-term implications for monarch survival and recovery. The drastic reduction in milkweed availability in agricultural fields and other factors reducing monarch habitat pushes butterflies into smaller habitat patches where they may be at higher risk of disease transmission. Global climate change magnifies the threat posed to monarchs from disease. Climate change could influence butterfly disease prevalence by affecting pathogen development, survival rates of parasites and hosts, processes of disease transmission, and stress and host susceptibility. The release of commercially-reared monarchs also heightens the threat posed to wild monarchs by disease due to both increased exposure risk and the potential introduction of novel strains of pathogens or pathogens that have evolved higher virulence in captivity.

Decreased monarch population sizes and reduced habitat availability exacerbate the threat of predation and parasitism to monarchs. The protective chemicals monarchs obtain from milkweeds provide some defense against predation, but monarchs have many natural predators, some of which are capable of consuming large numbers of eggs, caterpillars, and butterflies. Ants are a common predator on monarch eggs and have been recorded consuming 100 percent of eggs at some study sites. Monarch caterpillars are subject to high levels of predation and parasitism. A large suite of invertebrate predators including ants, spiders, crab spiders, and wasps prey on developing monarch larvae, and several species of flies and wasps parasitize larvae. Mortality rates as high as 100 percent at study sites have been reported for monarch caterpillars due to parasitism. Overall, only approximately 8 to 12 percent of monarch eggs and larvae survive to become adults. Adult monarch mortality rates as high as 44 percent from bird predation have been reported from winter colonies in Mexico. Overwintering adults are also subject to predation from mice, with mortality rates as high as 5 percent of an overwintering colony. Migrating and breeding adults face predation from birds, wasps, spiders, mantids, and dragonflies. While predation is a natural phenomenon, high levels of predation are of increasing concern given recent dramatic population declines and shrinking availability of both winter and summer habitat.

The high rates of mortality of monarch eggs, caterpillars, and adults from disease and predation underscore the importance to the long-term survival of the species of having a very large population size, and magnify the threat posed to the long-term survival of the species by recent dramatic population declines.

Factor Three: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization poses a significant potential threat to monarchs especially in light of recent dramatic population declines and in conjunction with the many other threats facing monarchs. Millions of monarchs are raised in captivity and sold commercially for primarily educational and entertainment purposes. Capture, sale, transport, and release of monarchs can threaten the wellbeing of wild monarch populations in several ways including disease transmission, loss of genetic diversity, and accumulation of deleterious genetic adaptations, especially when rearing and release is conducted without following careful protocols. Release of captive butterflies can also interfere with studies of the distribution and movement of wild butterflies which are increasingly important in light of habitat loss and climate change. Harvesting wild monarchs also has the potential to exacerbate population decline. In addition, viewing aggregations of wintering monarchs in Mexico and California is a popular tourist activity, and some of these activities may harm wild monarch populations if conducted improperly.

Petitioners recognize the valuable roles that scientific research, citizen monitoring, and classroom and at-home rearing of monarchs can play in monarch conservation and hence request that upon listing, the Service facilitate or waive permitting requirements for such activities that are beneficial to monarch conservation. See Appendix B of this petition for requested rules to facilitate monarch butterfly conservation, science, citizen monitoring, and education.

Factor Four: The Inadequacy of Existing Regulatory Mechanisms

Though numerous voluntary efforts are in place that benefit monarch conservation, there are no existing regulatory mechanisms which adequately address the multitude of complex and synergistic threats that are driving the monarch’s precipitous decline. Some programs are in place at the international, federal, state, and local levels that benefit monarchs, but due to the butterfly’s rapid and severe decline and the significant, ongoing threats to its survival, the monarch needs the comprehensive protection that only the ESA can provide to ensure its persistence and recovery.

Factor Five: Other Natural or Manmade Factors Affecting the Monarch’s Continued Existence

The monarch is threatened by several other factors including global climate change, severe weather events, pesticides, and the spread of invasive species. Unfavorable weather conditions have been identified as a primary factor contributing to the recent drastic declines in monarch populations. Weather that is too hot or too cold at critical times in monarch development can cause massive mortality of caterpillars and adults. A single winter storm event in Mexican overwintering habitat in 2002 killed an estimated 450-500 million monarchs. This high death toll from a single storm event is particularly staggering given that the entire monarch population now numbers only about 35 million butterflies. Because of their narrow thermal tolerance and specific microhabitat requirements, climate change threatens monarchs in their summer and winter ranges. The threat from climate change in the monarch’s overwintering habitat in Mexico is so dire that monarchs may no longer occur in the Monarch Butterfly Biosphere Reserve by the end of the century due to climatic changes. The monarch’s summer breeding habitat in the United States is also predicted to become too hot in many areas for monarch’s to be able to successfully reproduce.

Pesticides are widely used in the United States, with more than one billion pounds applied each year, including in the core of the monarch’s breeding range where they threaten all monarch life stages. In particular, monarchs are threatened by pesticides used in agriculture, in lawns and gardens, and for mosquito and grasshopper control. Monarchs are threatened by habitat loss due to increasing use of glyphosate and other herbicides that kill host and nectar plants, and also by lethal and sub-lethal effects of insecticides such as neonicotinoids, which are persistent in the environment and are known to be highly toxic to pollinators.

Monarchs are also threatened by the spread of invasive tropical milkweed species, which are actively planted by gardeners with the intent to attract monarchs to their gardens. Unlike native milkweeds, this species grows year round so may disrupt migratory cues, and monarchs that breed on the same plants year round may have increased pathogen infections.

In sum, monarch butterfly numbers have declined severely and the monarch is threatened by all five of the ESA listing factors.

Accordingly, we hereby request that the Service list the monarch as a threatened species with a 4(d) rule, which would allow for protection of the monarch but also still permit activities to continue that promote the conservation of the species, such as scientific research and monitoring, citizen monitoring and tagging, and non-commercial classroom and household rearing of monarchs for educational purposes.

INTRODUCTION

The charismatic monarch butterfly is an irreplaceable piece of the natural heritage of North America. Yet this butterfly, that was once common across the country, is now plummeting toward extinction and needs protection or is at risk of being lost forever.

The monarch has played a unique and prominent role in the imagination of our country, especially so for an insect. Millions of school children have reared monarchs in classrooms and learned about metamorphosis by watching the caterpillars transform. Monarchs are pivotal in science education and provide a textbook example of the principle of co-evolution and mimicry due to their complex relationship with milkweeds, their sole host plants, and with viceroy butterflies (*Limenitis archippus)*, which are mutual mimics with monarchs, helping both butterflies avert predation. Monarchs have been reared on the international space station and were the first butterflies to have their genome sequenced. They are the official state butterfly of no less than seven states. For generations of Americans and Canadians, these large orange and black butterflies have been symbols of summer time outdoors and have served as ambassadors of nature in people's backyards and gardens. In Mexico, the arrival of monarchs heralds Day of the Dead celebrations, and the beginning of winter.

No other butterfly species on Earth undertakes a migration like the North American monarch. The multi-generational migration of the monarch butterfly can cover thousands of miles and is often described as spectacular, mysterious, and extraordinary. In late summer the butterflies begin their journey from Canada and northern states to the mountains of central Mexico or the coast of California where they will overwinter. The following spring that same generation of butterflies will return north to lay eggs on milkweed plants. Those eggs hatch into caterpillars, which feed on milkweeds, and transform into butterflies that continue to fly north in search of newly emerging milkweeds. This process is repeated for several generations, until the last generation—the "great-great-grandchildren" of the butterflies that departed overwintering sites the previous spring—returns to winter roosts the following autumn. Scientists are still trying to understand exactly how monarchs—multiple generations later—find their way to the very same winter roosts that hosted their ancestors. Visitation of overwintering monarch groves is of economic value in California and in Mexico, where such tourism is an important source of revenue for rural communities.

Monarchs are important not only educationally and scientifically, but also within the ecosystem. The monarch plays a valuable role in the food web. Despite the toxins they accumulate from milkweeds, monarchs provide food for overwintering migratory songbirds, especially for orioles, grosbeaks, and towhees. Many invertebrate animals prey on monarch eggs and caterpillars including numerous species of ants, spiders, beetles, true bugs, lacewings, and wasps. Overwintering adults also provide food for small mammals in the forest.

Monarchs visit many different species of flowers to drink nectar and probably act as incidental pollinators in many cases. While the monarch's contribution to plant pollination has not been well studied, it may play an important role in the long distance transfer of pollen for some plants, and, due to its historical abundance, its contribution to the pollination of some plants may be significant.

The monarch was very recently a highly abundant species, and its population reduction indicates environmental change on a large and rapid scale. The factors that are causing monarch numbers to plummet also threaten many other species of butterflies and bees, which in turn threatens the wellbeing of people because the food security of humans is dependent on the ecological services that pollinators provide.

In their overwintering groves there were once so many monarchs that the sound of their fluttering wings was commonly described as a rippling stream or a summer rain. Early newspaper descriptions of monarchs gathered on trees in California described branches breaking under the weight of so many butterflies, and depicted the masses of butterflies as "the personification of happiness" (in Lane 1993, p. 341). As recently as the winter of 1996-1997 the number of monarchs from east of the Rockies alone was estimated at around one billion butterflies. In the course of less than 20 years, that number has fallen to fewer than 35 million monarchs, representing a decline of 97 percent from the 1996-1997 high and a 90 percent decline from the 20-year average. The number of monarchs that overwinter west of the Rockies has also undergone a dramatic recent decline of 90 percent from the 1997 high (when monitoring began) and a 51 percent decline from the 17-year average.

Numerous landscape-level factors have contributed to the decline of the monarch and pose ongoing threats to its continued existence. The monarch is entirely dependent on milkweeds in its summer breeding range, and milkweed availability has been drastically reduced as a result of the increased spraying of herbicides caused by the widespread planting of genetically-engineered, herbicide-resistant crops, as predicted over a decade ago (Brower 2001). Milkweed loss has been exacerbated by the push for increased biofuel production and the planting of millions of acres of land formerly in the Conservation Reserve Program or other milkweed-compatible land uses with genetically-engineered, herbicide-resistant corn and soybean crops. Monarch overwintering habitat is threatened by development in California and by illegal logging in Mexico. Monarchs are further threatened by pesticide use, drought and other severe weather events, and climate change. Monarchs are also threatened by disease, predation, and overutilization, all of which are exacerbated by other stressors.

The total population of monarchs in North America is now approximately 35 million butterflies, which could be misinterpreted to mean that the butterfly is not threatened with extinction. That millions of monarchs still survive, however, does not indicate that the species is secure. While rare species with narrow ranges are often given conservation priority, common species that face multiple environmental stressors, such as those impacting the monarch, can undergo unanticipated rapid decline or extirpation. Monarchs face multiple, synergistic, complex threats that have contributed to an extreme and rapid reduction in population size. Moreover, monarch life history strategy requires a very large population size to compensate for high levels of predation and mortality from multiple factors.

It would be unwise to assume that the monarch is too common to be threatened with extinction. There is a distressing record of the rapid and unexpected decline of once common and widespread species. Examples of extremely abundant species that plummeted to unforeseen extinction include the passenger pigeon (*Ectopistes simigratorius*) and the Rocky Mountain grasshopper (*Melanoplus spretus*) (Schorger 1973). The passenger pigeon went extinct in the early 20th century, yet in the late 19th century it was one of the most abundant birds in the country, with flocks so numerous they darkened the sky and took 14 hours to fly past. Habitat loss and hunting reduced the pigeon from billions of birds to extinction in a matter of decades. Similarly, the Rocky Mountain grasshopper once ranged throughout western North America and was so numerous that a swarm that passed through Nebraska in 1874 numbered more than 12 trillion grasshoppers covering an estimated 198,000 square miles, an area larger than the state of California (Chapco and Litzenberger 2004). Due to habitat loss from plowing and irrigation, the grasshopper plunged to extinction in less than 30 years, and the last living individual was seen in Canada in 1902 (Ibid.).

Unfortunately, there is a long and growing list of abundant species that have undergone precipitous population declines. The once common woodland caribou (*Rangifer tarandus caribou*) once inhabited much of the northern lower 48 states, including the northern Rocky Mountains, upper Midwest and Northeast, but in less than a century habitat alteration and hunting reduced the population to just a few dozen individuals in Idaho and Washington. Numerous native mammalian species in Australia that were at one time abundant and widespread have gone extinct or have been wiped out of more than 95 percent of their historic ranges (Dickman 2007, Bilney et al. 2009). Lindenmayer et al. (2011) document the rapid and unanticipated decline of the common Australian arboreal marsupial, the greater glider (*Petauroides volans*) which was lost from a 6,500-hectare study area in just a 3-year period due to changing environmental conditions. Widespread declines have also been noted in migratory animal populations—such as birds and ungulates—that involve billions of individuals (Bolger et al. 2008, Robbins et al. 1989, Wilcove 2008).

The collapse of numerous species of fishes resulting from overharvesting is a well-documented example of the rapid decline of once-abundant populations (Levin et al. 2006). Four North American bumblebee species with broad geographic ranges have recently declined in abundance by up to 96 percent, some over just a twenty-year period (Cameron et al. 2011). Nearly seven million bats in North America have perished since 2006 due to the rapid spread of a fungal disease known as white nose syndrome (*Geomyces destructans*), which has affected seven species and spread to 25 states, wiping out the majority of some species' populations and causing declines of more than 90 percent within timeframes of less than three years. The once common little brown bat (*Myotis lucifugus*) has nearly been extirpated in the Northeast due to the fungus (Frick et al. 2010). Thousands of frog populations have been decimated by the spread of amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) since 1998 including dozens of species extinctions and precipitous declines of even widespread species (La Marca et al. 2005, Skerratt et al. 2007). Many species of well-known birds have undergone recent dramatic decline in agricultural areas in Europe (Vincent 2005, Freeman et al. 2008). In the United States, rusty blackbirds (*Euphagus carolinus*) have experienced one of the most significant declines ever documented among North American birds in recent times. Data from long-term surveys indicate that rusty blackbird numbers have plummeted 85-95 percent since the mid-1900s due to habitat alteration and other factors (Greenberg and Droege 1999).

These examples of the rapid and unanticipated loss of common species illustrate how complacency towards species with large population sizes can have disastrous consequences when timely action is not undertaken to safeguard their populations (Lindenmayer et al. 2011). As a further example, recent failure to act quickly on evidence of rapid population decline led to the extinction of a bat in Australia, the Christmas Island pipistrelle (*Pipistrellus murrayi*), which was a common species as recently as 1984 (Martin et al. 2012, p. 275). By 1994 it was in marked decline and recommendations from scientists to form an emergency response plan were considered but not carried out. Delays in decision making resulted in lack of action and the bat became extinct; the last individual was seen in 2009 ((Martin et al. 2012, p. 274).

Delays in protection for declining species and assumptions about the resiliency of once-common species can lead to lack of timely intervention, further population declines, greater recovery costs, or ultimately, extinction. The downward trajectory of the monarch and the enormity of the threats it is facing plainly show that this charismatic butterfly warrants protection under the ESA. Timely protection is imperative to ensure that the monarch survives for future generations.

NATURAL HISTORY

TAXONOMY

The monarch (*Danaus plexippus plexippus)* is a member of the family Nymphalidae (Rafinesque, 1815), a family characterized in part by small front legs with specialized hairs, giving them the common name “brushfoot butterflies”; they also have particular wing venation patterns, and antennal clubs with two grooves. Monarchs are in the subfamily Danaianae, “milkweed butterflies” (Boisduval, 1833), which lay their eggs only on plants in the family Apocynaceae (dogbane) in the milkweed subfamily Asclepiadoideae, genus *Asclepias* (L.) and related genera. Milkweed butterflies are specialized to accumulate toxins from milkweed plants into their larval and adult bodies for predator defense (Brower 1984).

The monarch was first described in 1758 by Linnaeus in *Systema Naturae* in the genus *Papilio*, and later became the type species for the genus *Danaus* (Kluk 1802), comprised of 12 mostly tropical species that are medium to large butterflies, typically with bright color patterns (Brower and Jeansonne 2004).

There are six currently recognized subspecies of monarch, including the subject of this petition, the nominal subspecies *D. p. plexippus*, which occurs in migratory populations across North America from southern Canada (about 50 degrees N), south to California and Mexico in winter, and also in non-migratory populations in southern Florida and other parts of the extreme southern United States. There are also recently established non-migratory populations of *D. p. plexippus* in Hawaii, and in other countries throughout Oceania in the Pacific and from the Bahamas to coastal Spain in the Atlantic (Smith et al. 2005, *see* Appendix A of this petition).

Danaus plexippus plexippus (Linnaeus, 1758) is a valid and currently recognized subspecies (Pelham 2008). Its standardized common name is simply monarch (*see*: http://lepsurvey.carolinanature.com/sc-nabn/danaids.html). Its Taxonomic Serial Number in the Integrated Taxonomic Information System is 779023.

Genetic research to determine the relationship between monarch populations is ongoing. Lyons et al. (2012) used microsatellite markers to evaluate the genetic structure of the migratory monarch populations in eastern and western North America, as well as the non-migratory populations of Hawaii and New Zealand. They did not find evidence for genetic differentiation between the migratory monarch populations of eastern and western North America, but did find that the migratory populations have diverged genetically from the non-migratory resident populations of Hawaii and New Zealand. However, no taxonomic changes have been made in response to this new research; the monarchs found in Hawaii and New Zealand are still considered to be the same subspecies as the migratory animals of eastern and western North America - *D. p. plexippus*. This petition requests ESA protection for the subspecies *D. p. plexippus*. Should future studies published within the time of review of this petition show that the North American migratory populations of monarch constitute a subspecies distinct from non-migratory populations of Hawaii, New Zealand, or other locations (such as south Florida), then in addition to determining if *D. p. plexippus* the subspecies should be protected, petitioners also request that the Service evaluate whether any newly identified North American subspecies may warrant federal protection.

DESCRIPTION

Photo © Jeffrey E. Belth

Figure 1. Female monarch on ovipositing on common milkweed flower bud.

The monarch, one of the most recognizable butterflies in North America, has several distinctive morphological characteristics (Ackery and Vane-Wright 1984, pp. 201 – 204, and references therein; Oberhauser and Solensky 2004, Commission for Environmental Cooperation 2008). It is a large butterfly that flies with its orange and black wings held in a "v" shape. The upper surfaces of both the forewing and hindwing have black or dark-brown veins outlining an orange background, with two rows of white and whitish-yellow spots at the margins (cover photo). The dark body is also white-spotted. Underwings have a similar color pattern but the hindwing background color is much lighter, from tan to light orange (Figure 1). The forewing is more angular than the hindwing with an elongated apex that has lighter orange spots near the tip. The wingspan is about 10 cm, with males averaging larger wing sizes than females, although there is substantial variability. Males also have a black scent pouch, or androconium, in the center of each hind wing. Females have thicker dark venation than do males.

There appears to be a relationship between wing size and shape and migratory behavior in monarchs. Monarchs east of the Rockies, which migrate longer distances than monarchs from the west, have larger and more angular forewings than their western counterparts on average, even when reared in a common environment, indicating a potential genetic basis for this morphological trait (Altizer and Davis 2010). Monarchs from Hawaii, which do not migrate, have even smaller forewings than western monarchs, although they are just as rounded as in the eastern North American butterflies. Forewings of monarchs from non-migratory monarch populations in South Florida are both smaller and rounder than forewings of migratory populations of *D. p. plexippus* (Dockx 2012).

RANGE

For *D. p. plexippus* in North America, the geographical range encompasses breeding areas, migration routes including staging areas, and winter roosts. During the spring and summer breeding season, *D. p. plexippus* disperses throughout the United States and southern Canada when successive generations migrate and expand north with the availability of suitable milkweeds as summer progresses. During winter, butterflies that primarily originate from east of the Rockies converge on specific locations in Mexico, contracting from a summer range of about 100 million hectares to winter roosts that total 20 hectares at most (Wassenaar and Hobson 1998, Oberhauser and Solensky 2004, p. 79, Commission for Environmental Cooperation 2008). Monarchs that breed along the east coast migrate to Florida (Knight and Brower 2009), where some fly west along the coast of the Gulf of Mexico and continue to Mexico, or apparently integrate into stable populations in Florida. A few continue migrating to Cuba and other islands in the Caribbean (Dockx 2012). Monarchs from west of the Rockies primarily fly to a series of roosting sites centered along coastal areas of south-central California (Jepsen and Black in press), although some migrate to the Mexican roosts used by eastern monarchs (Brower and Pyle 2004, Lyons et al. 2012).

Some monarchs have established small non-migratory populations in southern Florida and areas along the Gulf of Mexico where they reside year-round. Some monarchs that migrate to Florida to overwinter apparently integrate into the stationary populations (Knight and Brower 2009), and some continue to Cuba and integrate into populations of a monarch subspecies found in the Caribbean (*D. p. megalippe)* (Dockx 2002, Dockx 2007, 2012). Since they do not migrate, some researchers classify monarchs in southern Florida as *D. p. megalippe* (Smith et al. 2005), but others consider them to be *D. p. plexippus* (Pelham 2008). The establishment of stationary populations in Florida and other southern areas may be facilitated by the spread of nonnative heat-tolerant milkweeds in the southeastern states (Harvey et al. 2009).

In the past two centuries, *D. p. plexippus* has established small non-migratory populations in non-native habitats outside of continental North America (*see* Appendix A of this petition). Monarchs are thought to have moved both east and west of North America, and between various islands via favorable winds and storms, by hitchhiking on boats, and by intentional human introduction (Clarke and Zalucki 2004, Zalucki et al. 2004). During the mid- to late-1800s, monarchs spread across the Pacific Ocean to Hawaii, Australia, New Zealand, and many other islands (Zalucki and Clarke 2004). During this same time period, monarchs also moved across the Atlantic, colonizing islands including the Azores and Canary Islands, and coastal areas of Spain (Haeger et al. 2011). Various lines of evidence point to more than one introduction event in the Pacific, with populations in Hawaii and Australia likely forming independently (Lyons et al. 2012, Shephard et al. 2002), and other Pacific islands being colonized by radiation from original areas (Zalucki et al. 2004). Introduction and spread in the Atlantic and Spain have not been as well studied.

Based on the short amount of time since the introduction of *D. p. plexippus* outside of North America, these populations are still considered part of the nominal subspecies. Genetic analyses show that they have less genetic diversity than monarchs in North America, and are now genetically isolated (Lyons et al. 2012). Whether or not such differences constitute grounds for ultimately separating these disjunct populations into subspecies, there does appear to be enough reproductive isolation for them to have begun the process of speciation. See Appendix A for more information on populations of monarchs that have become established outside of their traditional North American range.

LIFE HISTORY

The life cycle of the monarch butterfly is intertwined directly with milkweed plants (Oberhauser 2004). The monarch life cycle has been described in great detail in various reports and proceedings (*see*: Malcolm and Zalucki 1993, Oberhauser and Solensky 2004, Commission for Environmental Cooperation 2008, Bériault et al. 2010).

Photo © Jeffrey E. Belth

Figure 2. Monarch egg on common milkweed leaf.

Photo © Jeffrey E. Belth

Figure 3. Monarch caterpillar, fifth instar, chewing on common milkweed leaf.

Photos © Jeffrey E. Belth

Figure 4. Monarch chrysalis in the process of development.

Monarchs lay their eggs only on plants in the Apocynaceae (dogbane family) in the milkweed subfamily Asclepiadoideae, genus *Asclepias* (L.) and related genera. Many milkweeds defend themselves from generalist herbivores by exuding sticky, bitter-tasting latex from cut leaves and other plant parts, and by producing compounds such as cardenolides that are toxic to many animals, including most vertebrates. Larvae of some milkweed butterflies are specialized to tolerate latex and accumulate cardenolides and/or other secondary compounds of the host plants into their bodies. They use the plant's chemicals for their own defense against predators (Brower 1984), for pheromone production, and for other specific functions during their lifecycle (Brower et al. 2010, Agrawal et al. 2012).

After mating a female must soon find milkweed plants of a suitable species on which to lay her eggs. Some milkweed-family species have such high levels of toxins that even the larvae of milkweed-adapted species such as monarchs will not thrive (Zalucki et al. 2001a, b). Other milkweed species have such low cardenolide levels that larvae and subsequent adults may not be chemically protected from predation (Lynch and Martin 1993). Nutrient content of milkweeds varies with environment, and declines during the season (Oyeyele and Zalucki 1990, Agrawal et al. 2012), so a female needs to locate healthy plants young enough to support the full development of her offspring.

Eggs are laid singly, on the underside of a young leaf or on a flower bud. The eggs are cream-colored or light green, ovate to conical in shape, and about 1.2 by 0.9 mm in size (Figure 2). The eggs weigh less than 0.5 mg each and have ridges running longitudinally from the pointed top to the truncated base. Eggs take three to eight days to develop and hatch into larvae (caterpillars). Larval monarchs take nine to 14 days to go through five instar stages before pupating. Instar stages can be distinguished by larval coloration and tentacle length, size of the head capsule, and other characteristics (Details of life history stages in this and following paragraphs, unless otherwise noted, are from the Monarch Larva Monitoring Project "Larval Field Guide," available at: http://www.mlmp.org/Resources/LarvalFieldGuide/Default.aspx; and the Larval Monitoring Handbook, available at: http://www.mlmp.org/Resources/pdf/Monarch-Monitoring_en.pdf).

The first instar larva, just out of the egg, is solid pale green and translucent, without banding coloration or tentacles. It eats the nutritious egg capsule first, and then uses a circular motion to eat milkweed leaf tissue without eliciting an overwhelming amount of latex that could entrap it. After the first molt, the second instar larva develops a characteristic pattern of white, yellow and black transverse bands. The opaque body is covered in short setae, and pairs of black tentacles start to grow, one pair on the thorax and another pair on the abdomen. The third instar larva has more distinct bands, particularly on the abdomen, and the two pairs of tentacles continue to elongate. Legs on the thorax differentiate into a smaller pair near the head and two larger pairs further back. These third-stage caterpillars begin to eat along leaf edges. The fourth instar is characterized by a new banding pattern on the thorax, and white spots on the prolegs near the back of the caterpillar.

The fifth and last instar larva (Figure 3) has a more complex banding pattern and white dots on the prolegs, with front legs that are small and very close to the head. The fifth instar is large relative to the earlier instars; the body is 25 to 45 mm long and 5 to 8 mm wide, compared to the tiny first instar that is only 2 to 6 mm long and 0.5 to 1.5 mm wide. The body mass of fifth stage caterpillars has increased about 2000-fold from first stage instars. Fifth stage instar larvae often cut the petiole or midrib of milkweed leaves to restrict the latex flow so that they can eat more leaf tissue to support the last growth period before pupation. Larvae must eat constantly to ingest enough milkweed to increase in mass so dramatically within a few weeks.

Larvae in the final stages of development stop feeding to search for a location to form a pupa, or chrysalis, the last stage of development before the emergence of the adult butterfly (Figure 4). The fifth stage larva attaches itself securely to a chosen leaf or branch with a silk pad, latching on with its hind legs and hanging down. The larva then molts to reveal an opaque, blue-green chrysalis adorned with gold dots. At normal summer temperatures, adult morphology develops within a few weeks. The cuticle of the chrysalis becomes transparent and the monarch's characteristic orange and black wings become visible. At the end of metamorphosis, the adult emerges from the chrysalis, expands its wings and flies away.

Monarch metamorphosis from egg to adult occurs in as little as 25 days during warm summer temperatures, to as many as 7 weeks during cool spring conditions. During the development period both larvae and their milkweed hosts are vulnerable to weather extremes, predators, parasites and diseases; commonly, fewer than 10 percent of monarch eggs and caterpillars survive.

Breeding adults first mate a few days after emergence. Females lay eggs on milkweed shortly after mating, and only live from two to five weeks, in which a single female may lay hundreds of eggs. During an average summer in North America, several generations of breeding butterflies will be produced.

Monarchs in the fall migratory generation go into reproductive diapause instead of mating. Diapause is usually maintained from late summer or fall through most of the winter, so most females do not mate and lay eggs until just before or during their return trip north in spring.

Diapause studies found that by the last week in August, one-third of wild-caught female monarchs in west-central Wisconsin and east-central Minnesota were in reproductive diapause, presumably in response to changing day length and temperature conditions (Goehring and Oberhauser 2002). By the end of the second week in September, all wild-caught and emerging captive female monarchs were in diapause (Goehring and Oberhauser 2002, Prysby and Oberhauser 2004). Not all migratory monarchs, however, enter reproductive diapause, at least in the southern states (Borland et al. 2004, Knight and Brower 2009, McCord and Davis 2010). Overwintering butterflies can live up to nine months, in contrast to the few-week lifespan of spring and summer generation adults.

Body condition and total fecundity are influenced by the temporal and spatial pattern of milkweed plants in the landscape, which determines how far adults must move in search of host plants for their eggs. Late-season decline in milkweed quality may be one of the triggers for larvae to turn into butterflies that enter diapause in the fall.

Some life history details differ between western and eastern *D. p. plexippus* in North America and elsewhere, in conjunction with their specific habitat requirements.

FEEDING

Adult monarchs obtain sugar from nectar and convert it to lipids to use as their energy source (Brower et al. 2006, Brower et al. in press). Adult monarchs are not directly dependent on milkweeds for food, although they benefit from milkweed-specific cardenolides and other chemicals sequestered during larval growth that make adults distasteful and toxic to predators. Both breeding and migrating adults sip nectar from many native and nonnative flowers including milkweeds, asters (*Asteraceae* spp*.),* forget-me-nots (*Boraginaceae* spp.), lilies (*Liliaceae* spp.), verbenas (*Verbenaceae* spp.), mallows (*Ranunculacea* spp.), wild carrots (*Apiaceae* spp.), legumes (*Fabaceae* spp.), goldenrod (*Solidago* spp.), clover (*Trifolium* spp.), alfalfa (*Medicago* spp.), butterfly bush (*Buddleja* spp.), and numerous others (Tooker et al. 2002, Brower et al. 2006). Tooker et al. (2002) analyzed and updated records from Robertson (1928) of butterfly visits to flowers near Carlinville, Illinois for 33 years. These records show monarchs visiting 61 different flower species in 39 genera from 15 families.

MIGRATION

No stage of development of monarchs can survive freezing temperatures during winters in most of North America, so during autumn, *D. p. plexippus* adults undergo a series of physiological changes that result in reproductive diapause, accumulation of lipids, and directional migration to the south and west (Solensky 2004a, Merlin et al. 2012).

Migrating adults put energy from nectar into lipids for fuel instead of reproduction, and are thus usually heavier than summer butterflies (Brower et al. 2006, Brower et al. in press). They move directionally toward their winter roosts, taking different routes depending on their origins (Brower and Pyle 2004, Howard and Davis 2008), and covering an average of 25 to 30 miles per day (Brower et al. 2006), stopping along the way for nectar and shelter (Davis et al. 2012).

Upon reaching their destination, butterflies cluster together in trees located in specific microclimates that keep them cool enough to conserve lipid reserves, but not so cold that the butterflies freeze (Brower et al. 2011). Monarchs at roosts are vulnerable to storms, freezing, dehydration (Brower et al. 2011), and predation (Arellano et al. 1993, Brower and Calvert 1985, Fink and Brower 1981, Glendinning 1993) that can result in high mortality. Surviving butterflies remain in winter locations until changing environmental conditions alter hormone levels in the spring and spur the butterflies to break diapause, begin mating, and journey north to begin the breeding cycles again (Oberhauser and Frey 1997).

Monarchs that migrate to inland Mexico merge and congregate in huge colonies occupying very small areas of specific habitat. Some mating occurs at these winter roosts before spring dispersal (Oberhauser and Frey 1997, Brower et al. 2007). Most individuals that overwinter colonize northern Mexico and the southern tier of the United States as milkweeds develop, although a few migrate directly to more northern areas (Miller et al. 2012, Flockhart et al. 2013). Because breeding monarch adults typically only live from two to five weeks, successive generations continue north and east as southern areas get too hot and milkweeds decline in number and quality. Remigration in spring must be timed so that females arrive at a particular latitude after milkweed plants have emerged, and when the weather is settled and warm enough so that larvae survive and develop at a healthy rate (Cockrell et al. 1993, Davis and Howard 2005).

Reproductive females generally head north from inland Mexico beginning in late February to early March. They start laying eggs on fresh milkweeds in northern Mexico, Texas, southern Oklahoma and Kansas, and to a lesser extent, Louisiana, Florida and other Gulf states, generally between mid-March and the beginning of May. In late April the first-generation butterflies—offspring of the migrants from Mexico—continue to move north, laying eggs throughout the mid-South into the Midwest and North. Then in June, the main colonization of the Midwest and

North takes place with two to three more generations being produced there before migration south begins in August (Cockrell et al. 1993, Howard and Davis 2004, Flockhart et al. 2013).

The small number of monarchs that migrate to Cuba and the Caribbean apparently do not return to North America (Dockx 2002, Dockx 2007, 2012, Knight and Brower 2009) perhaps because they do not experience the suite of environmental conditions required to trigger migration (Guerra and Reppert 2013).

The fall migratory route of eastern monarchs has been studied since the 1930s (Urquhart and Urquhart 1978) and monitoring continues through the present via several citizen science projects (Howard and Davis 2008 and references therein). Monarchs east of the Rockies follow one main "central" flyway from southern Ontario and Midwest states south-southwest through the states of Kansas, Missouri, Oklahoma and Arkansas to Texas and Northern Mexico (Howard and Davis 2008). There is also a second flyway along the easternmost states and coastal areas. A large gap without monarch roost sightings exists between the central and eastern/coastal flyway (Howard and Davis 2008, *see* Figure 5, below). During spring migration, monarchs do not congregate in roosts and monarch occurrence is largely coincident with breeding habitat and the seasonal development of milkweed (Solensky 2004a).

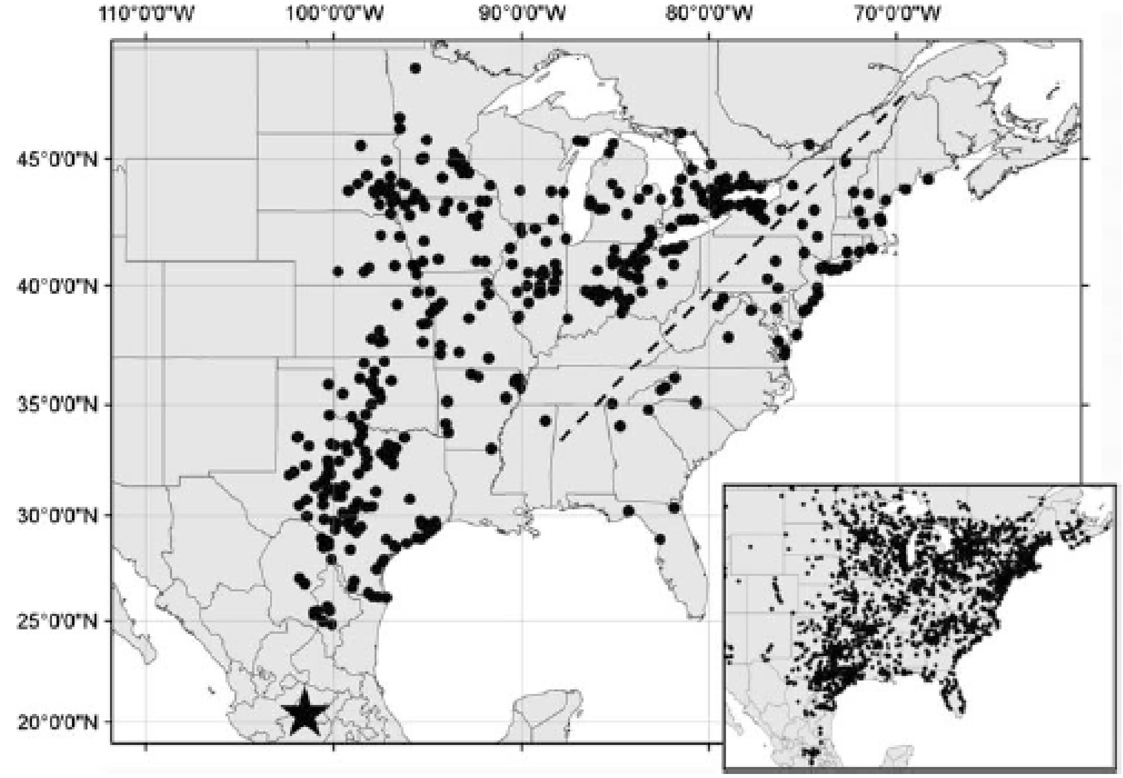


Figure 5. Central and eastern northward migratory flyways of monarchs east of the Rockies. Dots represent observations of roost sightings from Journey North data. The dashed line represents an apparent gap in monarch flyways. The star represents the overwintering sites in inland Mexico. Figure 2 from Howard and Davis 2008, original caption omitted.

Monarch butterflies in western North America migrate to overwintering sites in coastal California and coastal Mexico (Figures 6, 7, 8). Monarchs have historically aggregated in the fall and winter at more than 450 wooded sites scattered along 620 miles of the California coast from northern Mendocino County to as far south as Baja California, Mexico (Lane 1993, Leong et al. 2004, Jepsen and Black in press), although in the past ten years, only 72 of these sites have hosted more than 1,000 butterflies (Figure 7). In the fall of 2013, only 22 sites hosted more than 1,000 butterflies. Smaller aggregations of monarchs consisting of tens to hundreds of butterflies have been reported from Arizona and southeastern California (Monroe et al. 2013, California Natural Diversity Database 2012, Xerces Society 2013).

Figure 6. Winter and potential breeding range of western monarchs. Dots represent western monarch overwintering sites. Shaded areas represent the most likely locations of breeding grounds for migratory monarchs based on late-summer milkweed occurrence and thermal conditions. Lines within state boundaries represent climatic regions. Figure 1 from Stevens and Frey 2010, original caption omitted.

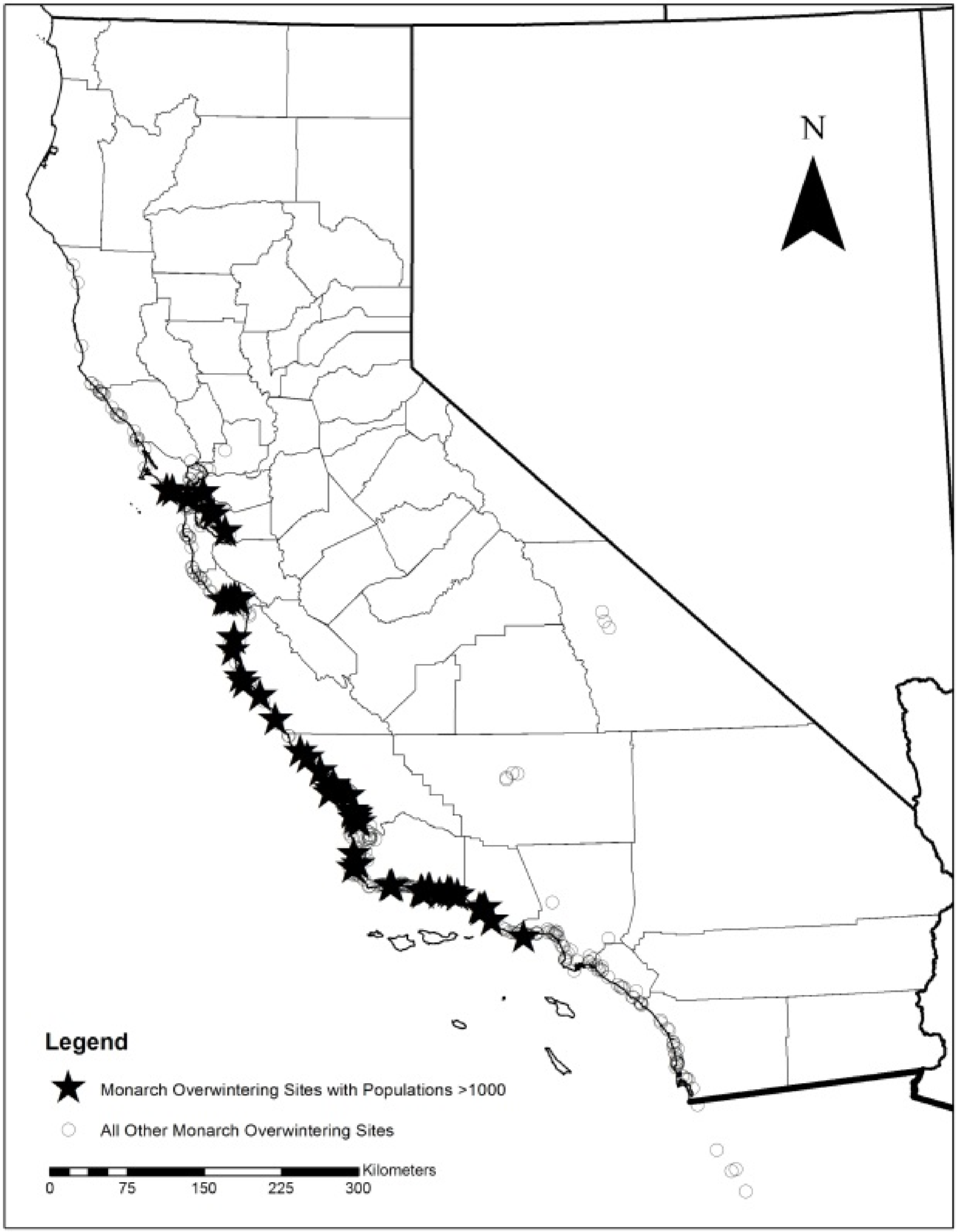


Figure 7. Western monarch overwintering sites. Dots represent all of the 458 recorded western monarch overwintering locations. Stars represent all overwintering sites that have hosted monarch populations of more than 1,000 butterflies at any point from 2003-2013. Figure from Jepsen and Black in press.

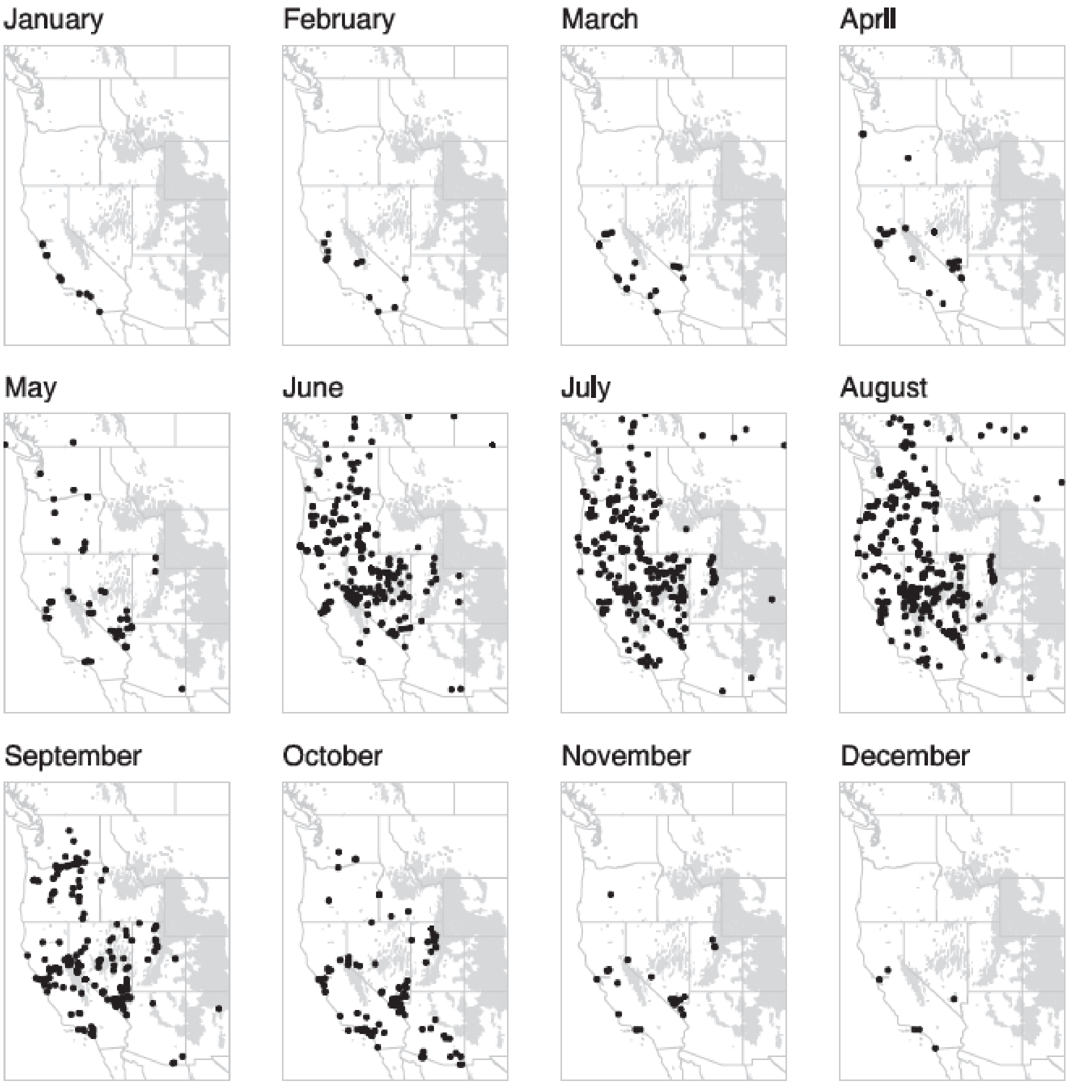


Figure 8. Western monarch collection records across the calendar year. Dots represent monarch specimens. Shaded regions are areas of high elevation (>2000 m). Figure 1 from Dingle et al. 2005, original caption omitted.

HABITAT

In general, butterfly habitat requirements include host plants for larvae, adult nectar sources, and sites for roosting, thermoregulation, mating, hibernation, and predator escape (Zalucki and Lammers 2010). In addition to these, the monarch butterfly requires conditions and resources for initiating and completing migration both to and from winter roosting areas, making them vulnerable to habitat degradation across wide areas. Because monarchs are host-plant specific, they are entirely dependent on the abundance of milkweeds, and threats to milkweed thus threaten their survival, as do threats to the specific forested areas that provide the microclimatic conditions they need to survive the winter. Monarchs and their habitat are also highly vulnerable to erratic climate conditions because their successful survival, metamorphosis and migration are dependent on appropriate temperature and moisture regimes.

In the broadest sense, monarch habitat is defined by the distribution of suitable species of milkweeds and their abundance and condition. Milkweeds contain species-specific suites of toxic secondary compounds used for defense against herbivores that include cardiac glycosides such as cardenolides, and various alkaloids. Monarchs use the toxic chemicals in milkweeds for their own defense, and generally will not lay eggs on any other species; nor will caterpillars eat leaves of other plants (Brower 1984).

Milkweeds are in the family Apocynaceae (dogbane family), subfamily Asclepiadoideae (Rapini et al. 2007). Milkweeds used by monarchs are in the tribe Asclepiadeae, subtribe Asclepiadinae (Nazar et al. 2013). Migrating monarchs evolved in North America using milkweeds in the exclusively American genus *Asclepias* (Fishbein et al. 2011), and also some related vine milkweeds in other genera that most likely dispersed northward from South America (e.g. *Cyanchum*, *Funastrum*, and *Matelea*). Although *D. p. plexippus* can and does thrive on some African milkweed species in non-native habitats (e.g. *Gomphoscarpus* and *Calotropis* species), it did not encounter African milkweeds until the plants were widely dispersed pan-tropically by human colonists, and became naturalized in the 1800s (*see* Appendix A).

Of the 130 species of milkweed in the genus *Asclepias* in North America, including the Caribbean and Mexico (Woodson 1954, Fishbein et al. 2011), monarch larvae have been observed feeding on 34 of these species (Malcolm and Brower 1986, Lynch and Martin 1993). In addition, monarchs have been observed successfully developing on some species of milkweed vines in related genera, such as *Cynanchum laeve* (honeyvine or blue vine milkweed), *Funastrum* (formerly *Sarcostemma*) *crispum* (wavyleaf twinevine), *F. cynanchoides* (fringed twinevine) and some species in the genus *Matelea* (Lynch and Martin 1993). Only a few of the milkweed species that monarchs use, however, are abundant, widely-distributed enough, and of sufficient quality at the right season to maintain large butterfly populations throughout their yearly cycles. The eastern range of *D. p. plexippus* during breeding is mainly coincident with the distribution of the most abundant and widely dispersed milkweeds—the northern species *A. syriaca* (common milkweed) and the southern species *A. asperula* (antelope horn milkweed), *A. viridis* (green or spider milkweed), and *A. humistrata* (pinewoods milkweed) (*see* Fig.1 in Malcolm et al. 1993).

By far the most abundant milkweed species in the northern breeding areas is common milkweed (*A. syriaca*) which is found from southern Canada to Virginia in the east, throughout the Midwest, and west to Kansas and the Dakotas (Woodson 1954, Woods et al. 2012). Common milkweed has recently expanded southward into Georgia, the Carolinas, and Louisiana (Wyatt et al. 1993, Wyatt 1996), and has also become naturalized in parts of the Pacific Northwest. Common milkweed inhabits places that have experienced soil disturbance, such as some cultivated fields, crop fields that have been abandoned or are fallow, pastures, logged land, riparian zones, suburban and urban vacant lots and waste areas, and along trails, railroad tracks, and roadways. It is also intentionally planted in gardens.

Cardenolide fingerprinting of monarchs in their Mexican winter roosts has shown that the majority of the butterflies that migrated there in the fall were raised on *A. syriaca*. Thin-layer chromatography studies found that 85 percent (Seiber et al. 1986) and 92 percent (Malcolm et al. 1993) of nearly 400 monarchs fingerprinted in Mexico in winter had fed as larvae on common milkweed (Brower et al. 2012a, p. 97).

Although *A. syriaca, A. asperula, a viridis*, and *A. humistrata* are the most important species for eastern monarchs, the butterflies also use other milkweed species as they spread throughout their breeding range. In the western portion of the range of eastern monarchs, the butterflies use *A. speciosa* (showy milkweed) and *A. incarnata* (swamp milkweed). In Texas, three of the most important milkweed species for monarchs are antelope horn milkweed, green milkweed, and Zizotes milkweed (*A. oenotheroides).* In eastern Louisiana and other Gulf states, pinewoods milkweed is a common monarch host. Non-native *A. curassavica* (bloodflower, or tropical milkweed) is now a common host in Texas and the southeast, in part due to the intentional planting of this species in gardens. Other southern milkweed vines also occasionally host monarch larvae including *Cyanchum leave* (honeyvine milkweed), *Matelea retiuclata* (green milkweed vine), and *Funastrum crispum* (wavy leaf milkweed vine) (*see* Texas Monarch Watch, http://www.texasento.net/dplex.htm#Milkweed).

The population of *D. p. plexippus* in western North America utilizes multiple species of milkweeds to reproduce, including the broadly distributed *A. fascicularis* and *A. speciosa*, along with other locally common species such as *A. eriocarpa* (woollypod milkweed), *A. cordifolia* (heartleaf milkweed), and *A. vestita* (woolly milkweed) (*see* http://monarchwatch.org/bring-back-the-monarchs/milkweed/milkweed-profiles).

The distribution of milkweeds in the landscape influences monarch productivity. The amount of time a female monarch spends searching for host plants, the number of eggs laid in a given area, and the degree of parasitism and predation of immature stages can be affected by the density and size of milkweed patches in different habitats (Zalucki and Lammers 2010, Pleasants and Oberhauser 2012). Monarchs lay more eggs per plant on milkweeds that occur in smaller milkweed patches (Oberhauser et al. 2001, Zalucki and Lammers 2010).

In studies of the distribution of common milkweed (*A. syriaca*) in Iowa, Maryland, Minnesota, Wisconsin, and Ontario, researchers found that milkweed density was higher and patch size was larger in nonagricultural habitats (such as road right of ways, pastures, and abandoned fields) than in cornfields (Oberhauser et al. 2001, Pleasants and Oberhauser 2012), meaning that monarchs are more likely to lay higher numbers of eggs per milkweed in the smaller milkweed patches found within agricultural fields (Zalucki and Lammers 2010). In Iowa, Minnesota, and Wisconsin, egg densities were higher on milkweeds within fields of corn and soybeans than on milkweeds at field edges or in non-agricultural habitats (Oberhauser et al. 2001). Further assessment over four years in Iowa revealed that milkweed growing in cropland harbored on average 3.89 times more eggs per plant versus that growing in other habitats (Pleasants and Oberhauser 2012). Females may prefer agricultural milkweeds because of their higher nitrogen content, because they can locate milkweed plants more readily within a corn or soybean monoculture because milkweed chemical cues stand out more, or because larval success rate may be higher within smaller patches (Ibid.).

By multiplying the number of eggs per milkweed in the growing season by the density of milkweeds in the landscape and the proportion of the landscape in crop fields versus other land uses, Pleasants and Oberhauser (2012), as updated in Pleasants (in press), estimated the total productivity of different habitats for monarchs and found that a significant proportion of the monarchs from the Midwest once originated in cropland. Based on milkweed densities in various habitats in Iowa in 1999 (Hartzler and Buhler 2000), they estimated that corn and soybean fields produced 78 percent of the state's monarchs, with another 16 percent from land enrolled in the Conservation Reserve Program (based on data supplied by John Pleasants).

Milkweeds vary in nutritional quality based on species and age. Southern milkweeds generally have higher cardenolide concentrations than northern milkweeds, which may help protect monarchs from bird predation during much of their breeding cycle and which may thus also influence migration strategy (Malcolm and Brower 1986, Malcolm et al. 1993, Lynch and Martin 1993, Rasmann and Agrawal 2011). Monarchs need milkweeds that are young, nutritious, and that supply the appropriate amount of protective cardenolides. Common milkweed leaves in shaded habitats tend to be larger, less tough, and have lower cardenolide content and lower induced latex production which possibly increases their quality for monarch larvae (Oyeyele and Zalucki 1990, Agrawal et al. 2012). Egg densities on milkweeds with young or re-sprouted leaves tend to be higher than on older leaves (Zalucki and Kitching 1982). The re-sprouting that follows non-glyphosate herbicide application may contribute to higher egg densities on milkweeds in agricultural fields (Oberhauser et al. 2001), though application of any herbicide causes defoliation that prevents development into larvae of monarch eggs laid prior to treatment (Pleasants in press). Some butterflies have been shown to be more likely to oviposit on leaves with higher nitrogen content, though this is not conclusive in monarch studies (Oyeyele and Zalucki 1990). Monarchs can compensate for lower nitrogen content in leaves by consuming more leaves (Lavoie and Oberhauser 2004).

In addition to milkweed, monarch habitat requirements during the breeding and migrating season include trees for roosting. During migration, monarchs have to make frequent stops to rest, to feed on nectar to maintain fat reserves, and during bad weather (Davis and Garland 2004, Brower et al. 2006, McCord and Davis 2010, Davis et al. 2012, Brower et al. in press). Monarchs form communal roosts at some of these stopover sites, particularly during the fall. Based on an analysis of four years of roost data collected by citizen scientists during fall migration for Journey North, a student wildlife monitoring program, monarchs can use trees with different branching patterns and leaf characteristics for roosting (Davis et al. 2012). Monarchs in northern states primarily roost in conifers and maples, while monarchs in the south commonly roost in pecan and oak trees. No particular land cover type is correlated with roosts, however, monarch roost sites are associated with large bodies of water, such as rivers and lakes, although reasons for this are unknown. In the southern part of the flyway, monarchs are found more often in grassland than would be expected by chance. Monarchs do not appear to consistently roost in the same locations within the flyways each year, suggesting that roost site selection is somewhat random (Davis et al. 2012).

The ephemeral nature of monarch roost site selection increases the importance of protecting nectar resources in the flyways, because nectar sources can be more easily predicted by land managers than roost sites (Brower et al. 2006, Howard and Davis 2008, Davis et al. 2012). Though monarch caterpillars are entirely dependent on milkweed, numerous species of flowering plants can provide suitable nectaring habitat for adult monarchs (Tooker et al. 2002).

Climate, including weather patterns and temperature, also plays a significant role in defining monarch habitat seasonally because suitable temperature regimes are required for monarch survival and reproductive success (Zalucki and Rochester 2004, Taylor and Lentz 2005, Stevens and Frey 2010).

Although basic overwintering habitat requirements are common to the subspecies, some details differ for *D. p. plexippus* east and west of the Rocky Mountains. The western monarchs roost in coastal areas of California in the winter, whereas the much larger numbers of monarchs east of the Rockies roost in a small area of Mexico, and these roosting locations have distinctive flora and microclimates.

Overwintering monarchs have very specific microclimatic habitat requirements, such as protection from wind and storms, absence of freezing temperatures, exposure to dappled sunlight, and presence of high humidity (Chaplin and Wells 1982, Calvert et al. 1983, Anderson and Brower 1996, Leong 1999). Fall or winter blooming flowers that provide monarchs with nectar may be important to maintain lipid reserves required for winter survival and the spring migration (Tuskes and Brower 1978).

In inland Mexico, monarchs gather on oyamel (sacred) fir (*Abies religiosa*) trees on the border between Michoacán and Mexico State in the mountains of the Trans-Mexican Volcanic Belt. The high altitude forests provide the microclimatic conditions that monarchs must have to survive the winter. Colonies are ecologically and geographically constrained to densely forested sites that are at high elevations (~2,900–3,300 m [9,500–10,800 ft]) and they are usually restricted to arroyos near streams on southwest-facing slopes that are moderately steep (Slayback et al. 2007, p. 28). The cool temperature and moisture inside the oyamel forests maintain the butterflies in a state of reproductive diapause and allow them to conserve lipid reserves that fuel the wintering period and the spring remigration north (Brower et al. 2011, p. 28). The benefits of the dense canopy and mature trees have been likened to an umbrella, a blanket, and a hot-water bottle, protecting the butterflies from rain and keeping them warm enough not to freeze but cool enough that diapause is not broken (Ibid.). The monarch's overwintering in habitat in Mexico is threatened by logging, forest disease, forest senescence, climate change, and severe weather events. Site fidelity and extreme localization of colonies within such a small area of available habitat heightens monarch vulnerability and highlights the urgent need for protecting the butterflies' habitat (Slayback et al. 2007, p. 38).

In coastal California, most overwintering sites are dominated by exotic blue gum (*Eucalyptus. globulus*) or red river gum *E. camaldulensis*), although many sites also contain native trees such as Monterey pine (*Pinus radiata*), Monterey cypress (*Cupressus macrocarpa*), western sycamore (*Platanus racemosa*) and other species (Xerces Society 2013). Recent research shows that monarchs do not prefer *Eucalyptus* over native tree species (Griffiths and Villablanca 2013), especially later in the season as storms become more severe. Historically, the composition of vegetation on the California coast differed from the contemporary composition, and groves of native trees presumably hosted dense monarch aggregations (Lane 1984, 1993). Monarch overwintering habitat in California is directly threatened by logging and other forest degradation for commercial and municipal development. Habitat alterations, such as tree trimming or tree removal, or natural factors such as fire, severe storms, or disease or senescence of trees, can alter the structure and microclimate of an overwintering site and reduce its suitability for monarchs (Sakai and Calvert 1991, Commission for Environmental Cooperation 2008).

All of the California sites are at low elevations (<300 ft) and in sheltered locations, and many occur within half a mile of the shoreline (Lane 1993). The sites shelter monarchs due to both canopy cover and local topography with most locations being in shallow canyons, gullies, or on the lee side of hills. Sites frequently occur where the coastline runs generally in an east-west direction offering protection from the predominate winds. Underlying shrub and herb layers also likely contribute to the specific microclimatic conditions the butterflies need, similar to conditions in the oyamel fir forests in inland Mexico (Lane 1993, p. 336). The surrounding forest conditions are important to maintain the microhabitat conditions on the “butterfly trees” where the monarchs gather (Lane 1993).

Populations of *D. p. plexippus* outside of North America share basic habitat requirements, but have less complex life histories without migration. They also inhabit areas with fewer species of milkweeds and with different climates (*see* Appendix A).

Because of their complex life history and specific habitat requirements, monarchs are highly vulnerable to habitat loss and degradation. Monarchs are threatened by habitat loss and degradation in their breeding, migrating and overwintering habitats, as discussed in detail in the Threats section of this petition.

POPULATION DISTRIBUTION AND STATUS

The historic distribution and abundance of monarchs is not known with certainty, but would have been broadly defined by the distribution of milkweed. Historically *D. p. plexippus* populations east of the Rockies would have bred mainly in the grasslands and prairies of the Great Plains that were populated by a mix of native milkweed species (Brower 1995) and copious nectar sources (Figure 9). Monarchs likely also inhabited meadows, Native American agricultural fields, and other open areas throughout North America wherever milkweeds occurred and weather conditions permitted. The butterflies would have been rare in heavily forested regions, mountainous areas, and arid zones. Monarchs were almost certainly confined to continental North America from pre-history until the mid- to late-1800s.

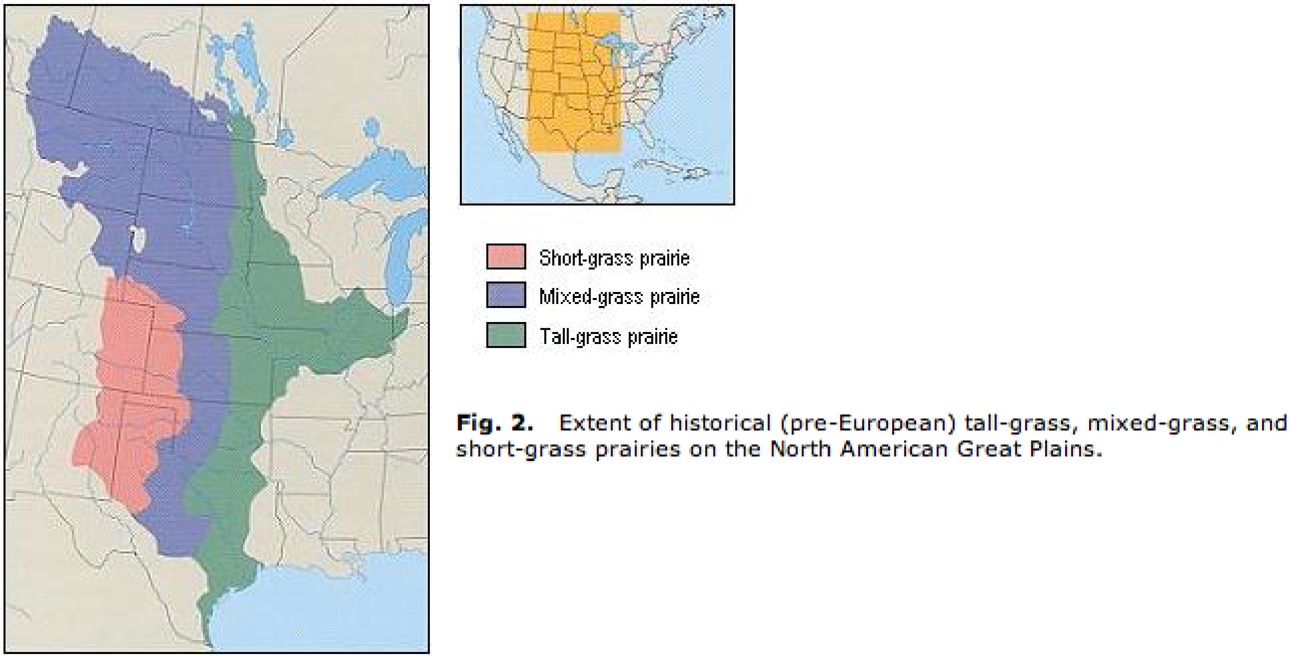
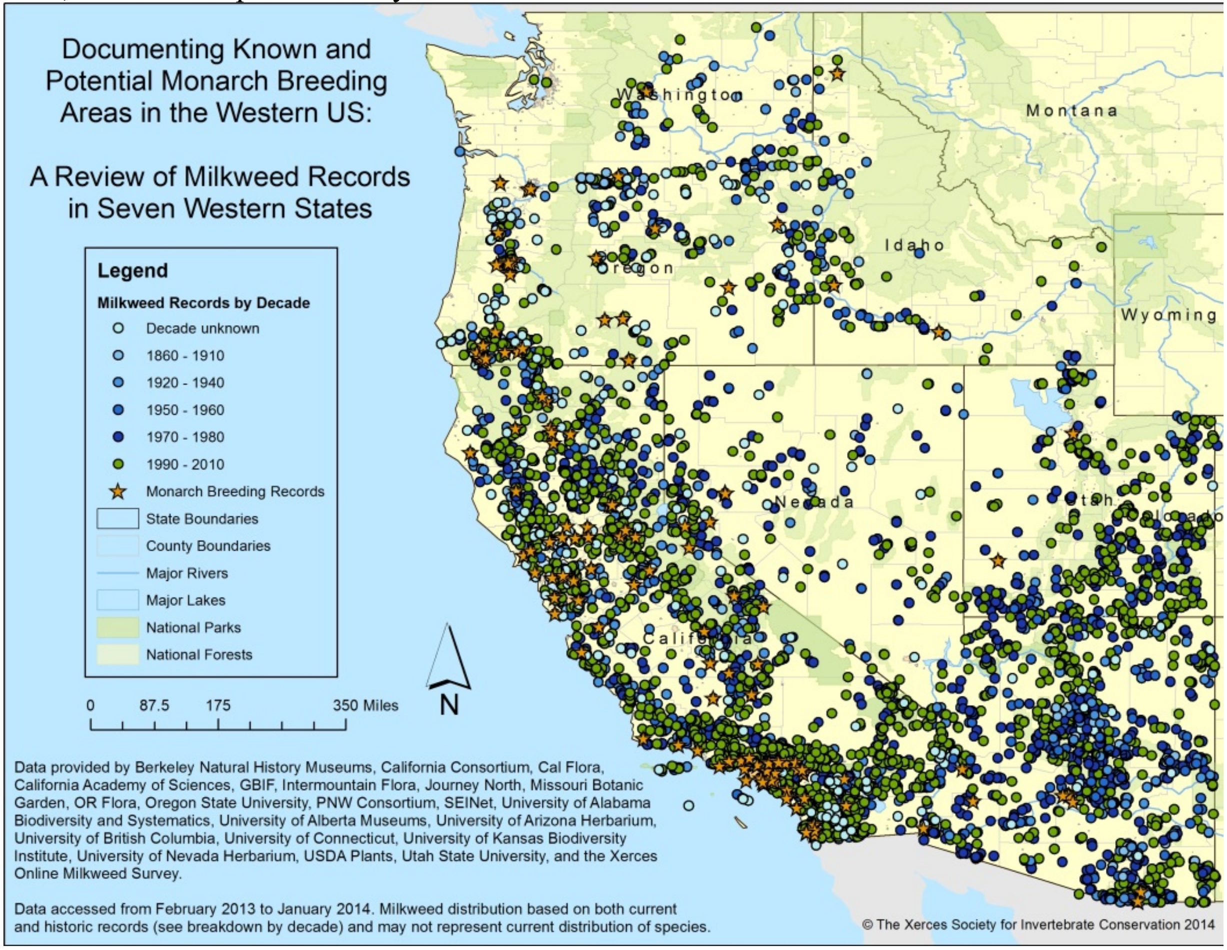


Fig. 2. Extent of historical (pre-European) tall-grass, mixed-grass, and short-grass prairies on the North American Great Plains.

Figure 9. Historic monarch distribution east of the Rockies likely coincided with pre-European prairie extent. Figure 2 from USGS 2013 Prairie Past and Present, caption included: http://www.npwrc.usgs.gov/resource/habitat/grlands/pastpres.htm#table1

It is likely that prairie milkweeds were abundant and supported high monarch populations, though abundance and distribution of particular milkweed species before widespread plowing of the prairies is unknown. Milkweed species and abundance have been measured in some current prairie remnant habitats in Iowa and extrapolated to provide an estimate of pre-agricultural milkweed occurrence. One measure of milkweed abundance is percent coverage of the landscape by milkweeds in relation to all other plant species in an area – how much space they take up. Pleasants (in press) estimates that statewide, the milkweed species in former prairies contributed 0.65 percent of the vegetation coverage in Iowa, which would have provided habitat to support highly abundant monarch populations. As of 1999, common milkweed comprised only 0.194 percent of coverage in Iowa, and that percentage has decreased nearly three-fold, to 0.068 percent by 2012, as the widespread planting of glyphosate-resistant Roundup Ready crops has led to a drastic decline in milkweed abundance in agricultural fields, as discussed in detail in the Threats section of this petition.

In the western United States, milkweeds are distributed across the landscape (Figure 10). More research is needed to understand how milkweed availability may have changed over time in the west, and what impact that may have had on monarchs.


Documenting Known and Potential Monarch Breeding Areas in the Western US:

A Review of Milkweed Records in Seven Western States

Data provided by Berkeley Natural History Museums, California Consortium, Cal Flora, California Academy of Sciences, GBIF, Intermountain Flora, Journey North, Missouri Botanic Garden, OR Flora, Oregon State University, PNW Consortium, SEINet, University of Alabama Biodiversity and Systematics, University of Alberta Museums, University of Arizona Herbarium, University of British Columbia, University of Connecticut, University of Kansas Biodiversity Institute, University of Nevada Herbarium, USDA Plants, Utah State University, and the Xerces Online Milkweed Survey.

Data accessed from February 2013 to January 2014. Milkweed distribution based on both current and historic records (see breakdown by decade) and may not represent current distribution of species.

© The Xerces Society for Invertebrate Conservation 2014

Figure 10. Records of milkweeds (multiple *Asclepias* species) from 1860-2010 (blue and green) and records of monarch caterpillars on milkweed (orange). Note that records for Montana and Wyoming are not displayed on this map. Figure courtesy of the Xerces Society, available at: http://monarchjointventure.org/our-work/western-us-milkweed-survey

The grasslands and prairies of North America were rapidly and almost completely converted to rangeland for domesticated animals and to agricultural fields after European settlers moved west beginning in the early to mid-1800s. Most milkweed species would have declined in abundance as a result. At about the same time that grasslands and prairies were being plowed under, forests east of the Mississippi were being cleared. Though most milkweed species declined following prairie conversion, common milkweed (*A. syriaca*), which thrives in areas of soil disturbance, increased in range and abundance in both agricultural and logged areas (Brower 1995). Monarchs thus would have been able to maintain high populations after European colonization of North America by shifting the center of their population east and north as formerly forested land was invaded by common milkweed, and by substituting this one milkweed for most of the others as their main host plant in the northern and eastern breeding range.

Based on the limited historical data that are available, monarchs were highly abundant in the mid- to late-1800s. Brower (1995 and references therein) discusses early observations of monarchs in the Midwest and east by naturalists, journalists, farmers, and scientists. D'Urban (1857) described monarchs appearing in the Mississippi Valley in “such vast numbers as to darken the air by the clouds of them” (in Brower 1995, p. 349). Scudder and Allen (1869) described monarchs gathered in groves of trees bordering the prairie in Iowa “in such vast numbers, on the lee sides of trees, and particularly on the lower branches, as almost to hide the foliage, and give to the trees their own peculiar color” (in Brower 1995, p. 306). In the 1870s swarms of monarchs were reported in New England and the Great Lakes. Saunders (1871) observed “vast numbers-- I might safely say millions” of monarchs clustering on trees on the Canadian shore of Lake Erie (in Brower 1995, p. 308). Scudder (1889) noted endless masses of monarchs migrating through Connecticut in 1871 (Ibid.). In 1872 an immense swarm of monarchs was observed in flight over Cleveland, Ohio (Brower 1995, p. 308).

Prior to monitoring efforts that began in the 1980s, the historic distribution and size of the western monarch population was largely unknown. There are early accounts of overwintering masses of monarchs from Monterey, California in 1869 and 1873, and from Santa Cruz in 1888 (Lane 1993, Brower 1995). In May 1874 the Monterey Weekly Herald published an account from near Pacific Grove of “millions” of monarchs “fluttering around,” “while overhead stout branches of firs dropped with their weight” (in Lane 1993, p. 341). An 1881 letter describes trees near Monterey “over one and a half feet in diameter, and completely covered with live butterflies. To say that there were as many butterflies as leaves upon the trees would not be a very great exaggeration” (in Lane 1993, p. 341). Historic estimates of the western overwintering population size range from 1 to 10 million (Nagano and Lane 1985, Nagano and Freese 1987). Leong et al. (2004) used data from the California Natural Diversity Database (CNDDB) from 1990 to 2000 to estimate the maximum number of overwintering monarchs for a single season to be more than 2.3 million. Historic estimates of monarch population size that are available for a few overwintering sites suggest that the monarch population was larger prior to the onset of a large-scale yearly monitoring effort that began in 1997 (Figure 11.)

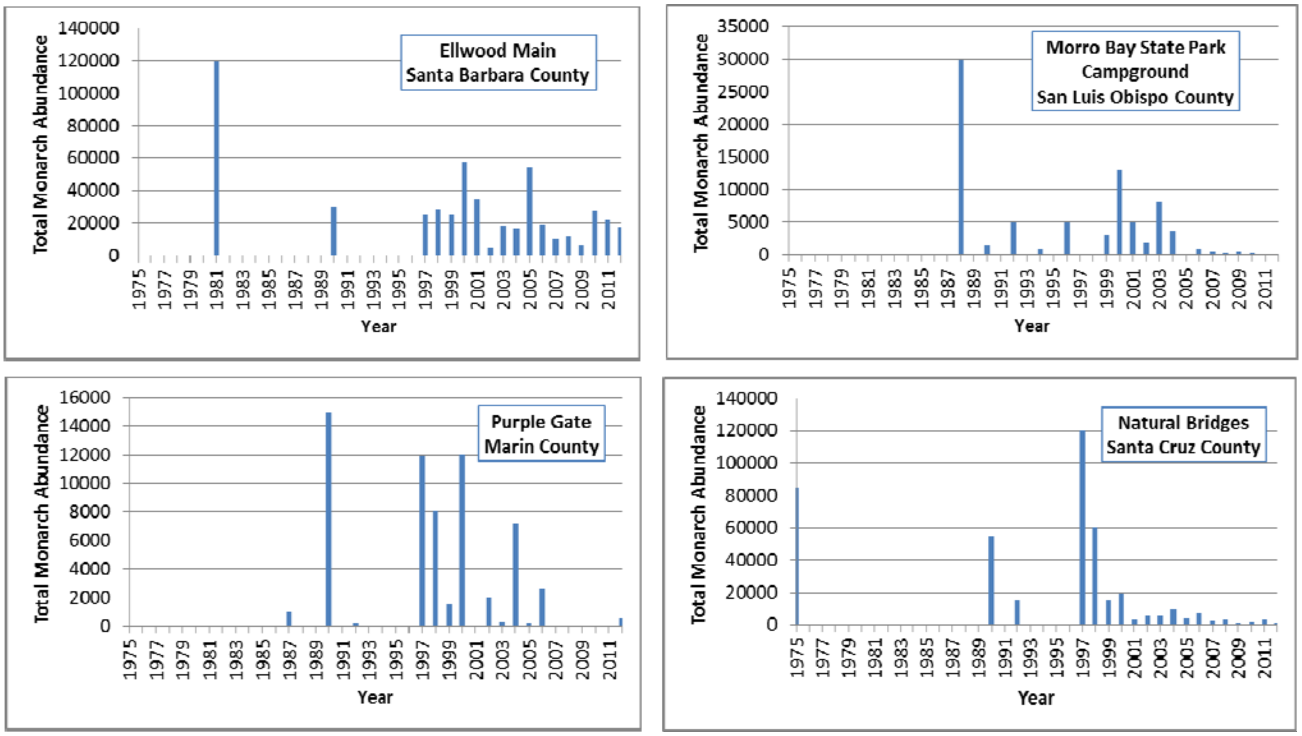


Figure 11. Western monarch population estimates from November 1 - December 15 at four sites: Ellwood Main (Santa Barbara County), Morro Bay State Park Campground (San Luis Obispo County), Purple Gate (Marin County) and Natural Bridges (Santa Cruz County); figure from Jepsen and Black in press.

Thus it is clear that historically monarchs were highly abundant, though annual population sizes were not quantified prior to the late 1990s when monitoring began Though monarchs are still widely distributed, their abundance has declined drastically across their U.S. range, as discussed in detail below. Very recently, the number of monarchs from east of the Rockies has declined from occupying an overwintering area of 7.8 hectares in the 1994-1995 overwintering season (the first year data are considered to be reliable), to occupying an area of only 0.67 hectares in the 2013-2014 overwintering season, a decline of more than 90 percent from the 20-year average, and a decline of 97 percent from the 1996-1997 population high (Rendón-Salinas and Tavera-Alonso 2014).

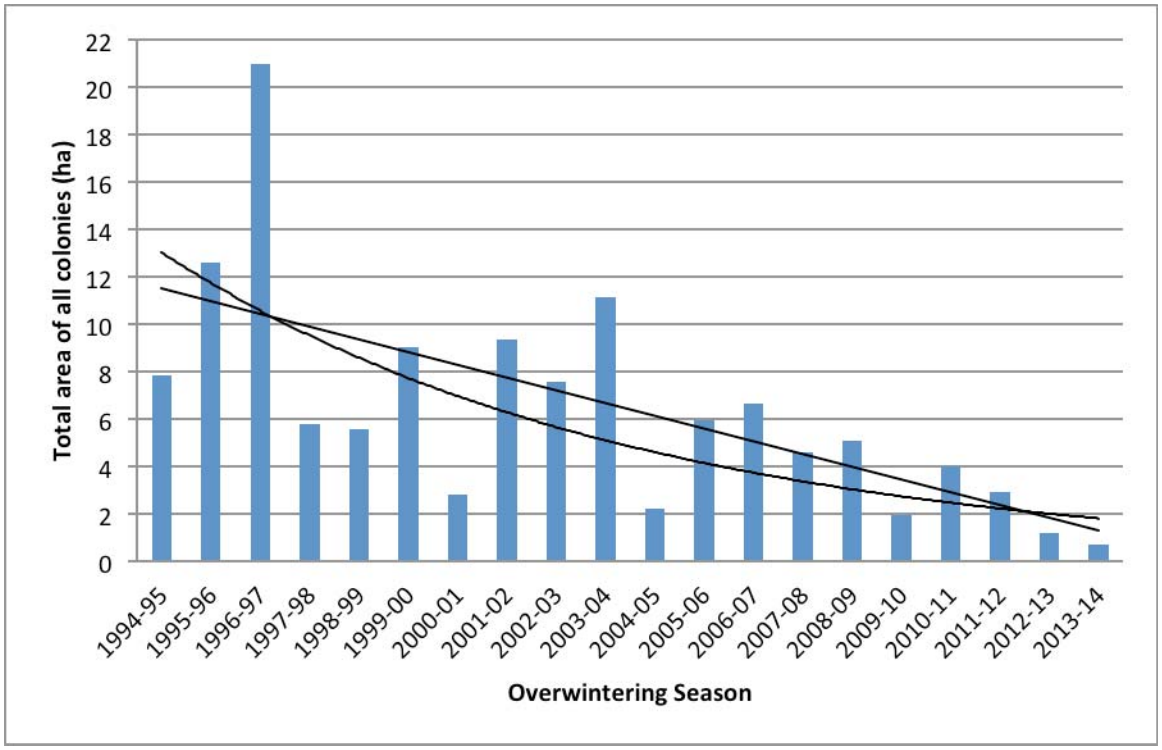
Monarchs from west of the Rockies have also undergone recent significant decline. In the winter of 1997, which is the year that monitoring began, there were more than 1.2 million monarchs overwintering in California (or an average of 12,232 monarchs per site), but in 2013 there were only about 200,000 monarchs counted (an average of 2,151 monarchs per site), representing a decline of 90 percent from the 1997 high and a 51 percent decline from the 17-year average (Monroe et al. 2014, Figure 13). Western monarch numbers have not reached the highs recorded in the late 1990s since that time, and have fluctuated around 200,000 butterflies since 2001 (Monroe et al. 2014). Historical estimates of the overall California overwintering population size range up to 10 million butterflies (Nagano and Lane 1985, Nagano and Freese 1987).

There are several research and citizen science programs that provide data on current monarch distribution and abundance, including the World Wildlife Fund Monarch Monitoring Project in

Mexico, the Monarch Larva Monitoring Project, Peninsula Point Migration Monitoring Project, Cape May Migration Monitoring Project, the Western Monarch Thanksgiving Count, annual censuses of monarchs in the Central Valley and Sierra Nevada by Dr. Art Shapiro, the North American Butterfly Association annual breeding adult surveys, and state-level programs (Monarch Net 2014, *see*: http://monarchnet.uga.edu/).

To estimate overall abundance of monarchs that overwinter in inland Mexico, scientists rely on the combined area of overwintering colonies because it is a direct measure of the entire migratory population (Brower et al. 2012b, p. 328). On-the-ground counts have resulted in estimates of 10 to 60 million butterflies per hectare of trees occupied, with 50 million monarchs per hectare being used as a standard estimate of overwintering butterfly numbers, since measurements are taken at a time of year when butterflies are likely to be most tightly packed, and since the higher density numbers are from more recent and standardized studies (Slayback et al. 2007). Monarch numbers in winter roosts generally correlate with numbers produced during breeding in a given season, although variable mortality does occur during migration. Reliable information on colony sizes and locations in Mexico is available since the 1994–1995 overwintering season for eastern North America; earlier information is considered less reliable because it was gathered on increasing numbers of colonies as they were discovered by diverse groups of investigators with variable expertise. The overall abundance of monarchs that overwinter on the California coast is estimated from counting the actual number of butterflies at each site; 76-162 overwintering sites have been counted each year, and 17 sites have been consistently monitored since 1997 (Figures 13 and 14).

The number of monarchs overwintering in Mexico, primarily representing the eastern migratory population, shows a statistically significant decline over the past twenty years (Figure 12). In winter 1994-1995, monarchs occupied 7.81 hectares of oyamel forest. The highest number observed was in winter 1996-1997 when monarchs occupied 20.97 hectares. By 2004-2005, the number of hectares had dropped to 2.19, and has not since risen to 7.0 hectares, the area covered when standardized counts began in 1994-1995. Regression analyses show statistically significant monarch population decline even when the highest and lowest measurements are removed (linear model, $P = 0.032$ or 0.042; exponential model, $P = 0.040$ or 0.049; Brower et al. 2012a, p. 96). We extended the Brower et al. (2012a, Fig. 1) graph to include the results of the three most recent winter surveys (Figure 12). Regression analysis of the extended data continues to show a statistically significant decline in monarch abundance ($P = 0.01$). In summary, there has been a 91 percent decline in overwintering eastern monarch numbers over the past twenty years, with numbers in winter 2013-2014 being the lowest ever recorded.



linear:	$y = -0.5372x + 12.028$	$R^2 = 0.4493$
exponential:	$y = 14.445e^{-0.104x}$	$R^2 = 0.5502$

Figure 12. Total annual area occupied by overwintering butterflies in Mexico from 1994 through 2013, with linear (upper line) and exponential (lower line) regression analyses. The significant decline charted by Brower et al. (2012a, Fig. 1) through 2010-11 continues through 2013-14.

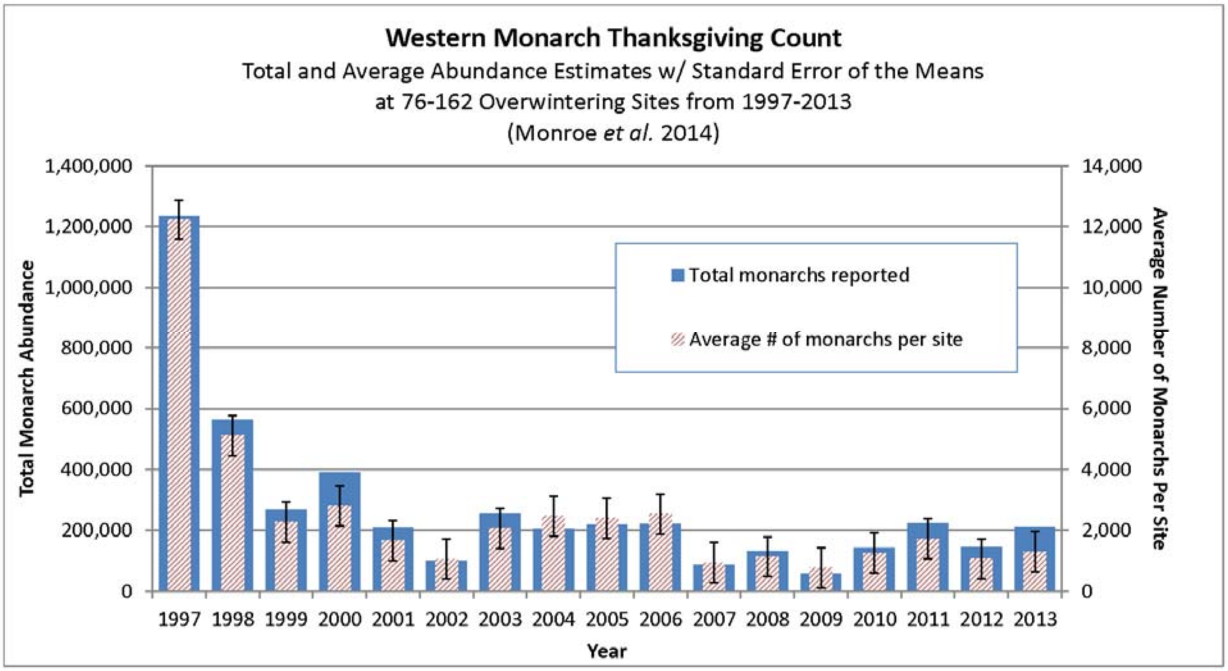


Figure 13. Western Monarch Thanksgiving Count Data 1997-2013. From Monroe et al. 2014

An analysis of the 17 western monarch overwintering sites that have been monitored every year shows that there has been a statistically significant population decline (Griffiths and Villablanca in preparation). There is evidence that a range contraction has also occurred, with significantly more sites declining at the southern and northern extremes of the monarch's winter range (Griffiths and Villablanca in preparation).

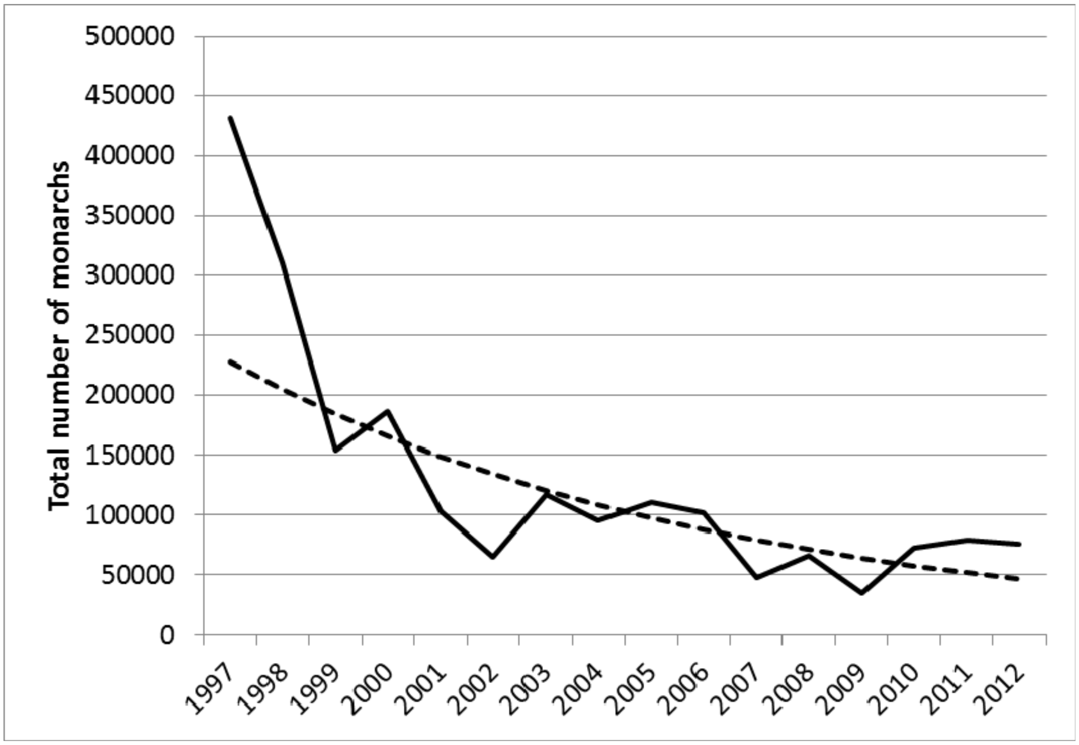


Figure 14. The total number of monarchs counted at 17 monarch overwintering sites during the Western Monarch Thanksgiving Count from 1997-2012. The solid line represents the actual survey data. The dotted line represents the regression function. Figure from Griffiths and Villablanca (in preparation).

Though their numbers have been drastically reduced, monarchs are still widespread in appropriate habitat in the continental United States. Flockhart et al. (2013) predicted where eastern monarchs are most likely to be found during the breeding season by determining the probable range based on amount and kind of vegetation, geographical limits (latitude, longitude, altitude, and slope), temperature, precipitation, and records from Journey North citizen scientist observations collected between 1997 and 2011 (Flockhart et al. 2013, Fig. 1). They determined that the majority of monarchs are found from east- and mid-Texas north into the Midwest, and then at a somewhat lower density throughout the east from southern Canada south to the Gulf. Some monarchs also occur much further west and north.

Although monarchs are distributed throughout the eastern United States during the breeding season, their reproductive success is not uniform across regions. Wassenaar and Hobson (1998) analyzed stable hydrogen and carbon isotope profiles from wings of butterflies overwintering in Mexico to determine the host plants and latitude where the caterpillars had developed. They determined that half of the overwintering monarchs had “originated from a fairly restricted part of the breeding range, including the states of Kansas, Nebraska, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, and Ohio, corresponding to an area of intense corn, soybean, and dairy production in the Midwestern United States” (Figure 15, below). It is important to note that the butterflies they analyzed developed during the 1996 breeding season, and overwintering monarchs from that year covered the largest area in Mexico recorded in the last 20 years, 20.97 hectares. Using the standard estimate of 50 million butterflies per hectare (Slayback et al. 2007), almost a billion individuals were in the population at that time, half of which metamorphosed on common milkweed in regions dominated by agriculture, particularly corn and soybeans.

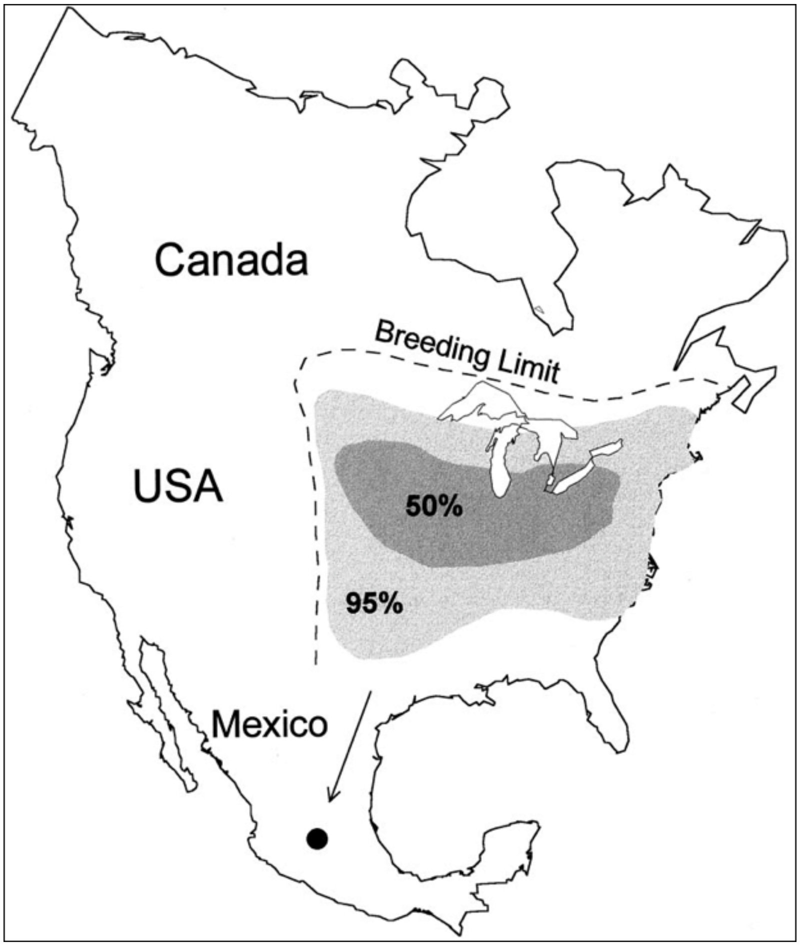


Figure 15. Natal origins of monarch butterflies in Mexico from the 1996 breeding season based on isotope data. The dark and light-shaded areas show the natal origins of 50% and 95% of the one billion monarchs that overwintered in 1996/97. The dashed line approximates the eastern breeding range. The Mexican monarch overwintering colonies are denoted by the solid circle. Figure 3 from Wassenaar and Hobson (1998), original caption omitted.

Flockhart et al. (2013) extended the monarch natal origin studies by measuring isotopes in butterflies collected throughout eastern North America at different times during the 2011 breeding season. Researchers collected monarchs as they arrived in the southern United States from overwintering in Mexico, and then continued to sample butterflies throughout the summer and into fall to determine where each successive generation had originated. They determined that the overwintered generation in 2010 – 2011 had natal origins throughout much of eastern North America, but that most individuals came from a swath running from the northeastern states through the lower Midwest into northern Texas, and that fewer overwintered butterflies had originated in the heart of the Corn Belt as compared to the 1996 season (Flockhart et al. 2013, Fig. 2, panel a: "overwintered generation"). Notably, fewer overwintered butterflies originated in northern Indiana, Illinois, Iowa, Michigan, or the upper Midwest compared to the 1996 breeding season.

Flockhart et al. (2013) went beyond study of the overwintering generation to determine the natal origins of successive monarch generations produced in the east throughout the 2011 breeding season. The natal origins showed a broad spatial distribution that encompassed the entire breeding range in eastern North America, though the preponderance of individuals originated from northern Texas to western Ohio, in a region extending from the southern Great Plains through the Midwestern Corn Belt (Figure 16). Over this particular breeding season, fewer butterflies originated in the upper Midwest, northeastern and eastern states, and southern Canada, than in the Texas-to-Ohio zone. There were few indications of natal origins from Mississippi, Alabama, Georgia and Florida despite the fact that areas located north of these locations were sampled extensively.

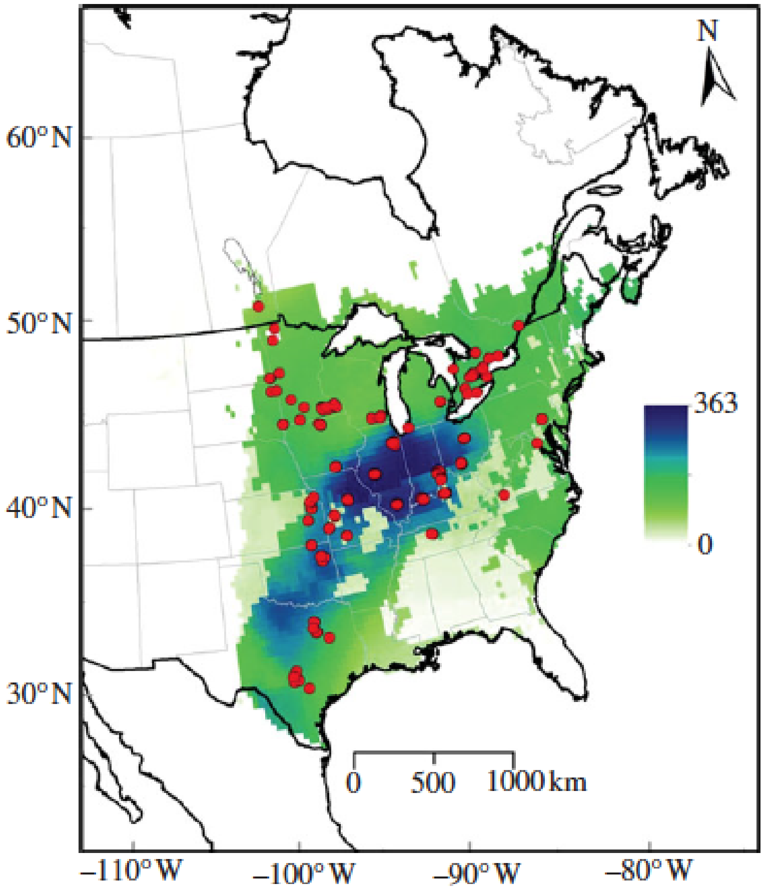


Figure 16. Probability distribution for natal origins of monarchs collected in eastern North America during the 2011 breeding season, based on isotope analysis of butterflies. Red dots represent monarch capture locations. The color gradient on the map (light green to dark blue) represents the natal origins of the 839 butterflies analyzed, with increasing numbers of butterflies born in areas with progressively darker coloration, as indicated by the scaled bar to the right of the map. Figure 3 from Flockhart et al. (2013), original caption omitted.

When butterflies were collected for the Flockhart et al. (2013) study, the overwintering monarch population size was drastically reduced from the 1996-1997 level. During the winter of 2010–2011, the estimated population size was 200 million individuals (Figure 12, above), compared to the estimated billion butterflies at the time of the earlier study. In 2010 almost all soybean and most corn fields were Roundup Ready and few milkweeds remained in those fields to provide habitat for breeding monarchs (as discussed in detail in the Threats—Habitat Loss section of this petition). Overwintering butterfly numbers have continued to decline, as discussed above, coinciding with the greatly reduced availability of common milkweed in agricultural fields as a result of the large increase in use of the herbicide glyphosate made possible by widespread planting of genetically-engineered, herbicide-resistant (Roundup Ready) crops (Pleasants and Oberhauser 2012).

To predict monarch risk of extinction, Flockhart et al. (2014) "developed a spatially-structured, stochastic and density-dependent periodic projection matrix model that integrates patterns of migratory connectivity and demographic vital rates across the annual cycle" (p. 2). Their "year-round population model predicted population declines of an additional 14 percent," from already drastically reduced population size, and a quasi-extinction probability (meaning less than 1000 surviving individuals) of greater than five percent within the next 100 years (p. 2). This "non-trivial" extinction risk (*see*: http://theconversation.com/iconic-monarch-butterflies-under-threat-from-rising-herbicide-use-27596) demonstrates that monarchs are threatened in the foreseeable future. The model is a conservative, yet realistic, minimum estimate of quasi-extinction of eastern monarch butterflies, and provides strong published evidence that breeding season habitat loss is driving monarch population decline.

Yet the model also underestimates the extinction risk facing monarchs for several reasons. The model does not incorporate further expected losses of milkweed in Conservation Reserve Program lands which are being rapidly converted to crop production, primarily Roundup Ready corn and soybeans, due to Program cutbacks and continuing strong demand for biofuels (*See* Threats…Habitat Loss and Degradation, Loss of Monarch Habitat Due to Agricultural Intensification to Produce Biofuels). It does not consider the imminent release of new genetically-engineered herbicide-resistant crops, which will reduce nectar resources for monarch adults via herbicide drift and continue to eliminate milkweed from cropland once commercialized (*See* Threats- Habitat Loss and Degradation, New Herbicide-Resistant Crops Promise Further Habitat Degradation). Nor does it take into consideration the release of new pesticides that are in development that will be harmful to monarchs (*See* Threats…Other Factors).

The model also underestimates the risk that climate change poses to monarch butterflies. The model is based on the assumption that there will be a reduced probability of catastrophic mortality events on the wintering grounds in Mexico, but other authors have predicted increased probability of winter mortality due to climate change (Brower et al. 2011, p. 28, Barve et al. 2012, p. 820, Brower et al. 2012a, p. 98). In fact, other models have predicted that the entire Mexican overwintering grounds could become unsuitable to support monarchs in the foreseeable future (Oberhauser and Peterson 2003, p. 14067, Saenz-Romero et al. 2012, p. 98). The model also underestimates climate risk because it uses temperatures from weather stations that are on average 274 m (~900 ft) below the elevation at which butterflies cluster (Flockhart et al. 2014, supporting materials, p. 30). The model is based on the assumption that increasing temperatures from climate change will decrease the risk of severe winter storm events, yet this assumption is not supported by other climate models. The model also fails to take into account the influence of predicted warmer temperatures on lipid depletion during overwintering which reduces butterfly fitness (*See* Threats…Other Factors, Global Climate Change).

Thus, the Flockhart et al. (2014) model demonstrates that the monarch is threatened, yet certainly still underestimates extinction risk. The model demonstrates that ongoing population declines will be driven by land-use change and global climate change, and identifies as a top priority for slowing future population declines the need to reduce the loss of milkweed host plants in the Midwest and Southern U.S. breeding grounds, which they determine is the primary driving force behind the current population decline (p. 3, 14). The model also demonstrates that the drastically reduced current population size of monarchs makes the species even more vulnerable to catastrophic events. The overall population of monarchs in North America is exhibiting a significant decline and the butterflies are facing high magnitude, imminent threats from multiple factors across their range.

THE MONARCH BUTTERFLY WARRANTS ESA PROTECTION

The Endangered Species Act states that a species shall be determined to be endangered or threatened based on any one of five factors (16 U.S.C. § 1533 (a)(1)). In this case, the monarch is threatened by all five of these factors and warrants protection under the Act. The monarch is threatened by the first factor, the modification and curtailment of habitat and range, due to the drastic reduction of milkweed in its summer breeding habitat that has occurred due to increased herbicide spraying caused by the widespread adoption of genetically-engineered, herbicide-resistant corn and soybean crops (Pleasants and Oberhauser 2012, Flockhart et al. 2014). Monarch habitat has also been reduced due to increased production of ethanol since 2007 that has resulted in conversion of grasslands to corn and eliminated milkweed from those habitats (Brower et al. 2012a), and by other factors such as urban development and aggressive management of roadside vegetation (Commission on Environmental Cooperation 2008). East of the Rockies, it has been very roughly estimated that approximately 167 million acres of monarch habitat, an area about the size of Texas, may have been lost since the mid-1990s due to agricultural changes and development, including nearly one-third of the monarch's total summer breeding range (Taylor 2014). The monarch's wintering grounds are threatened by illegal logging, legal wood gathering, water diversion, and agricultural conversion of forest land in Mexico, and by development, aging forests, and other threats in California. The butterfly is potentially threatened by the second factor, overutilization, due to commercial production and release of large numbers of butterflies, which threatens to spread disease and undesirable genetic traits to wild populations. The monarch is also threatened by the third factor, disease or predation. High levels of predation are a significant threat at all life stages, especially in synergy with habitat loss and declining populations. Disease further threatens the monarch, and the spread of one protozoan parasite in particular may be reducing the proportion of females in the population and thus reducing the monarch's potential for population growth and recovery (Davis and Rendón-Salinas 2010). The fourth factor, inadequacy of existing regulatory mechanisms, is a threat because voluntary efforts undertaken have not been able to stop and reverse population decline. Finally, monarchs are also threatened by the fifth factor, other natural and manmade factors affecting their continued existence, including pesticides, invasive species, global climate change, and stochastic weather events. Severe weather conditions have been identified as one of the primary factors in the recent precipitous decline in monarch numbers (Brower et al. 2012a,b).

Synergies between all of these factors magnify the intensity of threats facing monarchs. Climate change, for example, will exacerbate other threat factors such as disease and habitat loss, and habitat loss will increase threats from other factors including disease and predation. There are no existing regulatory mechanisms that are adequate to protect the monarch butterfly from all of these threat factors. As discussed in detail in the Significant Portion of Range section of this petition, below, the monarch is at risk of extinction in a significant portion of its range in North America because without the significant North American population, the redundancy, resiliency, and representation of the species would be so impaired that the monarch would have an increased vulnerability to threats to the point that the overall species would be likely to become endangered in the foreseeable future. The monarch butterfly needs ESA protection as a threatened species to address landscape level threats to its existence before its population declines to the level of endangerment.

THREATS

FACTOR ONE: MODIFICATION OR CURTAILMENT OF HABITAT OR RANGE

Monarch Habitat Loss Due to Pesticides

The monarch butterfly is threatened by modification and curtailment of habitat and range due to the drastic loss of milkweeds, especially common milkweed (*Asclepias syriaca* L.), caused by increased and later-season use of the herbicide glyphosate. Glyphosate use has increased dramatically because of the widespread planting of genetically-engineered, herbicide-resistant corn and soybeans in the Corn Belt region of the United States and to planting of genetically-engineered cotton in the southern United States and California. In the Midwest, nearly ubiquitous commercial planting of, glyphosate-resistant Roundup Ready corn and soybeans has caused a precipitous decline of common milkweed, and thus of monarchs, which lay their eggs only on milkweeds. Moreover, milkweed from crop fields is particularly significant for maintaining monarch abundance (Oberhauser et al. 2001, Pleasants and Oberhauser 2012, Flockhart et al. 2014).

On top of the loss of milkweed in crop fields, much habitat that once hosted milkweed, particularly Conservation Reserve Program land, has recently been converted to genetically-engineered, glyphosate-resistant corn and soybeans to produce biofuels. In addition, new multiple genetically-engineered, herbicide-resistant crops, soon to be introduced, will further degrade monarch habitat by reducing nectar resources for monarch adults via increased herbicide drift damage, and causing further loss of milkweed in agricultural fields. Threats posed to monarchs from pesticides in addition to habitat loss are discussed in the petition section Other Factors- Pesticides.

As discussed in detail in the Natural History section of this petition, the majority of the world’s monarchs originate in the Corn Belt region of the United States, and the demographic importance of this region to the resiliency, redundancy, and representation of *Danaus plexippus plexippus* cannot be overstated (Wassenaar and Hobson 1998, Oberhauser et al. 2001, Brower et al. 2012a, b; Flockhart et al. 2013, 2014; Pleasants and Oberhauser 2013, Pleasants in press). The dramatic loss of milkweed from the monarch's summer breeding grounds thus puts the monarch at risk of extinction (Flockhart et al. 2014), and this risk is magnified by other ongoing threat factors such as climate change, severe weather events, and habitat loss to development (Brower et al. 2011, 2012a, b; Saenz Romero et al. 2012, Vidal et al. 2013).

Loss of Monarch Habitat in Croplands Due to Increased Use of Glyphosate With Roundup Ready Crops

First introduced by the Monsanto Company in 1974, glyphosate is an extremely effective herbicide that kills a broader range of plants than most weed-killers (Duke and Powles 2008). This is because glyphosate inhibits a critical enzyme—5-enolpyruvyl-shikimate-3-phosphate synthase (EPSPS) —that is found in virtually all green plants, and which helps the plant synthesize various compounds it requires for growth and survival. Glyphosate is thought to kill plants by inducing shortages of these essential compounds (Henderson et al. 2010), though other potentially complementary mechanisms have been proposed (Lorentz et al. 2011, Johal and Rahe 1984, Duke et al. 2007).

Glyphosate is a systemic herbicide that has unparalleled effectiveness on perennial weeds—such as common milkweed—that most other herbicides fail to kill (Franz et al. 1997). When glyphosate is sprayed on a weed, it is absorbed by the leaves and stems and then translocated (moved) inside the plant to concentrate in actively growing meristematic tissues, including the plant's roots and developing buds (Duke and Powles 2008). By killing common milkweed at the root, regrowth the following year is largely prevented (Bhowmik 1994).

In 1996 Monsanto introduced the first of a series of Roundup Ready crops, which are genetically engineered to survive direct broadcast application of glyphosate, sold under the brand name of Roundup, but also in many generic versions produced by other firms. Roundup Ready crops enable glyphosate to be used post-emergence (to the growing crop) to kill weeds through much of the growing season without crop injury. Glyphosate is particularly lethal to milkweed when used in conjunction with Roundup Ready crops because it is applied more frequently, at higher rates, and later in the season—during milkweed's most vulnerable flowering stage of growth—than when used with traditional crops. The increasingly common practice of growing Roundup Ready crops continuously and sequentially (corn, soybean, corn, and so on) on the same fields means that milkweed is exposed to glyphosate every year, with no opportunity to recover.

Prior to the Roundup Ready crop era, glyphosate was little used in corn and soybean production. From 1990 to 1995, glyphosate was applied to only 5-20 percent of national soybean acres and from 1-6 percent of corn acres each year [U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS) 1991-2008]. Monsanto introduced Roundup Ready soybeans in 1996 and Roundup Ready corn in 1998. Herbicide-resistant varieties (nearly all Roundup Ready) comprised 93 percent of soybeans and 85 percent of all corn grown in the United States in 2013 (USDA ERS 2014a).

Pesticide usage figures from USDA's National Agricultural Statistics Service (NASS) and the U.S. Geological Survey (USGS) show the dramatically increasing use of glyphosate in American agriculture triggered by Roundup Ready corn and soybeans. The glyphosate data discussed below are based primarily on NASS, which surveys thousands of farmers to arrive at the best available estimates of pesticide use in American agriculture (USDA NASS Advisory 2006). NASS reports pesticide use by crop—including percent of total crop acres treated, application rate, number of applications, and total amount used—for the "Program States" where most of the crop (corn or soybeans) is grown in the survey year. Several operations were required to derive the figures reported below. First, use figures for different types (salts) of glyphosate (these include "sulfosate," which is the trimethylsulfonium salt of glyphosate, *see*: http://www.weeds.iastate.edu/mgmt/qtr00-1/touchdown2.htm) as reported by NASS were combined: total amounts and percent area treated of different types were summed, while weighted averages were calculated for application rates and frequencies. Second, because NASS figures on total amount of glyphosate reflect usage only in those Program States surveyed in a given year, the totals are normalized to estimate national usage, and to enable valid comparisons from year to year. On average, NASS surveyed pesticide use on 88 percent of corn acres and 88 percent of soybean acres for the reported time period (USDA NASS 2013, 2011, 1991-2008). Thus, for example, if total glyphosate use as reported by NASS is 50.00 million pounds on corn in a year in which 90 percent of corn acres were surveyed, national glyphosate use on corn is 55.56 million pounds (50.00 million lbs./0.90). Third, because NASS did not survey pesticide use on corn and soybeans every year (particularly after 2005), glyphosate figures are interpolated or extrapolated for un-surveyed years. USGS also reports use of pesticides, including glyphosate, based primarily on proprietary data from GfK Kynetec, Inc. (Thelin and Stone 2012), and these data corroborate our NASS-derived figures.

Between 1995, the year before Roundup Ready soybeans were introduced, and 2013, total glyphosate use on corn and soybeans rose from 10 million to 205 million pounds per year, a 20-fold increase (*see* Figure 17). USGS figures on national glyphosate use on corn and soybeans agree closely with those derived from NASS data (*see* Figures 17 and 18). This dramatic increase is attributable to increased acreage treated, more glyphosate being applied per acre, and increasingly frequent applications in a single year and over the course of years. Each of these factors and its relevance to common milkweed is discussed below.

From 1995 to 2013, combined corn and soybean acreage treated with glyphosate increased from 17 to 157 million acres, a nine-fold increase (*see* Figure 19), tracking the rising adoption of Roundup Ready varieties (*see* Figure 20). For perspective, these 157 million glyphosate-treated acres represent half of all harvested cropland in the entire country in 2012 (315 million acres), an area nearly the size of Texas (USDA Census 2012, Table 8).

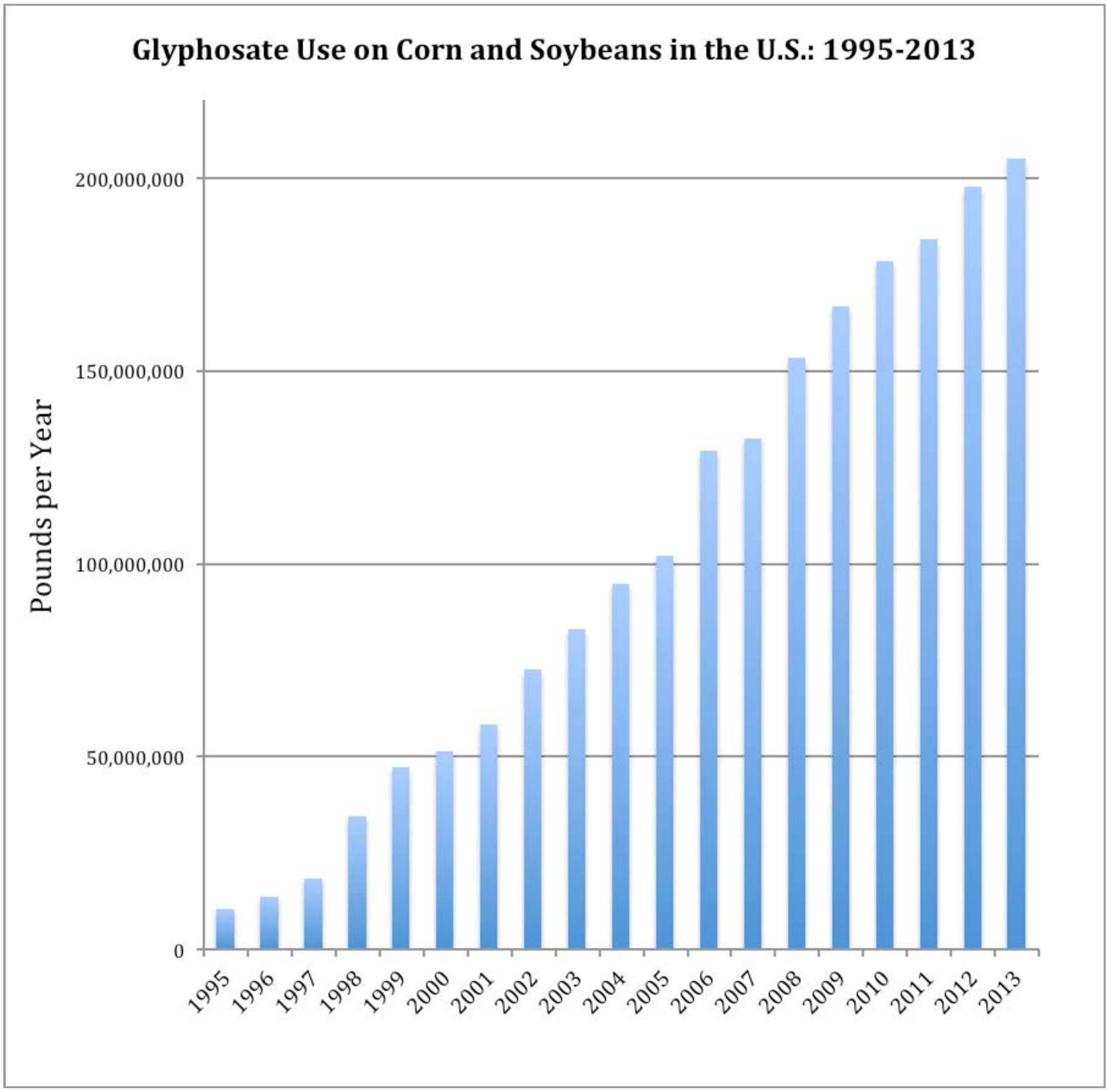


Figure 17. Glyphosate use on corn and soybeans: 1995-2013. Sources: USDA NASS (2013, 2011, 1991-2008).

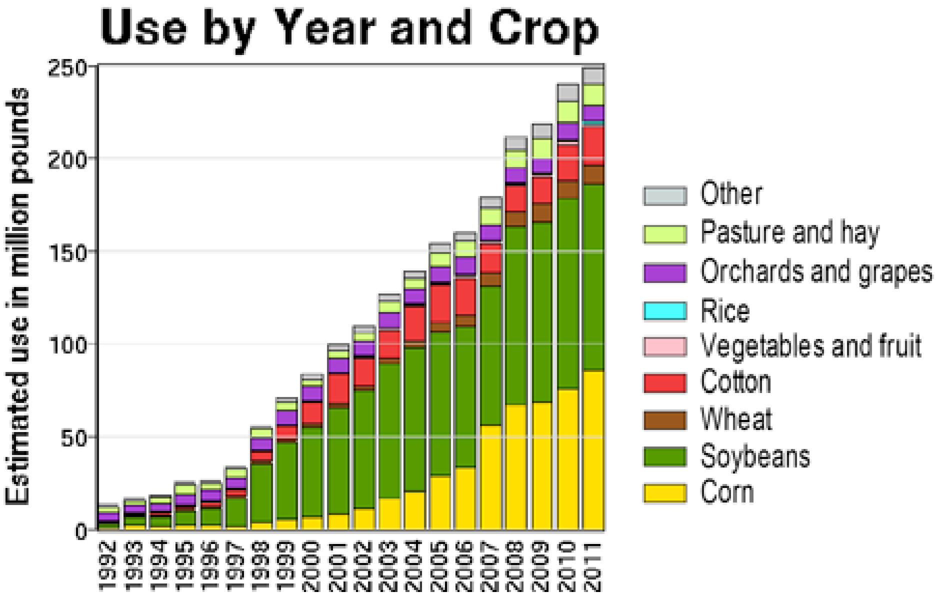


Figure 18. Estimated Agricultural Use of Glyphosate: Epest-Low. U.S. Geological Survey. *Compare* yellow and green bars for corn and soybean *with* NASS-derived data in preceding figure. http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=2005&map=GLYPHOSATE&hilo=L, accessed July 29, 2014.

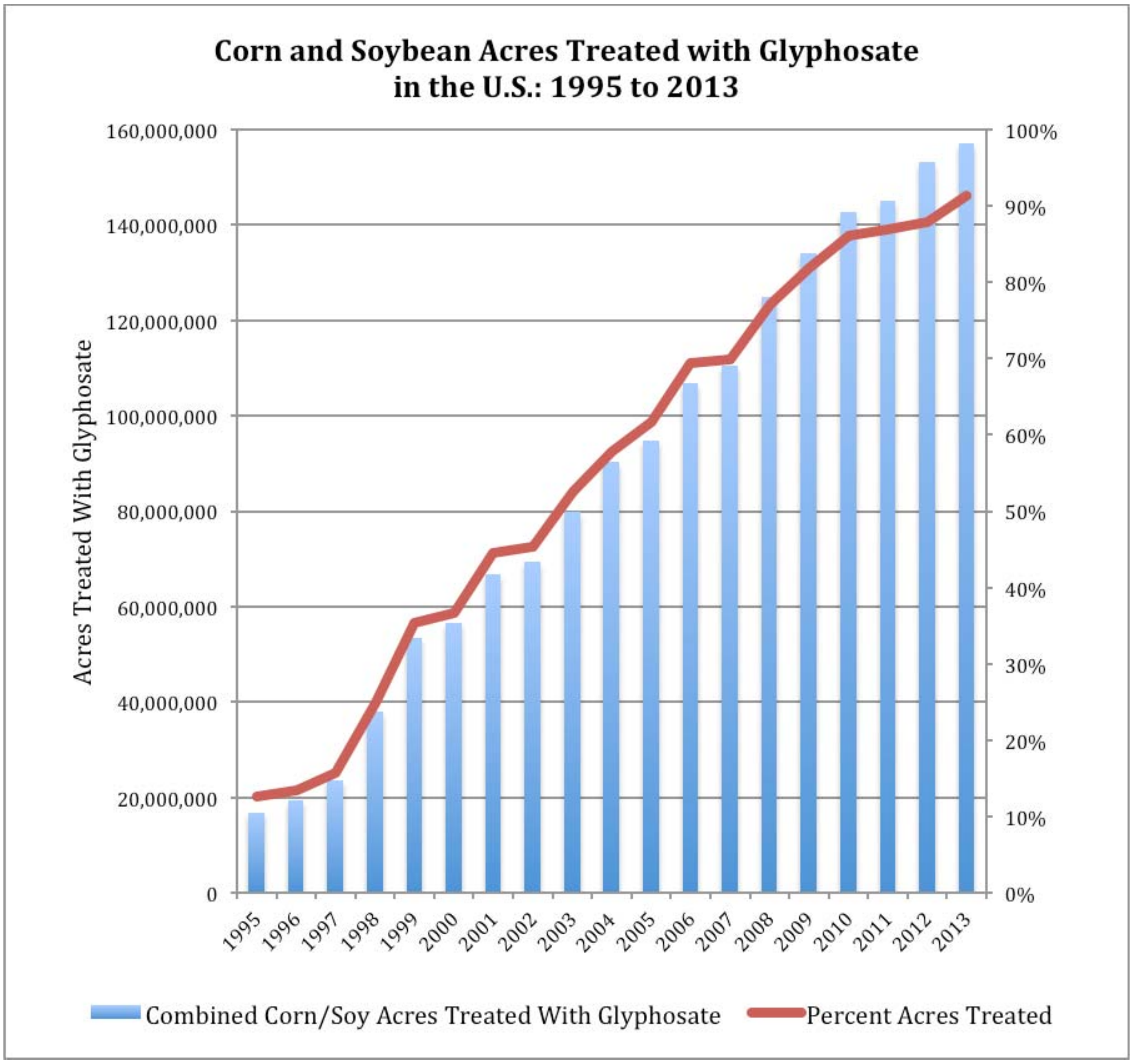


Figure 19. U.S. Corn and Soybean Acres Treated with Glyphosate: 1995-2013. Sources: USDA NASS (2014, 2013, 2011, 1991-2008).

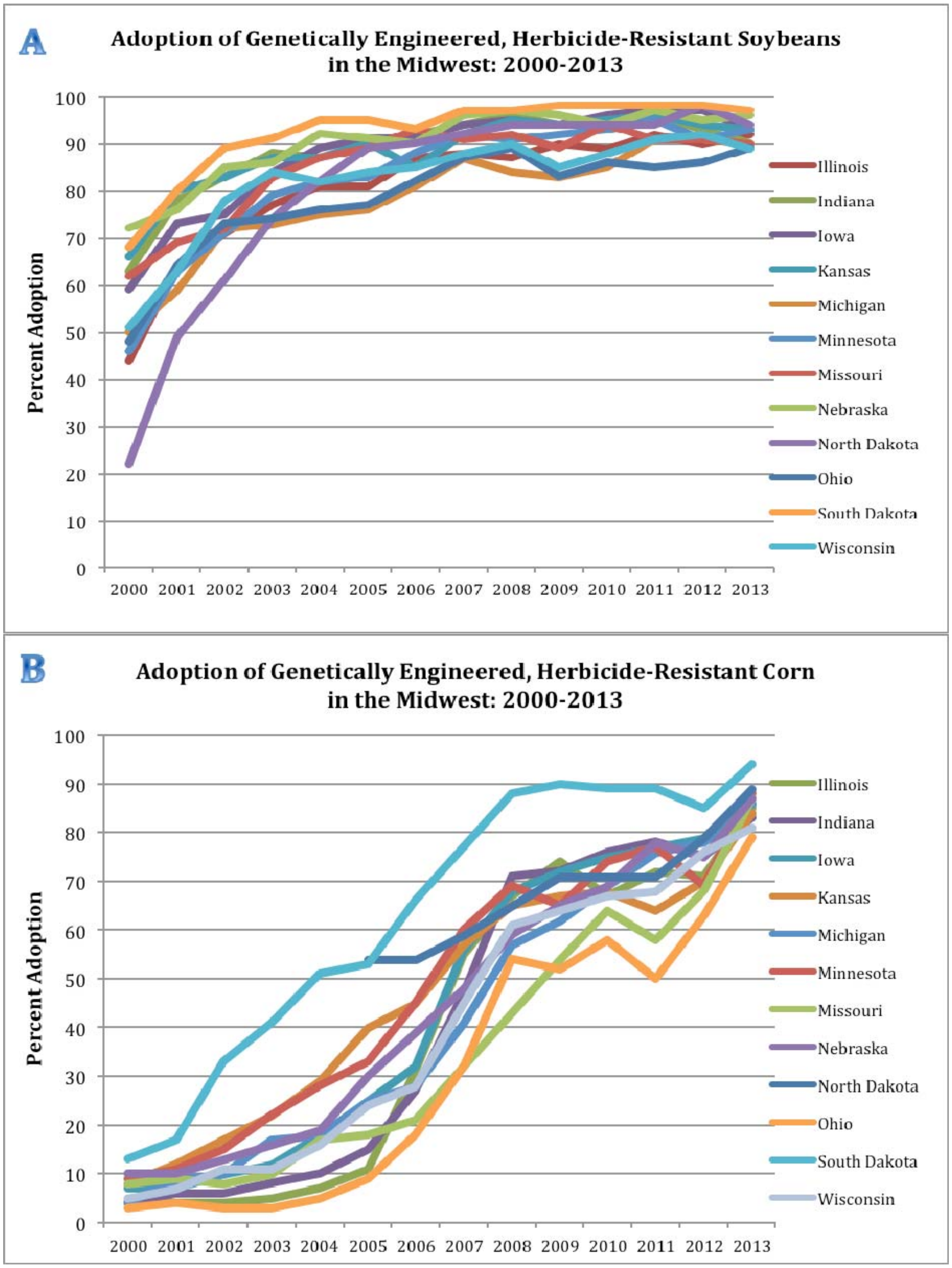


Figure 20. A: Percentage of U.S. soybean acreage planted to genetically engineered, herbicide-resistant soybeans. B: Percentage of U.S. corn acreage planted to genetically engineered, herbicide-resistant corn. Source: USDA ERS (2014b).

Glyphosate is not only being applied to vastly more acres than ever before, it is also being applied more intensively to the acres that are treated with it. From 1995 to 2013, the average glyphosate application rate increased by 58 percent on soybeans, from 0.60 to 0.95 pounds per acre, and increased by 41 percent on corn, from 0.61 to 0.86 pounds per acre (USDA NASS 2013, 2011, 1991-2008). Because higher rates of glyphosate are recommended to kill perennial weeds like common milkweed more effectively (Monsanto 2009, 12.7 and 12.8), this rising intensity of use is one factor in common milkweed's demise in cropland.

The average frequency of glyphosate applications has also increased over this same period: from 1.0 to 1.64 applications per year on soybeans (a 64 percent increase), and from 1.1 to 1.27 applications per year on corn (a 15 percent increase) (USDA NASS 2013, 2011, 1991-2008). This means that progressively more acres of Roundup Ready corn, and especially Roundup Ready soybeans, have been treated twice rather than once per season. Because perennial weeds like common milkweed that regenerate from roots are more effectively killed by "repeat treatments" of glyphosate than by just one treatment (Monsanto 2009, 15.0), increased application frequency is another factor in common milkweed's disappearance from cropland.

Over three decades ago, weed scientists in Nebraska recommended glyphosate to control common milkweed, but noted that production practices to decrease common milkweed must be continued over a number of years to have a significant impact on the plant (Cramer and Burnside 1981). Roundup Ready crops have greatly facilitated continual use of such milkweed-killing practices. From the late 1990s to early 2000s, most farmers grew only Roundup Ready (RR) soybeans (*see* Figure 20A). Because most soybeans are rotated (grown in alternating years) with corn (USDA ERS 2012), any milkweed that survived glyphosate spraying in Roundup Ready soybeans had a chance to recover in the non-Roundup Ready corn year. That opportunity to recover was lost as Roundup Ready corn adoption rose after the mid-2000s (*see* Figure 20B), and common milkweed was increasingly exposed to glyphosate every year in now ubiquitous Roundup Ready corn/Roundup Ready soybean rotations.

Roundup Ready crops have not only increased the extent, intensity, and frequency of glyphosate use, they have also shifted the application period later into the growing season, when milkweed is more susceptible to glyphosate (Loux et al. 2001). When used with traditional corn and soybeans, glyphosate is usually applied pre-emergence, around planting time, in order to avoid injuring the growing crop. In Iowa, this corresponds to late April to mid-May for corn, and the month of May for soybeans (USDA NASS 2010). This early-season use occurs predominantly before milkweed's reproductive phase (formation of buds and flowering), which in the Midwest occurs from the latter part of May to mid-July (Sauer and Feir 1974, Martin and Burnside 1977/1984). In contrast, Roundup Ready soybeans are sprayed once or twice, two to eight weeks after planting (Monsanto 2009, 12.0, 12.7, 12.8). Roundup Ready corn is typically sprayed once or twice, two to six weeks after planting (Johnson and Leer 2006, Monsanto 2009, Section 12.0). These later application periods coincide with common milkweed's reproductive phase, when it is more vulnerable to glyphosate's killing effects (Bhowmik 1982, Martin and Burnside 1977/1984).

In sum, the limited and early-season use of glyphosate with traditional crops had little effect on common milkweed populations. As used with Roundup Ready crops, however, glyphosate has nearly eliminated milkweeds from cropland throughout the monarch's Midwest breeding range.

The loss of milkweed habitat in recent decades has been dramatic. In 1980, common milkweed was found on at least 26 million acres of land in the 13 north central states (Cramer and Burnside 1980). The two crops harboring the most milkweed were corn (12 million acres) and soybeans (6 million acres), although given the common practice of rotating these two crops the difference in reported acreage may not be very significant. Milkweed was also found to a much lesser extent in small grains, pastures, roadsides and sorghum (Bhowmik 1994). Iowa, Nebraska and Wisconsin had the most land occupied by milkweed (Cramer and Burnside 1980). Common milkweed continued to be a common inhabitant of Midwestern cropland throughout the 1980s and 1990s in Iowa (Hartzler and Buhler 2000), Minnesota and Wisconsin (Oberhauser et al. 2001), southwestern Ontario (Frick and Thomas 1992), and other areas. Milkweed acreage was expanding into the late 1990s in parts of North Dakota (Zollinger 1998), Wisconsin (Doll 1998), and likely other states. Despite its wide distribution, however, common milkweed was far less prevalent than many more agriculturally significant weeds even before the Roundup Ready crop era, and for the most part was not problematic for farmers (Doll 2001, Hartzler 2010).

Common milkweed's success in 20th century corn and soybean fields is attributable in large part to its tolerance to commonly used herbicides of the period (Martin and Burnside 1977/1984). While these non-glyphosate herbicides wither milkweed leaves, the plant usually recovers in two to three weeks by sprouting new branches from leaf axils and new stems from the perennial root; in contrast, with glyphosate treatment most plants do not recover (Pleasants in press).

Iowa is the state where common milkweed was once most abundant, occupying more than five million acres in 1980 (Cramer and Burnside 1980). In 1999 and again in 2009, Iowa State University scientists conducted surveys that established the prevalence and distribution of common milkweed in both crop fields and other land types throughout the state (n = 859 fields in 1999, n = 432 fields in 2009) (Hartzler and Buhler 2000, Hartzler 2010). In 1999, common milkweed was detected in half (51 percent) of Iowa corn and soybean fields, but by 2009 it was detected in just eight percent of fields, a more than six-fold reduction. In addition, the average milkweed density in fields where it was present declined by nearly five-fold, from 23 to just five square meters per hectare. The declining number of fields with milkweed, and the reduced density where it was found, translate to a 96.5 percent decline in milkweed in Iowa corn and soybean fields from 1999 to 2009 (based on Hartzler and Buhler 2000, Hartzler 2010, *see* Figure 21).

These survey results are corroborated by a second, more limited survey conducted by entomologist John Pleasants in Iowa from 2000 to 2008 (Pleasants and Oberhauser 2012). Pleasants charted declining milkweed populations in seven fields surveyed over a nine-year period. Of roughly 1,000 milkweed stems counted in 2000, none remained by 2009 (Pleasants in press) (Figure 21). Milkweed loss has continued since 2009, and it is estimated that Iowa cropland lost 98.7 percent of its milkweed from 1999 to 2012 (Pleasants in press).

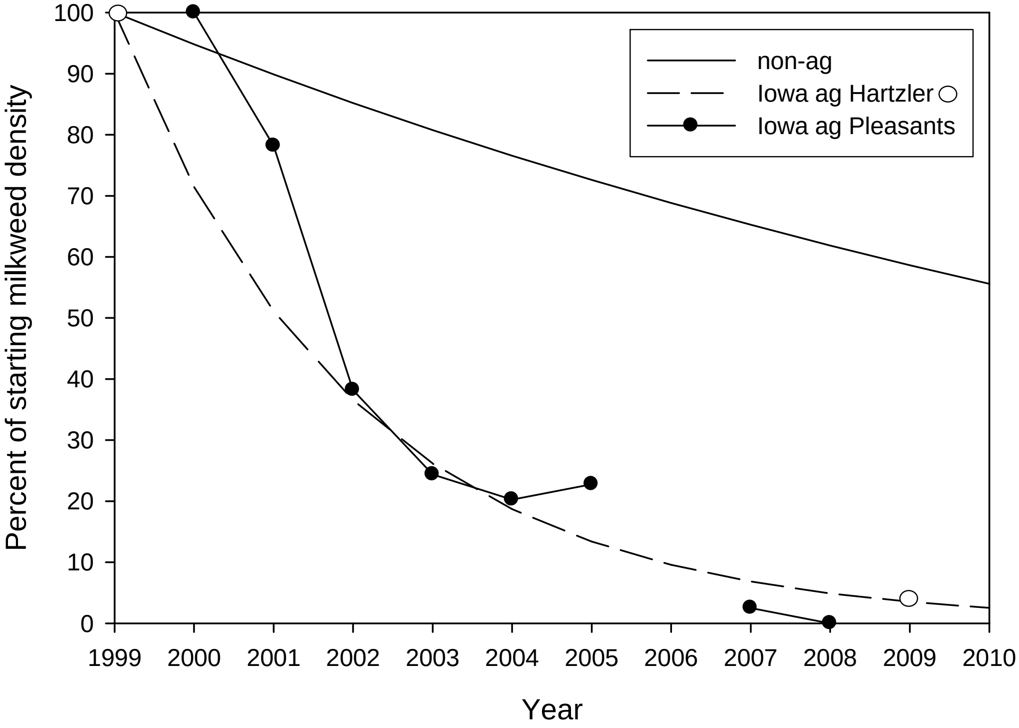


Figure 21. Change in milkweed density in Iowa: agricultural and non-agricultural habitats (updated from Pleasants and Oberhauser 2012, Figure 1, supplied by authors).

Data from Minnesota also indicate widespread milkweed decline. Extensive milkweed surveys were conducted from 2003 to 2005 in Minnesota crop fields (Koch 2005). The survey covered 72 Minnesota counties with appreciable acreage planted to corn and soybeans, with an average of six to seven fields surveyed per county. Each year 453 fields were surveyed on average, equally divided between soybeans and corn. Averaged over the three years, milkweed was detected in just 3.4 percent of surveyed fields, and those fields harbored 0.084 milkweed plants/m^2. Averaged over all fields (including those with no milkweed), milkweed density came to just 30 plants per hectare. Milkweed plants were much more numerous in this area just three to five years before the Koch surveys. In the year 2000, Oberhauser et al. (2001) studied milkweed in five cornfields in east central Minnesota/west central Wisconsin, finding on average 2,850 milkweed plants per hectare, roughly two orders of magnitude (100-fold) higher than the level found in the Koch (2003-2005) surveys. Although these sites were not necessarily representative of landscape milkweed prevalence because candidate fields with less than 10 milkweed stems/ha were excluded, the authors report that the majority of sites visited during their site selection process had some milkweed (Karen Oberhauser, personal communication to Bill Freese, 3/20/14), as opposed to only 3.4 percent of fields with milkweed in the 2003-2005 Minnesota surveys. Dr. Oberhauser reported that the study fields in 2000 had never been planted with herbicide-resistant soybeans or corn, and attributed the drop in milkweed numbers by 2003-2005 to the widespread planting of genetically engineered, glyphosate-resistant soybeans and corn (personal communication to Bill Freese, 3/20/14, Pleasants and Oberhauser 2012).

The Iowa and Minnesota surveys exemplify the broader picture of milkweed decline throughout the major monarch breeding grounds in the Midwest due to the similarity in land use. The entire region is dominated by corn and soybean fields (Figure 22), the vast majority of which are Roundup Ready varieties. Figure 20 shows that adoption trends for genetically engineered, herbicide-resistant corn and soybeans (nearly all Roundup Ready) are quite similar in the 12 Midwestern states, with 89 to 97 percent of soybeans, and 81 to 94 percent of corn, herbicide-resistant by 2013. Anecdotal evidence reported by farmers and scientists of common milkweed's absence from or rarity in crop fields in Nebraska, Kansas, Michigan and North Dakota—all states where it was once quite prevalent—provide further corroboration of the near eradication of milkweed from cropland by glyphosate use with Roundup Ready crops (Center for Food Safety 2014a).

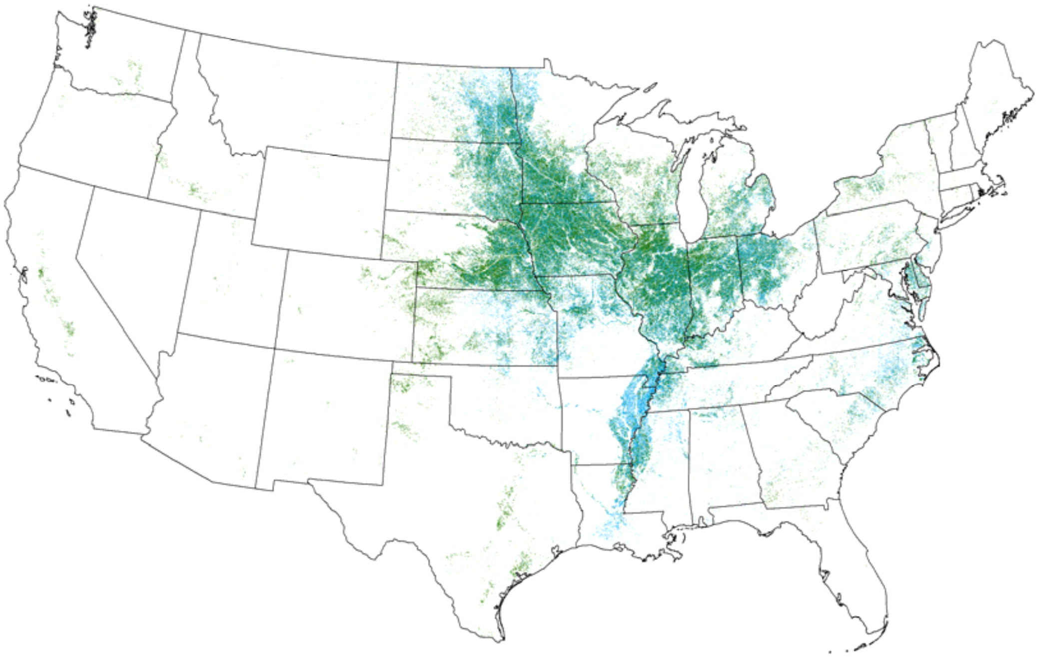


Figure 22. Corn and soybean production in the United States 2013. Source: USDA CropScape (2013). Green represents corn, blue represents soybeans. Depth of color signifies intensity of cultivation.

The extensive loss of milkweed from croplands has contributed significantly to the dramatic decline in monarch abundance since the mid-1990s. Common milkweed in crop fields is of particular importance to monarchs because it produces considerably more monarchs per plant than milkweeds growing elsewhere. Oberhauser et al. (2001) analyzed milkweed distribution and per-plant monarch productivity and found that in Iowa, Minnesota, and Wisconsin, the number of eggs deposited per milkweed plant was higher on milkweeds in corn fields than on milkweeds in old fields, pastures and field edges. Pleasants and Oberhauser (2012) extended this analysis over four years (2000-2003) in Iowa, and found that per-plant egg density on milkweed was on average 3.89 times greater when growing in corn and soybean fields versus non-agricultural habitats. Survival of eggs to adulthood was similar between habitats.

In just the 13 years from 1999 to 2012, it is estimated there was a 64 percent decline in overall milkweed in the Midwest, most of which was from croplands (Pleasants in press). However, because cropland milkweed produces nearly four times as many monarchs as plants in other settings, their loss has a disproportionate impact on monarch numbers. Pleasants (in press) estimates that in 2012, the Midwest produced 88 percent fewer monarchs than it did in 1999.

Loss of Western Monarch Habitat Due to Glyphosate

Glyphosate is also heavily used in the western portion of the monarch's range, and may be degrading habitat there as well. In 2012 in California, glyphosate was among the top five pesticides (and the top herbicide) in terms of amount used (California Department of Pesticide Regulation 2014, p. 15), and the leading pesticide as measured by cumulative acres treated (California Department of Pesticide Regulation 2014, pp. 66-67; Figure 11, p. 70). In addition to almonds and wine grapes, leading crops treated with glyphosate include cotton and alfalfa. Glyphosate accounts for 74 percent of total pounds of herbicides applied to cotton "due to the large acreage of Roundup Ready cotton," and its use is rising on alfalfa "because of increased planting of Roundup Ready alfalfa" (California Department of Pesticide Regulation 2014, pp. 85, 89). Genetically engineered, herbicide-resistant cotton rose from 21 percent to 68 percent of total California cotton acres from 2000 to 2013 (USDA ERS 2014b). Heavy use of glyphosate in California, a state with extensive agriculture production, threatens the multiple species of milkweed that provide habitat in California, and thus monarch reproduction and survival west of the Rockies.

Loss of Monarch Habitat Due to Agricultural Intensification to Produce Biofuels

The 88 percent decline in Midwest monarch production discussed above means that the Midwest produces only 12 percent as many monarchs as it did in 1999. This dramatic decline is driven primarily by loss of milkweed in cropland, which is being lost at the astonishing rate of nearly 50 percent every two years (Figure 21, based on data supplied by John Pleasants). Without conservation and restoration efforts, common milkweed will for all practical purposes disappear from the largely Roundup Ready corn and soybean fields that dominate the Midwest landscape (Pleasants and Oberhauser 2012). Moreover, monarch habitat outside of crop fields is also being rapidly degraded.

The majority of remaining Midwest monarch habitat is today found on lands enrolled in the Conservation Reserve Program (CRP). The CRP is a program administered by the U.S. Department of Agriculture that compensates farmers for taking environmentally sensitive land out of crop production for 10-15 year periods and instead planting species (usually grasses) that improve environmental quality by reducing soil erosion, providing wildlife habitat and improving water quality (USDA Farm Service Agency 2014). Because of the precipitous decline in milkweed in cropland, CRP lands that contributed only 16 percent of Midwest monarchs in

1999 accounted for 56 percent of the much-reduced population remaining in 2012 (based on data supplied by John Pleasants).

Conversion of CRP acreage to corn and soybean production is being driven by federal biofuels policy. The 2005 Energy Policy Act and the 2007 Energy Independence and Security Act established subsidies and quotas for biofuels production, chiefly ethanol from corn. These incentives drove construction of new ethanol plants, increased demand for corn, sharply rising corn prices, and huge increases in corn acreage (USDA ERS Corn 2014). The share of the U.S. corn harvest processed for ethanol rose from 6 percent in the year 2000 and 14 percent in 2005 to 43 percent in the drought year 2012, and a still substantial 36 percent in 2013 (USDA ERS Feed Grains 2014). To meet this increased demand, corn acreage has increased by 17 million acres since 2006 (USDA NASS 2014).

While some of this increased corn acreage has come at the expense of other crops (Wallander 2011), a substantial portion has come from the CRP. Enticed by the greater profitability of corn versus CRP payments, farmers have responded to the ethanol-driven "corn rush" by taking their land out of the CRP to grow corn (Love 2012, Cappiello and Apuzzo 2013). These land conversions are reflected in CRP enrollment figures. Nationally, CRP acreage has shrunk by 11.2 million acres (30 percent) since 2007 (USDA FAS CRP 2014). Over half of this decline has taken place in the twelve Midwest states, which have lost 6.2 million CRP acres (Figure 23). Wright and Wimberly (2013) estimate that 1.3 million acres of grassland in the western Corn Belt (much of it CRP land) was converted to corn and soybean production from 2006 to 2011. CRP acreage has declined substantially since 2011 (Figure 23), suggesting a continuation of this disturbing trend.

CRP lands will continue to shrink in the future. In the 2014 Farm Bill, Congress sharply reduced the maximum acreage that can be enrolled in the program. This "CRP cap," which stood at 39.2 million acres from 2002 to 2009, will decline by 39 percent to just 24 million acres by 2017 and 2018 (National Sustainable Agriculture Coalition undated, National Council of Farmer Cooperatives 2014), ensuring that each year progressively more of monarchs' most important breeding habitat will be converted to corn and soybean fields stripped of common milkweed by use of glyphosate and other herbicides.

CRP land is the major remaining habitat for Midwest monarchs, and conversion to corn and soybeans that are engineered to be resistant to glyphosate (and other herbicides, *see* next section) will continue to drive monarch population decline in the core of the species' range.

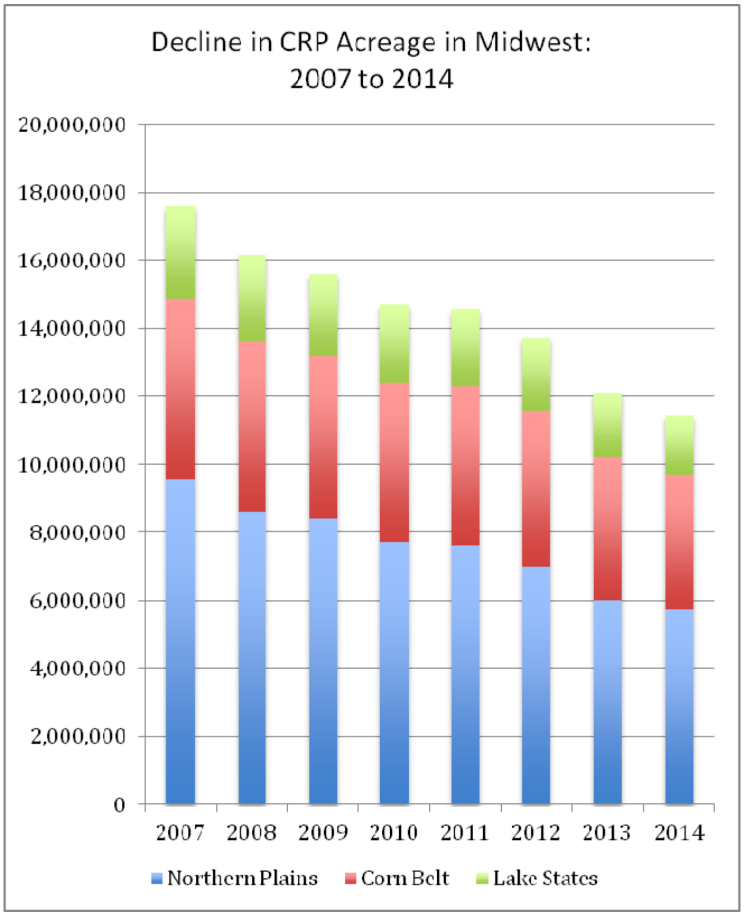


Figure 23. Decline in Acreage Enrolled in Conservation Reserve Program: 2007-2014. Source: USDA FAS CRP (2014). Midwest here defined as the 12 states of the Corn Belt (IA, IL, IN, MO, OH), the Lake States (MI, MN, WI) and the Northern Plains (KS, NE, ND, SD).

New Herbicide-Resistant Crops Promise Further Habitat Degradation

Monarch habitat is further threatened by the imminent introduction of new herbicide-resistant crops that are genetically engineered to be resistant to multiple herbicides. These new crops pose two distinct risks: (1) continued elimination of common milkweed from cropland, and (2) reduction via herbicide drift of flowering plants that provide monarch adults with nectar.

The widespread use of glyphosate with Roundup Ready crops has spawned an epidemic of glyphosate-resistant weeds (Benbrook 2009). In the United States, 135 populations of 14 different weed species in 36 states have evolved resistance to glyphosate (International Survey of Herbicide Resistant Weeds 2014), and they infest an estimated 50-62 million acres of U.S. cropland (Benbrook 2012, Fraser 2012), an area the size of Wyoming. A recent survey found that the problem is expanding, with 49 percent of farmers reporting glyphosate-resistant weeds in 2012, up from 34 percent in 2011 (Fraser 2012).

In response, all of the major agricultural biotechnology companies have developed "next-generation" crops resistant to other herbicides that will still kill glyphosate-resistant weeds, at least for a time (Kilman 2010, Table 1). The most popular are expected to be corn, soybeans and cotton engineered by Dow AgroSciences for resistance to 2,4-D-dichlorophenoxyacetic acid (2,4-D), and the Monsanto Company's dicamba-resistant soybeans and cotton, which collectively will likely supplant a substantial portion of Roundup Ready crop acreage (Mortensen et al 2012). Genetically engineered 2,4-D-resistant corn and soybeans were recently approved by USDA, which also gave preliminary approval to the genetically engineered dicamba-resistant crops (Table 1, *see*: http://www.aphis.usda.gov/biotechnology/petitions_table_pending.shtml). Commercial introduction is expected in the next two years.

GE Herbicide-Resistant Crops Approved or Pending Approval by USDA				
Petition No.	Company	Crop	Herbicides	Status
13-262-01p	Dow	Cotton	2,4-D, glufosinate, ***glyphosate***	Pending approval
12-251-01p	Syngenta	Soybeans	HPPD inhibitors, glufosinate, ***glyphosate***	Approved 2014
12-185-01p	Monsanto	Cotton	Dicamba, glufosinate, ***glyphosate***	Pending approval
11-234-01p	Dow	Soybean	2,4-D, glufosinate, glyphosate	Approved 2014
10-188-01p	Monsanto	Soybean	Dicamba, ***glyphosate***	Preliminary approval
09-349-01p	Dow	Soybean	2,4-D, glufosinate, ***glyphosate***	Approved 2014
09-328-01p	Bayer	Soybean	Isoxaflutole, glyphosate	Approved 2013
09-233-01p	Dow	Corn	2,4-D, ACCase inhibitors, ***glyphosate***	Approved 2014
09-015-01p	BASF	Soybean	Imidazolinones	Approved 2014
07-152-01p	DuPont Pioneer	Corn	Imidazolinones, glyphosate	Approved 2009

Table 1. Partial list of genetically engineered, herbicide-resistant crops recently approved or pending approval by USDA. Source: USDA's Petitions for Determination of Nonregulated Status, http://www.aphis.usda.gov/biotechnology/petitions_table_pending.shtml, accessed August 6, 2014. Where glyphosate is bolded and italicized, the company has not genetically engineered glyphosate resistance into the GE crop for its review by USDA, but has announced plans to breed a glyphosate resistance trait into commercial cultivars to be sold to farmers.

At present, 2,4-D and dicamba are minor corn and soybean herbicides (USDA NASS 2013, 2011), and where used they are applied early in the season at relatively low rates to avoid crop injury. However the high-level resistance conferred by genetic engineering to the new crops will facilitate application of several-fold higher rates of 2,4-D and dicamba than are used at present. Applications will also be made more frequently, and later in the season, similar to the use pattern of glyphosate with Roundup Ready crops (Center for Food Safety 2012b, Center for Food Safety 2012c).

2,4-D and dicamba will not displace glyphosate where these crops are grown, for several reasons. First, the new crops will come with additional resistance to glyphosate (and in some cases still other herbicides) (Table 1). Second, glyphosate will continue to be used because it kills certain weeds (e.g. grass family and perennial weeds) more effectively than either 2,4-D or dicamba. Third, the chemical companies will market dual products specifically for use with the resistant crops: Dow's Enlist Duo (a combination of 2,4-D and glyphosate) and Monsanto's Roundup Xtend (a dicamba/glyphosate mix). Thus, Roundup Ready farmers who switch over to these next-generation seeds will be applying high rates of 2,4-D or dicamba *in addition to* glyphosate at rates currently used (Center for Food Safety 2014b, Monsanto 2012).

Herbicide efficacy trials show that application of high rates of either 2,4-D or dicamba alone cause considerable lasting damage to common milkweed, though not as much as glyphosate (Zollinger 1998). Ohio agronomists recommend either glyphosate or dicamba alone, or a mix of 2,4-D and glyphosate, to kill common milkweed (Loux et al. 2001). Thus, the application of the dual herbicide products (Enlist Duo or Roundup Xtend) to crops resistant to them will continue to eliminate what little common milkweed remains in corn and soybean fields at least as effectively as glyphosate has with Roundup Ready crops.

The second major threat posed by these new multiple herbicide-resistant crops is a reduction in flowering plant communities that supply nectar to monarch adults.

Loss of Habitat Due to Pesticide Drift

Although monarch larvae can only thrive on milkweeds, adult butterflies feed on a wide variety of nectar-producing flowers (Tooker et al. 2002). They depend on flowers that are in bloom in their breeding habitat during the spring and summer, and then along migration routes to their winter roosts (Brower and Pyle 2004, Brower et al. in press). Monarchs that are breeding during spring and summer require energy derived from nectar for flying, laying eggs, mating, and other activities. In addition, the generation that migrates in the fall depends on nectar sugars (stored in the form of fat) to sustain themselves while overwintering, and perhaps also to fuel their northern migration the following spring (Brower et al. 2006).

Herbicides, by definition, are toxic to plants, and they frequently drift beyond the boundaries of crop fields to affect wild plants growing nearby. Various models of herbicide spray drift suggest that from one percent (commonly) to 25 percent (occasionally) of the applied herbicide dose drifts beyond field boundaries to reach wild plants growing nearby (Holterman et al. 1997, Wang and Rautmann 2008, Boutin et al. 2014). Areas surrounding cropland provide most of the biodiversity in agriculture-dominated landscapes (e.g. Boutin and Jobin 1998) such as the Midwest. Herbicide drift threatens the wild plants monarchs depend upon for nectar. The imminent introduction of next-generation herbicide-resistant crops, such as those resistant to 2,4-D and dicamba, discussed above, will lead to sharply increased herbicide use, drift, and associated damage to wild plants, reducing monarch nectaring habitat.

Herbicide drift is greatly exacerbated by herbicide-resistant crops. This is demonstrated quite clearly by experience with Roundup Ready crops. Glyphosate has relatively low volatility and is not regarded as a drift-prone weed killer (Lee et al. 2005, p. 135). Nevertheless, it has become one of the top two herbicides (along with 2,4-D) implicated in herbicide drift complaints nationwide since the Roundup Ready era began (Association of American Pesticide Control Officials 1999, 2005). The high incidence of glyphosate drift injury is partly attributable to the expanded acreage and increased volume of use with Roundup Ready crops. The late application period—mid-season with Roundup Ready crops versus early season with conventional varieties—also increases the risk of drift injury. In a comprehensive study of the potential for herbicide drift to injure crops in Fresno, CA, scientists from the U.S. Environmental Protection Agency found that:

> Increased use of herbicide-resistant technology by producers creates the possibility of off-site movement onto adjacent conventional crops . . . Post-emergence application of herbicide to a genetically-modified (GM) crop often occurs when non-GM plants are in the early reproductive growth stage and are most susceptible to damage from herbicide drift (Ghosheh et al.,1994; Hurst, 1982; Snipes et al., 1991, 1992). Consequently, most drift complaints occur in spring and summer as the use of post-emergence herbicide applications increases (Lee et al. 2005, p. 15).

Glyphosate drift from Roundup Ready crops has repeatedly caused extensive damage to wheat (Baldwin 2011) and rice (Scott 2009) in Arkansas, to rice (Wagner 2011) and corn (Dodds et al. 2007) in Mississippi, to rice in Louisiana (Bennett 2008), and to tomatoes in Indiana and adjacent states (Smith 2010), to cite just a few of many examples. A search of the online farm publication Delta Farm Press using the search term “glyphosate drift” yields 127 articles (search conducted June 5, 2014, *see*: www.deltafarmpress.com). Drift episodes sometimes give rise to lawsuits, as when farmers won compensation for onions damaged by glyphosate applied to Roundup Ready soybeans in Ontario, Canada (Lockery vs. Hayter 2006).

Glyphosate drift injury can be extensive. In Mississippi, damage was reported on 30,000 to 50,000 acres of rice in 2006 (Wagner 2011). Glyphosate drift damage to wheat has prompted suggestions that it simply not be grown in Arkansas (Baldwin 2011). Tomato growers in Indiana, Michigan and Ohio suffered more than $1 million in glyphosate drift damage over four years (Smith 2010). Arkansas corn growers felt so threatened by drift that they switched to Roundup Ready varieties out of “self-defense” against glyphosate drifting from Roundup Ready soybean and cotton fields (Baldwin 2010).

The frequency of crop injury from glyphosate drift demonstrates the threat that genetically engineered, herbicide-resistant crops pose to monarch habitat. Several studies suggest that glyphosate applied to crops engineered with resistance may have already reduced the abundance and diversity of nectar plants in and around agricultural fields, from direct applications as well as spray drift (e.g. Blackburn and Boutin 2003, Gove et al. 2007). Next-generation, genetically engineered, herbicide-resistant crops will greatly exacerbate these impacts.

2,4-D and dicamba are volatile herbicides prone not only to spray drift (like glyphosate), but also vapor drift, which is much more unpredictable and difficult to control (Behrens and Lueschen 1979, Sciumbato et al. 2004). While spray drift happens only while the herbicide is being applied, vapor drift occurs when an herbicide previously deposited on plant surfaces and the ground volatilizes and moves off-site, and is favored by hot conditions and temperature inversions (Johnson and VanGressel 2012, United States Geological Survey 2003). Vapor drift helps explain why 2,4-D and dicamba, though much less heavily used than glyphosate, have been leading culprits in drift-related crop injury, with 2,4-D ranking first or second along with glyphosate (Association of American Pesticide Control Officials 1999, 2005).

Crops damaged by 2,4-D and dicamba drift, often at quite low levels, include grapes, cotton, soybeans, sunflowers, and many fruits and vegetables (Hebert 2004, Egan et al. 2014a, Doohan et al. 2014). Despite numerous restrictions on formulation types and application methods intended to mitigate drift, 2,4-D continues to cause widespread crop injury (Hebert 2004). Though damage often occurs to crops in adjacent fields, area-wide impacts are not uncommon. For instance, in 2006 volatilization of 2,4-D damaged cotton on upwards of 200,000 to 250,000 acres in five counties in Arkansas, likely due to multiple applications in the area and weather conditions that promoted vapor drift (Bennett 2006). In 2012, a single 2,4-D application damaged 15,000 acres of California cotton as well as a pomegranate orchard, with cotton damage verified as far as 100 miles from the application site (Cline 2012).

In the Canadian Prairies, 2,4-D, dicamba and other herbicides are frequently found in the air and in rain (Tuduri et al. 2006). At the high end of concentrations detected in rainfall in Alberta, Canada, a mixture of four herbicides (2,4-D, dicamba, MCPA and bromoxynil) was found to negatively impact test plants, leading the researchers to conclude that “occasional high levels of herbicides detected in rainfall in southern Alberta could harm beans and tomatoes grown in the area” (Hill et al. 2002). Extensive monitoring in Washington State has shown that 2,4-D injury to grapes occurs “from regional nonpoint sources estimated to be as far as 10 to 50 miles away, and correlates with airborne 2,4-D concentrations rather than local pesticide use” (Hebert 2004).

The frequency of such area-wide impacts, including those from regional off-target movement and “toxic rainfall,” will increase dramatically with the surge in use anticipated with the planting of resistant crops. USDA has projected that 2,4-D-resistant corn and soybeans would increase annual agricultural use of 2,4-D by three- to seven-fold: from 25.6 million pounds at present to anywhere from 77.8 to 176 million lbs./year by 2020, depending on how widely they are grown (Figure 24). Pennsylvania State University weed scientists have projected a similarly large increase in 2,4-D and dicamba applications if soybeans resistant to them are approved (Mortensen et al. 2012).

Increased drift injury will not be limited to sensitive crops, but will affect wild plants as well. 2,4-D and dicamba selectively kill broadleaf plants, and are less effective on grasses (Rasmussen 2001, US EPA 2006, Center for Food Safety 2012a). This will make them particularly injurious to butterflies, especially with frequent application over a broad area, as would occur with 2,4-D and dicamba-resistant crops. A study of pesticide effects on butterflies in agricultural areas of England showed that restricting the use of “persistent broadleaf herbicides” near field edges would result in more butterflies in the landscape. In one experiment, researchers sprayed the bulk of the field with the usual complement of pesticides, but modified the spraying apparatus such that only selective grass-killing herbicides were applied to the field edges. They found that there were indeed more butterflies after implementing this measure, and also that there were more flowering plants, “thereby increasing the availability of nectar resources for butterfly species,” as well as more biodiversity in general (Longley and Sotherton 1997, pp. 8-9).

Several new field studies in the United States—undertaken to assess the potential effects of dicamba use with dicamba-resistant crops—support the English findings. Bohnenblust (2014) found that drift-level doses of dicamba delayed flowering of alfalfa, and both delayed and reduced flowering of common boneset (*Eupatorium perfoliatum*), a wildflower that provides resources to many insect species. In addition, common boneset flowers were less visited by all pollinators when treated with dicamba at rates simulating drift.

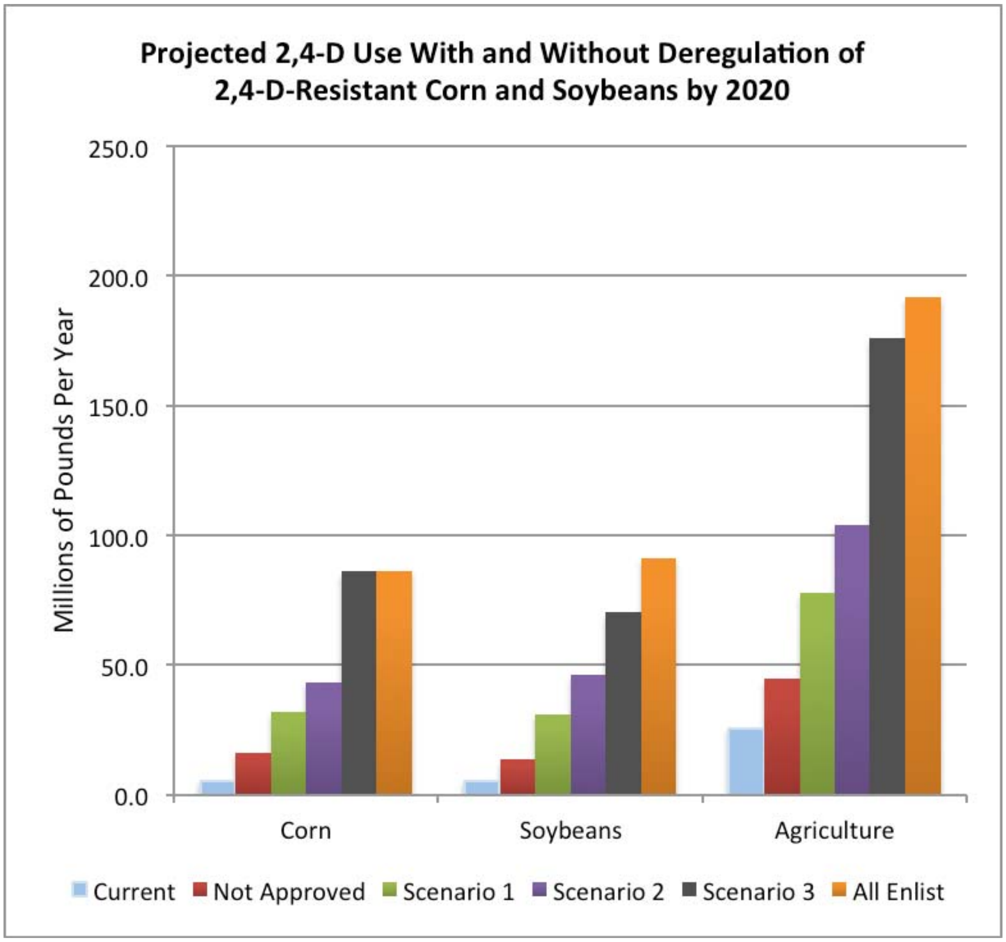


Figure 24. Projected Use of 2,4-D With and Without USDA Approval of 2,4-D-Resistant Corn and Soybeans by 2020. Source: CFS (2014a), based on projections made by Dow in USDA APHIS (2013), Appendix 4. Scenarios 1, 2, 3 and All Enlist represent 2,4-D use based on various adoption scenarios for 2,4-D-resistant corn and soybeans by 2020. Scenario 1: 30% of corn and soybean acres are 2,4-D-resistant and sprayed with 2,4-D; Scenario 2: 40.5% of corn and 45% of soybean acres are 2,4-D-resistant and sprayed with 2,4-D; Scenario 3: 80% of corn and 68% of soybean acres are 2,4-D-resistant and sprayed with 2,4-D; All Enlist: 85% of corn and 89% of soybean acres are 2,4-D-resistant and sprayed with 2,4-D (representing complete displacement of glyphosate-resistant varieties by 2,4-D-resistant corn and soybeans). *See* CFS (2014a) for more details.

A second study explored the impact of a range of drift-level dicamba doses on the plant and arthropod communities in agricultural "edge" habitats (Egan et al. 2014b). The most striking result was a significant decline in the abundance of broadleaf plants over time and with increasing dicamba dose. Impacts were observed at substantially lower levels (about one percent of the dicamba field application rate) than have been reported to affect plant communities in other studies. This study was conservative in design: dicamba alone was applied just once per year over two years. More severe impacts would be expected with longer-term use, and with the dicamba-glyphosate mix to be used with dicamba-resistant crops, which could be applied up to three times per year according to the proposed label (CFS 2012c). In general, the complementary action of glyphosate and either 2,4-D or dicamba, applied in the form of Enlist Duo or Roundup Xtend to resistant crops, would kill or injure a broader range of plants more effectively, and over a broader range of plant growth stages, than either component alone.

The implications of these studies are plain for use of dicamba and 2,4-D with crops engineered for resistance: these are herbicides that selectively kill broadleaf plants, the main nectar source for adult butterflies, including monarchs. Dicamba and 2,4-D will be used more often during a season, more extensively in an area, and more continuously over years with resistant crops than they are currently used in agriculture. This is precisely the use pattern that the studies discussed above suggest would have long-term, harmful effects on butterflies and other species. Herbicide drift thus poses a present and increasing threat to monarch habitat.

Remnant Monarch Habitat Insufficient to Sustain Monarch Populations

Remnant monarch habitats have become increasingly important, because of the overwhelming loss of milkweed from crop fields and CRP lands. Remnant habitats include pasturelands, roadsides, and field edges, though milkweeds in these habitats produce fewer monarchs per stem than milkweeds in crop fields (Oberhauser et al. 2001, Pleasants and Oberhauser 2012). All of these habitats are threatened by pesticide drift or direct application.

Pastureland represents the most abundant non-cropland habitat for milkweed, but milkweed is very sparse in pastures (Hartzler and Buhler 2000), probably because it does not compete well with long-established grasses. The already-low milkweed density in pastures in 1999 declined by half by 2012, and it is estimated that milkweeds in pastures now account for just three percent of monarch production in the Midwest breeding range (based on data supplied by John Pleasants). Pastures are also often sprayed with broadleaf herbicides (Johnson and VanGressel 2012), which kill flowering plants that provide nectar to monarch adults and may also be a factor in milkweed decline. For instance, the largest single use of 2,4-D and one of the major uses of dicamba is on pasturelands (US EPA BEAD 2012, Monsanto 2010, Table VIII-12, p. 199).

In light of milkweed loss from other areas, roadsides have become an important component of remnant monarch habitat (Flockhart et al. 2014). When crop fields had more milkweed in 1999, roadside plants accounted for only six percent of monarchs (based on Hartzler and Buhler 2000 and data supplied by John Pleasants). Because of the decimation of cropland milkweed, roadsides now produce 35 percent of Midwest monarchs, second only to CRP lands (based on data supplied by John Pleasants). Monarch habitat on roadsides is threatened by aggressive management (e.g., mowing and herbicide applications) of roadside vegetation (Commission for Environmental Cooperation 2008), and also potentially by application of road salt (Snell-Rood et al. 2014). Field edges that do not abut roads may also harbor milkweed, but increasing farm and field size has sharply reduced such fencerow habitat (Doll 1998; R. Hartzler personal communication to Martha Crouch, January 21, 2014), which becomes incorporated into cropland planted primarily to Roundup Ready corn and soybeans, where any milkweed is eliminated through glyphosate use.

In sum, the resiliency and extinction risk of monarchs is largely driven by availability of milkweed and nectar sources and appropriate weather conditions on the breeding grounds in the

Corn Belt region (Wassenaar and Hobson 1998, Oberhauser et al. 2001, Brower et al. 2012a, b; Flockhart et al. 2013, Pleasants and Oberhauser 2012). Due to the loss of common milkweed, Pleasants (in press) estimates that in 2012, the Midwest produced 88 percent fewer monarchs than it did in 1999. Increased herbicide use and drift with new herbicide-resistant crops further threatens continuing loss of milkweed for monarch larvae and loss of nectar resources for monarch adults. Remnant monarch habitat outside of croplands is also shrinking. Habitat loss in the monarch's U.S. breeding grounds threatens the monarch with extinction because of the significance of this portion of the range to the redundancy, resiliency, and representation of *Danaus plexippus plexippus* overall, as discussed further in the Significant Portion of Range section of this petition. The rapid loss of milkweed attributable to increased pesticide use and land cover changes puts the monarch at risk of extinction in the foreseeable future (Hartzler 2010, Brower et al. 2012a, b; Pleasants and Oberhauser 2012, Flockhart et al. 2014, p. 18). Extensive loss of milkweed due to increased use of glyphosate and near ubiquitous planting of Roundup Ready crops has contributed substantially to the drastic population decline of eastern monarchs of 90 percent from the twenty-year average, and glyphosate use in California has also likely contributed to the decline of western monarchs. Because monarch survival is dependent on maintaining a large population size, the relatively low remaining population size puts the species at heightened risk of extinction from global climate change, stochastic weather events, disease, predation, and other habitat-destroying activities including further loss of nectar sources from next-generation genetically engineered, herbicide-resistant crops.

Development

Monarchs are also threatened by habitat loss due to residential, industrial, commercial, and other development activities that cause conversion of habitat. Between 1982 and 2010, 43 million acres of land in the United States were newly developed, bringing the total acreage of developed land to approximately 113 million acres, a 58 percent increase in developed land over a roughly 30-year period (U.S. Department of Agriculture 2013, p. 8). Of note, more than 37 percent of developed land in the 48 conterminous states, Hawaii, Puerto Rico and the U.S. Virgin Islands was developed during the last 28 years, with every one of the 48 conterminous states, Hawaii, and the Caribbean having statistically significant increases in developed land area since 1982 (U.S. Department of Agriculture 2013, p. 8).

Development causes direct loss of monarch butterfly habitat. It threatens monarch overwintering sites in coastal California and breeding, nectaring, and roosting sites throughout the country. For example, trees required for winter roosts are uprooted to make way for housing and other urban and suburban infrastructure. Areas with milkweed are converted to lawns, covered with concrete and asphalt, and otherwise made unsuitable for breeding and nectaring. Development also contributes to increased pesticide use which can be harmful to monarchs.

More than two decades ago, a California statewide report documented the loss or destruction of 38 overwintering sites in the state, 16 of which were lost to housing developments (Sakai and Calvert 1991). Then, in the 1990s, housing developments replaced 11 additional monarch overwintering sites (Meade 1999). At present, at least three California overwintering sites are slated for housing developments (Sarina Jepsen personal observation).

Though the total area of monarch habitat that has been lost to development has not been quantified, it is certainly substantial and is a threat factor that has been noted by several authors.

Brower et al. (2012a) identify loss of breeding habitat due to land development as one of the primary factors implicated in the drastic downward trend in monarch abundance in recent years (in conjunction with other threat factors, including severe weather events and loss of milkweed due to increased herbicide use caused by the cultivation of genetically-engineered, herbicide-resistant crops) (p. 96). Flockhart et al. (2014) also identify urbanization as a contributing factor in the land-use change that is driving monarch declines (p. 4).

Development of roads causes direct loss of monarch habitat, and chemicals sprayed on roadsides can also be harmful to monarchs including herbicides. Road maintenance and other related activities may also impact the butterflies. For instance, the application of road salt to melt snow and ice during winter can affect butterflies the following summer. Road salts are applied widely during winter months. For example, in Minnesota in the metropolitan area of Minneapolis and St. Paul, approximately 300,000 tons of sodium chloride are applied to roads each winter (Snell-Rood et al. 2014, p. 1).

Sodium is important for the function of neural and muscle tissue and influences brain size and other traits, but can have varying effects at different life stages. Sodium availability is limited in most ecosystems, which likely led to the evolution of sodium cravings and sodium foraging behaviors. For example, adult male butterflies of many species engage in "puddling" to get sodium that they then transfer to females as part of mating practices (Snell-Rood et al. 2014, p. 1). Changes in sodium availability translate into physiological effects on butterflies including effects on neural and muscle tissue development.

Excessive sodium, however, appears to have detrimental impacts on monarch larvae. Snell-Rood et al. (2014) reared monarchs on milkweed collected from roadsides or milkweed collected from prairies and found that milkweeds readily take up roadside sodium which is then taken up by larvae. They found that the survival rates of monarch caterpillars were significantly lower on roadside milkweed leaves than on milkweed leaves from prairies (40.5% vs. 58.2%, $P = 0.02$). In surviving butterflies, the fitness effects of the induced physiological changes were unclear. They also reared cabbage white butterflies (*Pieris rapae*) on diets with varying levels of sodium and found that butterfly survival was significantly lower on a high-sodium artificial diet than on a medium- or low-sodium diet (high: 10.9%; medium: 34.3%; low: 41.7%; $P < 0.0001$).

Due to widespread loss of milkweed in agricultural fields attributable to increased use of herbicides resulting from near-ubiquitous planting of genetically engineered, herbicide-resistant corn and soybeans, roadside milkweeds are becoming increasingly important habitat for monarchs. Flockhart et al. (2014) estimate that roadside habitats now harbor 10 percent of all milkweeds in eastern North America (p. 16). It is estimated that in Iowa, which is representative of the monarch's Midwest breeding grounds, roadsides harbored 13 percent of milkweed in 1999, and 36 percent of milkweed in 2012 (based on data supplied by John Pleasants). Reduced caterpillar survival due to road salt could thus have significant effects on monarch populations, particularly so given the newly heightened reliance on roadside milkweed for recruitment.

Loss and Degradation of Overwintering Habitat in Mexico

The eastern monarch population primarily overwinters in oyamel (sacred) fir (*Abies religiosa*) forests in the mountains of the Trans-Mexican Volcanic Belt in Central Mexico. The high altitude forests provide the microclimatic conditions that monarchs must have to survive the winter. Loss of overwintering habitat threatens the survival of the monarch because the butterflies are limited to very specific habitat areas. Because of ecological and geographical requirements, colonies are only found in densely forested sites at high elevations (~2,900–3,300 m [9,500–10,800 ft]), and they are usually restricted to arroyos near stream headwaters located on moderately steep southwest-facing slopes (Slayback et al. 2007, p. 28). The cool temperature and moisture inside the oyamel forests maintain the butterflies in a state of reproductive diapause and allow them to conserve lipid reserves that fuel the wintering period and the spring remigration north (Brower et al. 2011, p. 28). The benefits that the dense canopy provide to monarchs have been likened to an umbrella, a blanket, and a hot-water bottle, protecting the butterflies from rain and keeping them warm enough not to freeze but cool enough that diapause is not broken which would deplete lipid reserves (Ibid.).

The monarch's overwintering habitat in Mexico is threatened by illegal and legal logging, water diversion, forest disease, and forest senescence. The habitat is also threatened by climate change and severe weather events, which are discussed further in the petition section on Other Factors Affecting the Species' Continued Existence.

The overwintering monarch colonies in Mexico were discovered in 1975 (Brower 1995). In 1980 a reserve was established for monarch protection, but exact protected locations were not specified, and logging was only restricted during winter months when monarchs were on site. A presidential decree in 1986 established the Monarch Butterfly Special Biosphere Reserve which protected five isolated areas in Mexico State and Michoacán comprising 16,110 ha, including 4,491 ha of core zone where all extractive activities were prohibited, and 11,619 ha of buffer zone where extractive activities were permitted if they were deemed sustainable.

Forest loss and degradation continued after the establishment of the 1986 reserve. The reserve did not protect all important overwintering sites, failed to compensate local landowners for imposed restrictions, offered no effective economic alternatives to subsistence uses including logging and agriculture, and angered indigenous communities who then set forest fires in protest (Solensky 2004b, p. 118, Vidal et al. 2013, p. 178). Based on aerial photographic comparisons of forest cover, between 1971 and 1999, the size of the largest patch of high quality forest was reduced by 75 percent, and 44 percent of forest patches with greater than 80 percent cover were degraded (Brower et al. 2002). The annual rate of degradation from 1971 to 1984 was 1.70 percent and increased to 2.41 percent from 1984 to 1999 (Brower et al. 2002).

In 2000 the current Monarch Butterfly Biosphere Reserve (Reserva de la Biosfera Mariposa Monarca) was established, linking the five areas from the 1986 decree and protecting 56,259 ha of forest including 13,552 ha in three core zones and 42,707 ha in two buffer zones (Vidal et al. 2013, p. 178).

Even though the habitat has been under some form of protected status since 1980, logging is known to have eliminated considerable habitat for the monarchs. On the 12 known massifs that host butterfly colonies, illegal logging has eliminated overwintering habitats on several and severely degraded habitat on others. Logging has eliminated colony areas including several on the north face of Cerro Pelon and at least three areas in Lomas de Aparacio on the southern portion of Sierra Campanario. Logging has severely degraded colony areas including the west face of Cerro Pelon and the south face of Cerro Altamirano (Brower et al. 2012a, p. 97). As recently as 2008, a small overwintering colony was documented to have been lost due to logging on the property of Crescencio Morales (Vidal et al. 2013, p. 183). Incremental logging has degraded habitat even in the two principal ecotourism colony areas, Rosario and the Sierra Chincua (Brower et al. 2012a, p. 97).

Due to increased enforcement efforts and economic support, large-scale logging has mostly been curtailed in the monarch reserve since 2007, but forest loss and degradation resulting from small-scale logging, forest diseases, water diversion, severe weather events, climate change, and edge effects continue to threaten the monarch's overwintering habitat.

Vidal et al. (2013) used aerial photographs, satellite images, and field surveys to monitor forest cover in the core zones of the Reserve from 2001 to 2012. They found that from 2001-2012, 1,254 ha were deforested (defined as areas with less than ten percent canopy cover remaining), 925 ha were degraded (defined as areas in which canopy forest decreased), and 122 ha were negatively affected by climatic conditions including winds, drought, fire, and floods (p. 180). Of the total 2,179 ha of affected area, 2,057 ha were affected by illegal logging, 1,503 ha of which were affected by large-scale logging and 554 ha of which were affected by small-scale logging. They found that Mexican authorities were effectively enforcing efforts to protect the monarch reserve, particularly from 2007 to 2012, and that together with financial support to create local alternative income generation and employment, large-scale illegal logging had decreased from 731 ha affected in 2005–2007 to none affected by large-scale logging in 2012. Small-scale logging, however, remains a present and growing concern (Vidal et al. 2013, p. 177).

Small-scale illegal logging for subsistence represents more than one-fourth of the total forest area that was lost and degraded from 2001-2012, and has severely affected the monarch core zones (Vidal et al. 2013, p. 183). Illegally logged wood is used mainly for local housing construction and firewood, and is primarily sold locally as the primary source of fuel in villages that lack electricity (Vidal et al. 2013, p. 184). As of 2010 approximately 27,000 people lived in 93 agrarian communities within the reserve's buffer zones, and more than one million people live around the reserve. The economy of the monarch butterfly region faces serious economic challenges which catalyze illegal logging as a short-term option to cope with poverty (Vidal et al. 2013, p. 184).

The monarch's winter habitat is threatened by degradation from edge effects from forest loss in the buffer zones and in surrounding habitats. The forests in the buffer zones have been, and continue to be, significantly degraded by logging, grazing, fires, and agricultural expansion. Habitat degradation in the buffer zones also harms habitat in the core zones due to edge effects and climatic effects (Vidal et al. 2013, p. 184).

Even small openings in the forest canopy can cause a lessening in temperature buffering effects that protect the microhabitat conditions monarchs require to remain at the correct temperatures for diapause. Opening of the forest canopy increases the daily temperature range at all heights in the forest, which can directly affect monarch physiology. Denser forest provides more optimal habitat than thinned forest and provides important temperature buffering effects, especially during severe weather events (Brower et al. 2011, p. 27, 42).

The integrity of the high-elevation cloud forest that supports the monarchs depends upon an extensive and dense forest structure to capture moisture (Brooks et al. 1997). Ongoing logging and canopy loss threatens to undermine the hydrological integrity of the ecosystem, which threatens the continued survival of the overwintering monarchs (Calvert et al. 1979, Slayback et al. 2007, p. 39). Small canopy openings also increase edge effects which increase the risks of wildfire, tree mortality, changes in plant and animal species, and increased human use of the land (Vidal et al. 2013, p. 8).

In addition to small-scale logging, the monarch's overwintering forest habitat is threatened by senescence and forest diseases. There has been a recent increase in the level of bark-beetle-induced tree mortality in the overwintering grounds. Several species of beetles are causing tree mortality including *Scolytus mundus* Wood, *Psuedohylesinus variegatus* [Blandford], *Pityopthorus* spp., and *Dendroctonus mexicanus* Hopkins (Steed and Willhite 2011, p. 12). Most tree mortality in the core area is in oyamel firs that have been attacked by *P. variegatus*, which was "observed in the lower bole of every examined dead and dying fir greater than 5 inches in diameter at breast height" during a recent forest health assessment (Steed and Willhite 2011, p. 3). Although only a small area has been affected, the beetle outbreak is occurring in multiple sites within the reserve. In an attempt to stop the spread of the beetle, 9,000 trees were felled in 2009 alone. It is estimated that 15 years of continued beetle population growth could decimate the fir trees in the reserve (COSEWIC 2010, p. 12).

Other disease agents are also contributing to increased levels of mortality of firs, pines, and other trees in the reserve including annosus root disease (*Heterobasidion annosum,* P-group [now *H. occidentale*]) and dwarf mistletoes (*Arceuthobium abietis-religiosae* Heil, *A. globosum* Hawksw. and Wiens) (Steed and Willhite 2011, p. 12). In field visits from 2011-2012, Vidal et al. (2013) identified 14 ha of forest that had been impacted by drought and parasitic plants (*Arceuthobium* spp. and *Psittacanthus calyculatus)* and an additional 7 ha that had been logged for disease control (p. 181). In addition to tree loss due to disease and disease-control activities, natural forest aging also threatens the reserve because monarchs typically form colonies in mature forests and as forest patches age, it is unclear whether they will be replaced (Keiman and Franco 2004).

Water diversion for human and domestic animal use may also pose a significant threat to overwintering habitat in Mexico (Commission for Environmental Cooperation 2008). At one major water source for monarchs—the Ojo de Aqua ravine on the south side of Cerro Pelón—water has been diverted so extensively that the stream is now dry for more than 1 km. Monarchs now have to fly farther distances to obtain water, which may deplete the lipid reserves needed to survive the winter and sustain the spring migration (Ibid).

As discussed in more detail in the Other Factors Affecting the Monarch's Continued Existence Section of this petition, severe weather events threaten the monarchs with direct mortality and with habitat degradation when trees fall down due to ice, wind, fire, floods, or drought. From 2009-2011, 115 hectares of forest were impacted by floods, strong winds, droughts, and fires, and 21 additional hectares were impacted by drought and parasitic plants in 2012 (Vidal et al. 2013, p. 182). From 2008 to 2011, the monarch reserve was affected by extreme drought which likely stressed the trees and made them more vulnerable to disease (Vidal et al. 2013, p. 182).

Climate change threatens to eliminate the monarch's current overwintering habitat. Oberhauser and Peterson (2003) used ecological niche modeling to identify areas suitable for overwintering monarch colonies under both current and future climate scenarios. The models predicted current monarch presence with a high degree of accuracy, and indicated that precipitation and diurnal temperature range are key environmental factors in making locations suitable for monarchs. The models predicted that future conditions are likely to become unsuitable across the entire current winter range, particularly owing to increased cool-weather precipitation that could cause increased mortality events (Oberhauser and Peterson 2003, p. 14063).

Saenz-Romero et al. (2012) likewise found that the forests which currently support monarchs are likely to become unsuitable habitat by the end of this century in the face of global climate change. They projected the contemporary climate niche into future climates provided by three General Circulation Models and found that the area occupied by the current climate niche will diminish rapidly in the next one hundred years. The models predicted a decrease in suitable climatic habitat conditions of 69.2 percent by the decade surrounding 2030, a decrease of 87.6 percent for the decade surrounding 2060, and a decrease of 96.5 percent for the decade surrounding 2090. Direly, "the projections show that by the end of the century, suitable habitat for the monarch butterfly may no longer occur inside the [Monarch] Biosphere Reserve" (Saenz-Romero et al. 2012, p. 98). Thus appropriate habitat for overwintering monarchs could be eradicated entirely within the century because the forests outside the reserve have largely been lost and degraded.

Loss and Degradation of Overwintering Habitat in California

In the western United States, hundreds of thousands of monarchs coalesce every fall at forested groves along the Pacific Coast. Monarchs generally begin to arrive to the California coast in mid-October (Hill et al. 1976) but may arrive as early as September (Leong 1990). These groves have historically been distributed as far north as Mendocino County, and south into Baja California, although the monarch's overwintering range has contracted in recent years (Griffiths and Villablanca unpublished data), and monarchs are rarely found overwintering in the far northern and southern extremes of their overwintering range. Similar to the monarchs that overwinter in Mexico, monarchs return to many of the same locations in California year after year. There are 458 distinct locations where overwintering monarchs have clustered, although currently only about 30 sites host more 1,000 monarchs annually (Xerces Monarch Overwintering Database 2014).

Historically, the composition of vegetation on the California coast differed from the contemporary composition, and groves of native trees presumably hosted dense monarch aggregations in the past (Lane 1984, 1993). At present, most overwintering sites in California are dominated by nonnative blue gum (*Eucalyptus globulus*) or red river gum (*E. camaldulensis*), although many sites also contain native trees such as Monterey pine (*Pinus radiata*), Monterey cypress (*Cupressus macrocarpa*), western sycamore (*Platanus racemosa*), coast redwood

(*Sequoia sempervirens*), coast live oak (*Quercus agrifolia*), and other native tree species (Xerces Monarch Overwintering Database 2014).

The mild environmental conditions at forested groves along the California coast provide the microclimate that monarchs require to survive the winter in western North America. The majority of these sites are at low elevations (below 200-300 feet), within 1.5 miles (about 2.37 km) from the Pacific Ocean or San Francisco Bay (Leong et al. 2004), where these water bodies moderate temperature fluctuations (Chaplin and Wells 1982), and in shallow canyons or gullies (Lane 1993). Many groves occur on slopes that are oriented to the south, southwest, or west, which likely offers the most favorable solar radiation exposure and wind shelter (Leong et al. 2004).

The suitability of habitat for overwintering monarchs is likely also influenced by landscape- and site-level characteristics that create very specific environmental conditions. These conditions include: protection from winds and storms, absence of freezing temperatures, exposure to dappled sunlight, high humidity, and access to nectar and water (Chaplin and Wells 1982, Calvert et al. 1983, Anderson and Brower 1996, Masters et al. 1988, Leong 1999). Monarch habitat includes the cluster trees that monarchs roost on as well as surrounding trees (Leong 1989, Leong et al. 1991). Fall or winter blooming flowers that provide monarchs with nectar are likely important in maintaining the lipid reserves required for the spring migration (Tuskes and Brower 1978).

Pyle and Monroe (2004) suggest that the most vulnerable element of the monarch annual cycle is the overwintering stage. Monarch overwintering habitat in California is directly threatened by urban development, and to a lesser extent, agricultural development. Habitat alterations, such as tree trimming or tree removal, and natural factors such as fire, severe storms, or disease or senescence of trees, can alter the structure and microclimate of an overwintering site and reduce its suitability for monarchs (Sakai and Calvert 1991, Commission for Environmental Cooperation 2008).

More than two decades ago, a statewide report documented the loss or destruction of 38 overwintering sites, 16 of which were lost to housing developments (Sakai and Calvert 1991). Eleven of these sites were lost in the period from 1985 to 1991; the remaining 27 sites were lost prior to 1985 (Sakai and Calvert 1991). In the 1990s, housing developments replaced 11 additional monarch overwintering sites (Meade 1999). The Xerces Society Database currently lists 62 sites that have likely been made unsuitable for monarchs, but many of those localities need to be monitored to determine whether monarchs have returned and assess the condition of the habitat. At present, at least three California overwintering sites are slated for housing developments (Sarina Jepsen personal observation). Anecdotal reports suggest that overwintering sites have been lost due to tree cutting or trimming (Sakai and Calvert 1991), or that the monarch population has declined after tree trimming, although this assertion can be difficult to demonstrate (*see* discussion in Villablanca 2010).

Most western overwintering sites are dominated by *Eucalyptus*, which are exotic invasive species that were introduced to California from Australia in 1853 (Butterfield 1935), and have been shown to reduce biodiversity (Bossard et al. 2000). *Eucalyptus* removal is a restoration goal for some natural areas (International Environmental Law Project and Xerces Society 2012), and conflicts can emerge between monarch habitat conservation and *Eucalyptus* removal. However, recent research suggests that monarchs do not prefer *Eucalyptus* trees. They use native tree species more than would be expected, given the low density of native trees relative to *Eucalyptus* in many overwintering groves (Griffiths 2012).

Many monarch overwintering sites contain aging or diseased trees. For example, Monterey pine is affected by pitch canker (*Fusarium circinatum),* a fungus that causes swollen lesions that girdle branches, trunks, and exposed roots. The disease was first observed in California in Santa Cruz County in 1986 and has since spread to 18 coastal counties (Winkler et al. 2003). As aging or diseased trees lose limbs or die, sites can become less suitable for monarchs and pose a public safety hazard. In 2004, a limb from a diseased tree within the Pacific Grove monarch sanctuary fell on a visitor and killed her. Her family subsequently sued the city and was awarded a settlement of $1 million (Chawkins 2010). To ameliorate safety hazards, land managers prune aging or diseased trees, yet the removal of tree limbs may result in microclimatic changes that make a site unsuitable for overwintering monarchs.

In sum, development, tree senescence, vegetation management activities, and severe weather events pose ongoing threats to monarch habitat in California.

FACTOR TWO: OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC, OR EDUCATIONAL PURPOSES

Risks associated with overutilization may pose a threat to the monarch, especially in light of recent dramatic population declines and in conjunction with the many other threats facing monarchs such as habitat loss and degradation and other factors.

Monarchs are reared in captivity and sold commercially for entertainment and educational purposes, such as for live releases at events including weddings, graduations, and funerals. Monarch adults and caterpillars are readily available for purchase on the internet and from catalogues. Monarchs are also sold in kits as “pets.”

Capture, sell, transport, and release of monarchs can threaten the wellbeing of wild monarch populations in several ways, as illustrated by several monarch scientists and other lepidopterists (Brower et al. 1995, Altizer et al. 2014, Young-Isebrand et al. 2015).

Releasing commercially-bred monarchs outside, where they can interact with wild monarchs, poses the following risks to wild monarchs: disease transmission, loss of genetic diversity, and introduction of deleterious genetic adaptations. Given that millions of monarchs are likely released each year, there is a significant opportunity for captive-bred and wild monarchs to interact.

Release of captive-bred butterflies can also interfere with studies of the distribution and movement of wild butterflies which are essential to understanding their conservation needs, and increasingly important in light of climate change. Harvesting wild monarchs, a common practice of the commercial butterfly industry to attempt to sustain the genetic diversity within commercial populations, also has the potential to exacerbate population decline.

Monarchs are very susceptible to diseases that can be transmitted among larvae, and mass production of monarchs facilitates disease transmission. Release of infected monarchs into the environment could threaten wild monarchs with increased exposure and infection (Altizer and de Roode 2010, p. 25). There are currently no requirements that butterfly breeders follow specific disease-prevention protocols, or that outside agencies conduct routine tests of captive stocks for diseases. Commercially-reared monarchs can be heavily infested with the parasite *Ophyrocystis elektroscirrha* (OE) (*see*: http://www.learner.org/jnorth/tm/monarch/conservation_action_release.html), discussed in the Disease section of this petition, below. Monarchs reared in captivity can also carry other pathogens including *Serratia*, *Nosema* and cytoplasmic viruses (Ibid.). A recent increase in disease in laboratory monarchs since 2004 coincides with an increase in the release of commercially-bred monarchs (Ibid). The spread of disease from captive-reared monarchs has high potential to negatively impact wild monarch populations, as has occurred with native bee species (Pyle et al. 2012).

The levels of genetic diversity among commercially-reared monarchs are not known or regulated, and the release of large numbers of captive monarchs with low genetic diversity threatens wild populations with deleterious effects such as inbreeding depression. It could also contribute to the accumulation of deleterious genetic adaptations due to the accumulation of alleles in captivity that are mal-adaptive in the wild, as has been observed with hatchery salmon These deleterious adaptations can accumulate rapidly and can contribute to reduced survivorship of wild monarchs (Frankham 2008).

The potential for captive-reared monarchs to transmit disease or undesirable genetic traits is high because of the vast number of commercially reared monarchs compared to wild monarchs. Though the exact number of monarchs sold commercially is unknown, there are an estimated 45 –60 butterfly farms in operation in the United States that distribute more than 11 million butterflies per year, most of which are monarchs or painted ladies (*Vanessa cardui*) (Altizer and de Roode 2010, p. 26; Pyle et al. 2012). Thus, it is likely that at least a few million monarchs are released into the wild annually, representing a substantial proportion of the overall monarch population (33.5 million wild monarchs estimated in the overwintering eastern population in 2013-2014, and less than half a million total western monarchs). A recent investigative report on this industry suggests that the commercial monarch industry is rapidly growing, in part due to the increasing popularity of releasing monarchs at weddings (Federman 2008).

Overutilization via tourism activities should also be considered as a potential threat to monarch populations. Tourists gather annually to view monarch wintering colonies. While these activities have educational benefits, if conducted inappropriately they could also be harmful to monarch colonies. Ecotourism is a significant source of income for people living in and around the Monarch Butterfly Biosphere Reserve in Mexico (Vidal et al. 2013). From 2002 to 2013 visitation numbers at monarch colonies in Mexico ranged from 54,500 to 133,000 people (Vidal et al. 2013, p. 184). To ensure the long-term conservation of overwintering forests in Mexico, the international community and Mexican communities and authorities must take action to address the region's pressing social and economic problems (Vidal et al. 2013, p. 184).

Monarchs are widely used in scientific research for a number of purposes including studies of predation, mimicry, toxicology and chemical defense, physiology, neuroscience, development, pathology, and ecology, among others. A large and growing body of scientific research has contributed hundreds of publications relevant to monarch life history and habitat needs, population status, and conservation. Scientific research clearly contributes to monarch conservation and permitted research activities should continue after the monarch is protected under the ESA in a manner that ensures that wild populations are not harmed by research activities and that facilitates the permitting process for scientists.

Monarchs are also popular subjects of citizen scientists, who engage in such activities as: observing and/or photographing all life stages of monarchs and milkweed and reporting these observations; censuses of eggs, larvae, and adults; collecting eggs and larvae and rearing them indoors, then releasing the adults; and collecting adults and tagging, then releasing, them. In addition to the valuable educational role that citizen science projects fulfill, many of these projects provide data that is helpful to understanding monarch conservation needs. Some of these citizen science programs include: Journey North, the Monarch Larval Monitoring Project, Monarch Alert, Correo Real, Monarchs in the Classroom, The Monarch Teacher Network, Monarch Watch, Southwest Monarch Study, the Western Monarch Thanksgiving Count, Monarchs Across Georgia, Monarch Monitoring Project, Monarch Health, and Monarchs Without Borders. Should the Fish and Wildlife Service list the monarch butterfly as a threatened species under the ESA, the agency should recognize the valuable role that citizen scientists play in monarch conservation and either waive the permit requirement for citizen scientists or make the permitting process easy, so that the listing will not hinder these activities.

Children often rear monarch caterpillars at home. Petitioners request that upon listing, the Service develop guidance such that any take associated with rearing of up to ten wild monarchs per year by any person not engaged in commercial activity is not prohibited or subject to permitting requirements.

See Appendix B of this petition for proposed rules to facilitate monarch butterfly conservation, science, citizen monitoring, and education.

FACTOR THREE: DISEASE OR PREDATION

Disease and predation are significant sources of mortality for monarchs. In light of recent population declines and the major threats facing monarch habitat, either predation or disease or both could quickly rise to population-level threats putting the monarch butterfly at risk of extinction.

Disease

Monarchs are threatened by disease, and this threat factor is magnified by habitat loss, reduced population size, global climate change, and release of captive-reared monarchs. Numerous pathogens infect monarchs including viruses, bacteria, and protozoan parasites. Common monarch infectious agents include *Pseudomonas* bacteria, a nuclear polyhedrosis virus, the protozoan parasite *Ophryocystis elektroscirrha* (OE), and a microsporidian *Nosema* species (McLaughlin and Myers 2007).

The protozoan parasite *O. elektroscirrha* has been relatively well studied and has significant lethal and sub-lethal effects on monarch populations. Monarchs that are infected with this parasite have reduced flight ability and reduced longevity (Altizer and de Roode 2010, p. 23). Female butterflies appear to be more susceptible to OE infection than males. In general, female butterflies exhibit higher infection intensities (de Roode et al. 2008) and greater reductions in body size due to infection than males (de Roode et al. 2007) (Davis and Rendon-Salinas 2010, p. 47), though on the Hawaiian Islands, Pierce et al. (2014) found that 49 percent of males were infected, but only 44 percent of females were infected (p. 7).

The OE parasite has become so prevalent that it may be responsible for the increasingly skewed sex ratio of monarchs with declining proportions of females. An analysis of 30 years of monarch population data reveals that between 1976 and 1985, 53 percent of overwintering monarchs in Mexico were female, but since the year 2000, the proportion of females has declined to 43 percent (Davis and Rendon-Salinas 2010). The proportion of females in the fall migration has also declined (Ibid., p. 45). Declining proportion of females is of conservation concern and could have serious ramifications for population growth and recovery.

The recent drastic reduction in the availability of milkweed in agricultural fields exacerbates the threat posed to monarchs by OE infection. OE spores can persist for years and accumulate in the environment as they are spread in milkweed patches by male and female adult butterflies (Zalucki 1993, de Roode et al. 2009). Ingestion of a single OE spore can cause heavy infections in adult butterflies (de Roode et al. 2007). Because of OE's environmental persistence, its high capacity to be spread by adult butterflies, and the low exposure rate needed for infection, there is high potential for rapid increases in infection among monarchs that use the same milkweed patches in multiple overlapping generations (Bartel et al. 2011, p. 345). Reduced availability of milkweed will push monarchs into smaller habitat patches and thus increase their infection risk.

Non-migrating monarchs can suffer especially high rates of infection. Along the Gulf and southern Atlantic coasts, monarchs are subject to very high rates of disease prevalence and reductions in overall population health due to their dependence on patches of tropical milkweeds that produce vegetation year-round (Bartel et al. 2011, p. 349). On the Hawaiian archipelago, Pierce et al. (2014) found that on average, 35.5 percent of monarchs across islands were heavily infected with OE across all study sites and years. They found high variation in prevalence both within and among islands, with the average proportion of heavily infected monarchs per site per year ranging from as low as zero to as high as 88 percent (Pierce et al. 2014, p. 7).

Human activities are influencing parasite dynamics in monarch populations due to several factors including the loss of breeding and overwintering habitat, the release of captive-bred butterflies, and factors related to global climate change including the spread of tropical milkweed (*A. currasavica*) and increased stress due to drought and severe temperatures (Bartel et al. 2011, p. 349). Where tropical milkweed has been widely planted, especially in the southern United States and California, monarchs are able to breed through the winter. These year round patches of tropical milkweed facilitate increased transmission of OE (Monarch Joint Venture 2014, *see*: http://monarchjointventure.org/images/uploads/documents/Oe_fact_sheet.pdf).

Overall, climate change will have serious ramifications for disease in monarchs. Global climate change will influence butterfly diseases by affecting pathogen development, survival rates of parasites and hosts, processes of disease transmission, and stress and host susceptibility. Increasingly warm winters in North America will prevent the die-off of pathogens that would otherwise be killed by cold weather. Warmer temperatures and reduced seasonality will likely lead to increased pathogen survival and transmission (Altizer and de Roode 2010, p. 25).

Modification and curtailment of habitat and range will crowd monarchs into smaller habitat patches, increasing the risk of disease transmission, and also increasing competition and exposure to pesticides and other environmental stressors that will heighten the susceptibility of monarchs to infection (Altizer and de Roode 2010, p. 25).

In sum, increasingly small population size, less habitat availability, and high magnitude ongoing threats to monarch habitat make disease a very real threat to the persistence of monarch butterflies, and one that could increase rapidly in synergy with other threat factors.

Predation

Though monarchs are important in the food web and predation occurs naturally, monarchs are increasingly threatened by predation due to declining populations and reduced habitat. The protective chemicals monarchs obtain from milkweeds provide some defense against predation, but monarchs have many natural predators, some of whom are capable of consuming large numbers of eggs, caterpillars, and butterflies. Predators exhibit differing levels of sensitivity to monarch toxins.

Avian predation of monarch adults at overwintering sites has been reported in Mexico and in California (Tuskes and Brower 1978, Sakai 1994) and can result in very high levels of mortality. At overwintering sites in Mexico, birds including black-backed orioles (*Icterus abeillei*) and black-headed grosbeaks (*Pheucticus melanocephalus*) consume very large numbers of monarchs (Fink and Brower 1981). These two species in particular are capable of circumventing the monarch’s chemical defense by avoiding eating the cuticle and/or by taking a recovery period after accumulating large amounts of cardenolides (Arellano et al. 1993, p. 315). Grosbeaks detach and consume the monarch’s abdomen, and orioles strip out the abdominal contents and thoracic muscles (Arellano et al. 1993, p. 316). Brower and Calvert (1985) reported that orioles and grosbeaks consumed more than 2 million monarchs over the course of the winter at a 2.25 hectare colony in Sierra Chincua, Mexico. Estimates of bird mortality at winter colonies range from 9 to 44 percent (Arellano et al. 1993, p. 315). Also, Calvert et al. (1979) found that the smaller the colonies, the greater was the percent bird predation. During especially cold winters, birds consume even more butterflies than in moderate years (Arellano et al. 1993). While predation is a natural phenomenon, high levels of predation such as those reported in overwintering colonies are of increasing concern given recent dramatic population declines and shrinking availability of forest habitat due to illegal logging, climate change, and forest diseases.

Mice also kill large numbers of wintering monarchs. Mice are estimated to kill about 5 percent of butterflies in a given overwintering colony (Brower et al. 1985, Glendinning et al. 1988). One species in particular, the black-eared mouse (*Peromyscus melanotis*), preys extensively on monarchs, establishing residency inside monarch colonies, and feeding on live, moribund, and recently dead monarchs on the forest floor (Glendinning 1993, p. 324). In cold conditions, monarchs fall to the ground at night, and though some re-animate once the sun rises, those that have fallen to the ground are exceedingly vulnerable to predation. Overwintering adults are also subject to predation from wasps (Leong et al. 1990). Monarchs are susceptible to very high levels of predation when they are clustered during the winter, but adults also face a number of predators during migration and the breeding season including birds, wasps, spiders, mantids, and dragonflies (Smithers 1973, White and Sexton 1989, in Prysby 2004, p. 27).

Monarch caterpillars and eggs are also subject to extremely high levels of both predation and parasitism. A large suite of invertebrate predators including ants, spiders, crab spiders, and wasps prey on developing monarch larvae, and several species of flies and wasps parasitize larvae. Monarch toxins do not stave off the very high levels of predation and parasitism from invertebrate natural enemies (Prysby 2004, p. 36). Only approximately 8 to 12 percent of monarch eggs and larvae survive through metamorphosis (Borkin 1982, Oberhauser et al. 2001, Prysby 2004, p. 27), indicating that a large population size is required to maintain population growth.

Twelve species of tachinid flies, and brachonid and pteromalid wasps are known to parasitize monarch caterpillars, with the tachinid fly *Lespesia archippivora* (Order Diptera) being a primary predator responsible for high rates of parasitism (Oberhauser 2012, p. 20). A single monarch pupa can host up to ten tachinid fly maggots (Altizer and de Roode 2010, p. 20). Studies of parasitism rates from tachinid flies have been reported from many regions and include mortality rates in the study area of one percent in southern Ontario, 12 percent in Wisconsin, 42 percent in Hawaii, 43 percent in Texas and Louisiana, 70 – 98 percent in central Mexico, and 100 percent in study sites in Australia (Prysby 2004, p. 28). Parasitoid flies alone comprise a very significant source of mortality for monarch caterpillars, and have been identified as a major factor regulating wild monarch populations (Altizer and de Roode 2010, p. 20). In addition to parasitoid flies, developing monarchs have numerous other predators (Prysby 2004, p. 35, Oberhauser et al. 2007, Oberhauser 2012, p. 20).

Spiders and ants have also been identified as contributing to high levels of early mortality, with ants being a significant predator during the egg stage (Lynch and Martin 1993, Prysby 2004, p. 36). Calvert (1996) reported 100 percent mortality of monarch eggs and larvae in a one-hectare Texas prairie due likely to predation from fire ants (*Solenapsis invicta* Buren, Formicidae) (p. 149).

The high rates of mortality of monarch eggs, caterpillars, and adults from predation underline the importance to the long-term survival of the species of having a very large population size, and magnify the threat posed to the long-term survival of the species of recent population declines of more than 50 percent from the 17-year average in the west and more than 90 percent from the 20-year average east of the Rockies. Monarch reproductive success is dependent on large numbers of butterflies being in the population. The threat of predation is greatly exacerbated by declining numbers of monarchs resulting from habitat loss and degradation, loss of milkweed, climate change, and other threats.

FACTOR FOUR: INADEQUACY OF EXISTING REGULATORY MECHANISMS

There are no existing regulatory mechanisms that adequately protect the monarch butterfly. This section analyzes voluntary mechanisms and existing monarch protective measures on federal, state, local, and private lands. Additionally, it reviews international monarch protection agreements and protective mechanisms established in other nations. To conduct this analysis, in the past year, petitioners sought, received, cataloged, and then evaluated both publicly available information and literally thousands of pages of documents obtained from federal and state agencies pursuant to Freedom of Information Act and similar state public records requests. Although these voluntary efforts are notable, they are not regulatory, nor are they sufficient to recover the monarch butterfly. Accordingly the lack of effective regulatory mechanisms for monarchs, in concert with the species' downward population trend, underscores the critical need to provide monarchs protection under the Act.

Voluntary Mechanisms

Numerous voluntary programs and partnerships exist that are contributing to monarch conservation, but none of these plans are regulatory mechanisms that are capable of addressing the high magnitude, range-wide threats to monarchs. Most monarch conservation measures are voluntary and are inadequate to reverse the butterfly's precipitous population decline and the range-wide threat factors driving this decline. Moreover, most of these programs lack reliable funding. Relying solely on voluntary measures to protect the monarch will delay the implementation of regulatory protection that the butterfly needs to survive and recover. Moreover, the Service cannot rely on voluntary measures to deny listing of species. Voluntary and unenforceable conservation efforts are simply *per se* insufficient as "regulatory mechanisms" under 16 U.S.C. 1533(a)(1)(d):

[T]he Secretary may not rely on plans for future actions to reduce threats and protect a species as a basis for deciding that listing is not currently warranted . . . . For the same reason that the Secretary may not rely on future actions, he should not be able to rely on unenforceable efforts. Absent some method of enforcing compliance, protection of a species can never be assured. Voluntary actions, like those planned in the future, are necessarily speculative . . . . Therefore, voluntary or future conservation efforts by a state should be given no weight in the listing decision (*Oregon Natural Resources Council v. Daley,* 6 F. Supp.2d 1139, 1154-155 (D. Or. 1998).

The existence of numerous monarch conservation plans illustrates that many entities understand the importance of monarchs and the need for urgent action to protect them. A broad array of public and private entities have undertaken voluntary monarch conservation efforts including milkweed seed production and planting activities, education and outreach efforts, tagging and monitoring, habitat creation programs, work plans, innovative collaborations, and reports. Yet monarch numbers continue to decline steeply despite the fact that many of the existing conservation plans have been in place for many years or even decades. This is not to say that the measures currently in place are insignificant, but the most significant current threats to monarchs are landscape-scale issues that can only be properly addressed by protecting the monarch under the ESA. Existing plans and piecemeal voluntary efforts simply cannot adequately address the complex and synergistic threats in the manner needed to reverse the decline of monarchs.

Federal Mechanisms

There are no existing federal mechanisms which are adequate to ensure the monarch's long-term survival and recovery. The Service is required to take into account other federal agencies' actions when considering the adequacy of existing regulatory mechanisms.

The genetically-engineered, herbicide-resistant varieties of crops that have decimated milkweed in the Midwest and hence monarch butterfly populations are approved by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). That agency regulates these genetically-engineered crops under the Plant Protection Act (PPA), 7 U.S.C. §§ 7701-7772, which provides APHIS authority to "prohibit or restrict . . . movement in interstate commerce of any plant" as necessary to prevent either "plant pest" or "noxious weed" harms. 7 U.S.C. § 7712(a). In the United States, there is no single overarching law or federal agency that oversees the products of biotechnology. There are no laws that were drafted and passed with the intent to regulate genetically engineered organisms. Instead, federal agencies apply their pre-existing legislative authorities to genetically engineered organisms in order to oversee them, laws that were never intended for that purpose, implemented by several agencies, including APHIS. The PPA's purpose is to protect not only agriculture, but also the "environment, and economy of the United States" through the "detection, control, eradication, suppression, prevention, or retardation" of these harms. 7 U.S.C. § 7701(1). Genetically engineered crops are classified as presumptive plant pests, and cannot be sold and grown commercially until approved, or deregulated, by APHIS. 7 C.F.R. 340.1, 340.2, 340.6; *Monsanto Co. v. Geertson Seed Farms*, 561 U.S. 139, 130 S. Ct. 2743, 2749-50 (2010) (explaining APHIS's regulation). Once a genetically engineered crop is approved by APHIS, the agency ceases to monitor it or regulate it in any way.

Unfortunately, APHIS's regulatory approach in applying the PPA to genetically engineered crops has been to narrowly cabin its statutory authority. As a result it has never denied a petition to deregulate a genetically engineered crop, or put restrictions on their use or planting post-commercialization. APHIS has claimed that the significant herbicide impacts of genetically engineered, herbicide resistant crop systems, despite their intertwined nature with the engineered plant (and its sole, engineered purpose) are beyond their purview. Further, in so approving some genetically engineered crops, including "Roundup Ready" crops, APHIS has claimed its approval decision is non-discretionary and thus it could not consult under the Endangered Species Act's Section 7 mandates, despite admitting that the genetically engineered, "Roundup Ready" crops might cause harm to protected species or their habitat. In summary, APHIS's regulatory approach in approving numerous genetically engineered, "Roundup Ready" crops at issue here has been wholly inadequate to protect monarch butterflies and their habitat, and instead has directly contributed to the need for their ESA listing, as shown in the section of this

Petition, Loss of Monarch Habitat in Croplands Due to Increased Use of Glyphosate With Roundup Ready Crops, *supra*.

Similarly, the U.S. Environmental Protection Agency (EPA) licenses the sale and use of the herbicides and insecticides that threaten monarch butterflies as explained *supra*. EPA regulates these pesticides under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), 7 U.S.C. § 136 *et seq*. FIFRA directs EPA to register a pesticide only upon determining that "when used in accordance with widespread and commonly recognized practice it will not generally cause unreasonable adverse effects on the environment". 7 U.S.C § 136a(c)(5)(D). Unfortunately, to date, EPA has not considered the broad suite of population-level impacts on monarch butterflies (or other insects) like those described herein as an "unreasonable adverse effect on the environment," or otherwise as a basis for denying, suspending, re-classifying, or otherwise limiting any pesticide registration approvals or use determinations, despite having the ongoing authority to take such actions.

The culmination of the FIFRA registration process is EPA's approval of a label for the pesticide, including use directions and appropriate warnings or cautions on safety and environmental risks. FIFRA, 7 U.S.C. § 136(q)(1), is explicit in requiring EPA to find a product is misbranded and may not be used if:

> (F) the labeling accompanying it does not contain directions for use which are necessary for effecting the purpose for which the product is intended and if complied with, together with any requirements imposed under section 136a(d) of this title, are adequate to protect health and the environment; [or]
> (G) the label does not contain a warning or caution statement which may be necessary and if complied with, together with any requirements imposed under section 136a(d) of this title, is adequate to protect health and the environment.

A review of the labels for the various glyphosate, neonicotinoid and other pesticides at issue here because of their harm to monarchs reveals no use directions, warnings or cautions aimed at protecting monarch butterflies.

In short, FIFRA's regulatory measures, as implemented by EPA in registering and labeling the large number of glyphosate and the other herbicidal and insecticidal products at issue, have been wholly inadequate to protect monarch butterflies. As with APHIS's actions, EPA's regulatory actions have instead directly contributed to the need for ESA listing.

Though some protective mechanisms for monarchs are in place on federal lands, including efforts of the Monarch Joint Venture (MJV) and various programs on National Wildlife Refuges, on U.S. Forest Service lands, and on National Park Service lands, none of these federal programs provide regulatory measures to give monarchs adequate protection.

The Monarch Joint Venture (MJV) is a partnership of entities across the United States that is guided by the North American Monarch Conservation Plan (NAMCP) (described below in the 'international mechanisms' section). The Monarch Joint Venture is a partnership of federal and state agencies, non-governmental organizations, and academic programs that are working together to support and coordinate efforts to protect the monarch migration across the lower 48 United States (http://www.monarchjointventure.org/). While some of these entities are working to further the conservation of monarchs and their habitat, the implementation of the MJV is not a regulatory mechanism because it is a voluntary and unenforceable effort.

Several programs exist on National Wildlife Refuges (NWRs) to foster monarch conservation. Refuges across the nation engage in monarch related activities, but all such activities are voluntary and none of them are adequate to provide monarchs with meaningful protections. Each NWR makes its own determination on how to manage monarchs. Many programs involve activities such as monarch festivals and citizen surveys. These voluntary efforts, while beneficial, are by their nature inadequate and not cognizable as regulatory mechanisms for purposes of ESA listing..

The U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) is part of the Monarch Joint Venture. Through a Conservation Innovation Grant, the NRCS has partnered with the Xerces Society and the seed industry to increase the availability of native milkweed seed for large-scale restoration efforts in the several states including California, Nevada, Arizona, New Mexico, Texas, and Florida. While this is an important program for monarch habitat creation, it is not a regulatory mechanism that can protect monarchs from the landscape level threats that they face (*see*: www.xerces.org/milkweed/).

The U.S. Forest Service has some programs that benefit monarchs, but it does not have an agency-wide mandate or policy on monarch protection. The Forest Services' efforts at protecting monarchs are inadequate regulatory mechanisms because the majority of the agency's efforts are voluntary, the policies that protect animals such as monarchs provide only minor benefits, and the agency cannot utilize its authority to address significant threats across the range of monarchs. An example of a Forest Service policy that tangentially benefits monarchs is the regulation requiring a permit for the collection of plants and animals on Forest Service lands. While in theory this could protect individual monarchs from being collected, it does not provide protection for the monarch's habitat.

The Forest Service also maintains several webpages containing information on monarch butterflies that are focused on education and monitoring. Under the Monarch Joint Venture, an organization comprised of numerous stakeholders and initiated by the U.S.Forest Service International Programs, some National Forests have made efforts on behalf of monarchs including the creation of gardens designed to attract pollinators at ranger stations, controlling weeds and encouraging native plants, conducting butterfly surveys, restoring overwintering sites, and endeavoring to use thinning and prescribed burns to create conditions that foster native plants. Though useful, these voluntary and unenforceable efforts cannot be considered adequate regulatory mechanisms to protect and recover monarch butterflies.

Several units of the National Park system in California contain monarch overwintering sites. National Park lands are protected from the development pressures facing other monarch habitats in California, but measures are not in place that specifically provide for monarch protection on Park Service lands.

Additionally, FWS will phase out the use of all genetically-engineered crops to feed wildlife and will ban neonicotinoid insecticides from all Wildlife Refuges nationwide, effective January 2016. The decision, applicable NWR System-wide, was announced on July 17, 2014, via a policy Memorandum issued by the Chief of the NWR System, James W. Kurth (http://www.centerforfoodsafety.com/files/agricultural-practices-in-wildlife-management_20849.pdf). While not specifically for monarch butterfly protection, the policy provides a strong monarch protection model, as it will largely eliminate the threat of genetically-engineered herbicide-resistant varieties and neonicotinoids on National Wildlife Refuges. However, the protected land area of these Refuges is minor in relation to the area of protected land needed to conserve monarch populations from further decline.

In sum, though some programs are in place on federally- managed lands that provide some benefit to monarchs, there are no existing regulatory mechanisms at the federal level which are adequate to safeguard the species.

In addition, there are no mechanisms to protect monarchs from overutilization or activities that facilitate the spread of disease. Although the USDA regulates the interstate shipment of live butterflies, existing permits do not track the number of butterflies transported nor do they require the butterflies to be screened for disease. The spread of parasites and diseases is a major factor of concern for monarch conservation. Given the growing popularity of butterfly releases, lack of required screening for parasites, and potential for cross-species transmission in operations where multiple butterfly species are reared together, the lack of regulatory mechanisms governing the commercial rearing and release of wild butterflies poses a significant threat to monarchs (*see* Altizer and de Roode 2010, p. 26).

In June 2014, the White House issued a Presidential Memorandum (2014) conceding that monarchs faced "an imminent risk of failed migration." The Memorandum established a federal strategy to address the alarming declines in populations of honey bees and other pollinators, including the monarch. Although the Memorandum is an important acknowledgement of the monarch crisis, it does not constitute a regulatory mechanism.

State Mechanisms

There are also no existing regulatory mechanisms at the state level that are adequate to protect monarchs. Some states have plans in place to protect some monarch habitat, but these protections are limited to specific sites and fail to provide monarchs with the landscape-scale protections necessary to stem their precipitous decline.

Because they are easily identifiable and charismatic, monarchs have been officially listed as state insects or butterflies across the country. Seven states list monarch butterflies as their official state insect or butterfly including Alabama, Idaho, Illinois, Minnesota, Texas, Vermont, and West Virginia. These designations do not, however, confer substantive protections to the monarch.

At the state level, Iowa and California provide examples of measures states have taken that can benefit butterflies, but because of its broad geographic range and the widespread environmental stressors affecting monarchs, piecemeal state programs are not adequate to safeguard the species.

The Iowa Department of Natural Resources and the Iowa Prairie Resource Center are members of the Monarch Joint Venture and have active programs for monarch protection. The Prairie Resource Center has focused its efforts on generating native prairie seeds, including milkweeds, and their engagement with the Monarch Joint Venture has generated additional funding for milkweed seeds that will be propagated through prairie habitat in Iowa. While certainly helpful, these programs cannot be considered as regulatory mechanisms that are adequate to safeguard the monarch.

California does not have a statewide plan to benefit monarchs, but monarch overwintering sites occur in many State Parks and on other land managed by state agencies in California. State Park rules prohibit visitors from collecting animals and disturbing monarch roost trees, which provides the butterflies with some protection from collection and disturbance. Each park has a General Plan which guides management, but only one of these plans specifically considers monarch protection. The Leo Carrillo State Park General Plan considers monarchs and focuses on issues such as restoring native plants and maintaining overwintering sites for monarchs in non-native eucalyptus groves. None of the other parks specifically provide for monarch protection in their management plan, even if they are known to support large numbers of butterflies. Pismo State Beach, for example, provides a significant overwintering site for migratory monarchs, yet Pismo's General Plan does not include any monarch specific management measures (International Environmental Law Project and Xerces Society 2012). While many parks do make good faith efforts to protect monarchs, the California State Park system does not provide an adequate regulatory mechanism for the protection of monarchs both due to the voluntary nature of monarch protection efforts and because it cannot provide protections for monarchs at the landscape scale.

Local Mechanisms

This petition does not attempt to analyze all county or city-level mechanisms that could provide some conservation benefit to monarchs because of the broad geographic range of monarchs. Though some areas may have programs in place that consider monarchs, these isolated programs are not an adequate replacement for range-wide regulatory protection. One example of a strong city ordinance that is beneficial to monarchs is the city of Capitola, California, which has adopted a year-round prohibition on the removal of trees within monarch habitat (with limited exceptions). The ordinance bars construction during monarch season, limits development in monarch habitat, requires developers to provide monarch-friendly landscaping, and mandates the collection of data both before and three years after construction to help develop a database for understanding environmental parameters associated with butterfly behavior (International Environmental Law Project and Xerces Society 2012). Unfortunately, this type of protection applies to a very small number of monarch sites and is an exception to the rule of weak or lacking protections. The vast majority of California's monarch sites remain unprotected, with almost all jurisdictions allowing tree trimming without appropriate protection for monarchs. Overall, monarchs remain inadequately protected on city and county lands throughout the country.

Private Lands

The vast majority of monarchs are dependent on habitat on private land where no existing regulatory mechanisms are in place to protect them. The breeding range of summer monarchs is largely on private agricultural land where protection is entirely lacking. Part of the winter range of western monarchs is on private lands in California, where they are threatened by development and disturbance and there are no existing regulatory mechanisms that are adequate to protect them. Monarchs on California's private lands do enjoy slightly more protection than monarchs in other states because many of California's monarch overwintering sites occur primarily within the coastal zone, generally defined as areas within 1,000 yards of the high tide line. Under the Coastal Zone Management Act, cities and counties are required to develop Local Coastal Programs (LCPs) for these areas. Most LCPs do not provide specific protections for monarch overwintering sites, but even the ones that do generally only provide protection during winter months when monarchs are actually overwintering, leaving vital habitat unprotected during the rest of the year (International Environmental Law Project and Xerces Society 2012). This means that landowners can cut limbs, trees, or even entire groves utilized by monarchs for overwintering habitat as long as they don't do the cutting during the time monarchs may be physically present. Further, many overwintering sites are not even within the coastal zone, thus they don't even benefit from this limited protection. Across the country, monarch habitat on private lands is under-protected or unprotected.

International Mechanisms

Monarchs migrate from Canada to Mexico, and the monarch migration is the subject of international attention and processes that reflect significant concern on the part of international bodies for the plight of monarchs. None of these endeavors, however, are adequate regulatory mechanisms due to their voluntary nature, their considerable reliance on anticipated future action, and because they are not equipped to address the most significant threats to monarchs.

The North American Monarch Conservation Plan (NAMCP)

Parties in Canada, Mexico, and the United States produced the North American Monarch Conservation Plan (NAMCP) in 2008 (Commission for Environmental Cooperation 2008). Like other efforts discussed *supra*, the NAMCP is not a cognizable "regulatory mechanism" for purposes of determining whether ESA listing is warranted because it is voluntary and relies on plans for future actions. Though the plan cannot be considered as a regulatory mechanism, it reflects a solid research effort and contains useful information on threats to migratory monarchs and recommended conservation actions to remedy such threats. The NAMCP is described by the U.S. Forest Service as a long-term cooperative agenda for monarch conservation, and it offers a list of key tri-national collaborative conservation actions, priorities, and targets to be considered for adoption by the three countries. The Commission for Economic Cooperation, an international body created by the North American Agreement on Environmental Cooperation at the same time as the North American Free Trade Agreement, released the plan. The NAMCP provides a status review of monarchs, and details the current factors causing monarch decline. It notes that the proliferation of genetically engineered, glyphosate-resistant crops in the Midwestern United

States is one of the most significant factors leading to the loss and degradation of monarch breeding habitat.

The NAMCP provides recommendations for the three party nations to consider implementing, but explicitly does not impose any obligations on the parties, and its recommended actions primarily focus on developing studies and recommendations, not specific actions. For example, while the NAMCP identifies genetically engineered crop glyphosate use as a significant threat to migratory monarchs, its recommended action is to study and limit impacts of herbicides and insecticides on monarch populations and their habitat. In general the NAMCP establishes goals for study and future actions that as such cannot be considered adequate regulatory mechanisms.

Monarch Butterfly Biosphere Reserve

The first reserve to protect overwintering monarchs in Mexico was established in 1986. In 2008, the United Nations Education, Scientific, and Cultural Organization (UNESCO) added Mexico's Monarch Butterfly Biosphere Reserve to its list of World Heritage sites. UNESCO's listing brought recognition of the significance of this site and efforts to protect the millions of monarchs who rely on it for overwintering habitat. However this effort is not a cognizable regulatory mechanism because it only requires voluntary actions, and because by its inherently-focused nature it cannot adequately address range-wide threats to monarchs, particularly those in the monarch's summer breeding habitat in the United States.

UNESCO recommends a principal focus on prevention of illegal logging on the property; additional areas of focus include achieving sustainable use of the property by making tourism to it more sustainable, involving local communities in benefit-sharing programs to incentivize conservation, and continued investment in continent-wide management of the migratory phenomenon. A 2011 UNESCO report indicates that these efforts have resulted in large reductions in illegal logging. The effort has also helped to develop infrastructure to better manage tourism. However efforts pursuant to this designation are voluntary and come in the form of recommendations. For example, in its list of requirements for protection and management at the site, UNESCO is careful to use "should" instead of "shall" when it offers suggestions such as "[t]he principal focus of protection and management should be to prevent illegal logging on the property" (*see*: http://whc.unesco.org/en/list/1290/). In addition, UNESCO's efforts do not adequately address the threats faced by migratory monarchs across their range, because its focus is on this one reserve and the surrounding area.

Small-scale logging in particular remains a problem in the Monarch Reserve. Vidal et al. (2013) used aerial photographs, satellite images, and field surveys to monitor forest cover in the core zones of the Reserve from 2001 to 2012. They found that from 2001-2012, 1,254 ha were deforested (defined as areas with less than ten percent canopy cover remaining), 925 ha were degraded (defined as areas in which canopy forest decreased), and 122 ha were negatively affected by climatic conditions including winds, drought, fire, and floods (p. 180). Of the total 2,179 ha of affected area, 2,057 ha were affected by illegal logging, 1,503 ha of which were affected by large-scale logging and 554 ha of which were affected by small-scale logging.

Vidal et al. (2013) identify small-scale logging as an increasing problem for the Monarch Reserve, and suggest that a strategy needs to be devised and implemented as a matter of urgency to address the socioeconomic and environmental problem of both the monarch reserve and the region as a whole which suffers from severe poverty and lack of basic services:

> We suggest a substantive increase and more focused and coordinated action with regards to the payments for environmental services to the local communities and ejidos by the federal and state authorities as part of a long-term investment in sustainable economic activities, such as ecotourism and production of trees. Those investments should be better coordinated with the financial support provided by private donors and the monarch fund. Simultaneously, federal, state, and municipal authorities should implement a year-round and effective on-the-ground surveillance and law-enforcement strategy to avoid the resurgence of large-scale logging and to stop small-scale logging. Finally, we suggest implementation of a comprehensive, regional plan to create (and maintain) new and better job opportunities, improve and expand basic education for children and youth, improve basic services (e.g., sanitation, electricity, and water), all of which should be in partnership with the people living in the region and take full account of their needs and aspirations (p. 184).

Slayback et al. (2007) also conclude that more protections need to be in place to safeguard the monarch reserve, stating: "The extraordinary site fidelity and extreme localization of colonies within such a small amount of available habitat underscores the urgency of implementing an ironclad conservation policy for this unique biological phenomenon" (p. 38).

Direly, global climate change models predict that the entire current Mexican winter range for monarchs could become unsuitable habitat by the end of the century (Oberhauser and Peterson 2003, p. 14063, Saenz-Romero et al. 2012, p. 98). There are currently no existing regulatory mechanisms in place to reduce greenhouse gas emissions and avoid impending climate catastrophes such as the entire loss of the Monarch Butterfly Biosphere Reserve. Just as Joshua Tree National Park is becoming unsuitable habitat for Joshua trees, the monarch reserve is undergoing climatic changes that are expected to entirely undermine its ability to provide appropriate climatic conditions for monarchs.

FWS and USFS International Efforts

The FWS and the U.S. Forest Service both support international monarch protection efforts. FWS' International Affairs office has been engaged in migratory monarch protection efforts through its Wildlife Without Borders-Mexico program since 1995 (*see*: http://www.fws.gov/international/animals/monarch-butterfly.html). This is a voluntary program and is focused on just a small portion of the monarch's range; it is not a regulatory program. This program entails FWS partnering with and providing funding to groups in Mexico that support communities around the Monarch Butterfly Biosphere Reserve to protect this overwintering habitat. FWS is providing useful support to a training program administered by a local non-governmental organization. The agency does not utilize its authority under this program to conserve monarchs or their habitat in their summer range in the United States where they are currently most threatened.

In addition to initiating the Monarch Joint Venture, the U.S. Forest Service International Programs runs a monarch protection campaign that unites partners across Canada, the United States, and Mexico, and coordinates habitat conservation efforts through training and community outreach (*see*: http://www.fs.fed.us/global/wings/butterflies/welcome.htm). These efforts rely on the voluntary participation of conservation partners, school children, and other agencies, and are not attached to any legal mandate. The agency also participates in efforts to conserve and restore monarch habitat in all three nations, on public lands, and on private lands, and is making plans to form partnerships with farming organizations to conserve milkweed as part of its international monarch protection program. Though important, these programs cannot be considered as cognizable regulatory mechanisms for ESA purposes.

Canadian Species of Special Concern

Monarchs were designated a "species of special concern" in Canada in 1997, 2001, and 2010 (*see*: http://www.sararegistry.gc.ca/document/default_e.cfm?documentID=2027). A species of special concern is a "wildlife species that may become threatened or endangered because of a combination of biological characteristics and special threats" (http://www.cosewic.gc.ca/eng/sct2/sct2_6_e.cfm). This status does not come with substantive protections and indeed the latest monarch status report does not include any discussion of how Canadian officials intend to provide monarchs with any substantive protections; thus it is not an adequate regulatory mechanism. Furthermore, the majority of this species' breeding habitat occurs in the United States, and threats in the States must be addressed in order for the butterfly to recover.

Importantly, the Assessment and Status Report published by Canadian authorities and associated with the most recent listing notes that herbicide and pesticide use across North America is a threat to monarchs, but the Report does not indicate that Canadian authorities are mandating or even strongly recommending any significant action to protect milkweed habitat from this threat; indeed, milkweeds remain listed under the noxious weed acts of multiple provinces. The continued inclusion of milkweed as a noxious weed in parts of Canada is another indication that a Canadian species of special concern status cannot be considered an adequate regulatory mechanism.

In sum, no existing regulatory mechanisms exist to adequately protect monarchs because the vast majority of monarch protection comes from voluntary measures, and even when measures are enforceable, they do not address monarch conservation on a rangewide scale. Some existing conservation efforts have undoubtedly increased and protected monarch habitat, but the continuing trend of steep decline plainly demonstrates that these existing measures are wholly insufficient to overcome the myriad threats to monarchs. Herbicide and pesticide use in summer habitat, development, climate change, and other synergistic threats are landscape-scale problems that cannot be adequately addressed through a mix of voluntary conservation measures. Rather, monarchs face threats that can only be adequately addressed through the comprehensive protections of the ESA.

As explained elsewhere in this petition (*see* Threats- Overutilization), upon listing the monarch butterfly, petitioners request that the Service implement measures that promote the continuance of activities that benefit monarch conservation such as citizen tagging and monitoring, scientific research, classroom rearing, education, and other activities that are beneficial for monarch conservation (*see* Appendix B).

Petitioners also recognize the valuable role that the native seed industry plays, and will continue to play, in propagating milkweed seed and plants to facilitate monarch habitat recovery. Take of monarch caterpillars, eggs, and pupae routinely occurs as part of normal milkweed production activities. Should the Fish and Wildlife Service list the monarch butterfly as a threatened species under the ESA, we strongly recommend that the agency recognize the valuable role that milkweed producers will play in monarch habitat recovery and streamline the permitting process for incidental take permits for milkweed producers, so that the listing will not hinder milkweed production efforts.

FACTOR FIVE: OTHER FACTORS AFFECTING THE MONARCH'S CONTINUED EXISTENCE

Several other factors also threaten the monarch butterfly including increased pesticide use, global climate change, severe weather events, the spread of invasive species, and mortality at solar energy facilities.

Pesticides

Monarchs face threats at all life stages from pesticides used throughout their range. The term "pesticides" encompasses herbicides, insecticides, fungicides, nematocides, rodenticides, and all of the other biocides. Impacts of pesticides on monarchs can occur from indirect and direct effects, and from lethal and sub-lethal injuries (e.g., Kohler and Triegskorn 2013).

Monarchs are harmed from widespread loss and degradation of habitat as a result of herbicide use that kills host milkweeds and alters nectar plant quality and abundance (e.g., Pleasants and Oberhauser 2012). As discussed in detail in the Modification and Curtailment of Habitat or Range section of this petition, use of glyphosate on genetically engineered, Roundup Ready corn and soybeans has been identified as the major cause of the precipitous drop in monarch numbers over the last 15 years, and this threat to the population continues as new areas are converted to corn and soybeans for biofuels, in addition to upcoming threats from the imminent introduction of new genetically engineered, herbicide-resistant crops (*see* discussion in Loss and Curtailment of Habitat and Range section of this petition).

Larvae and adults, and under some circumstances, eggs and pupae, of monarch butterflies can be killed or impaired by exposure to pesticides via contact from overspray, drift of spray particles and vapor, runoff, dust, and through ingestion of pesticide-contaminated food and water. Pesticides also have "inert" ingredients, many of which are also toxic to butterflies (Stark et al. 2012).

Pesticide use is ubiquitous in North America. In the United States, pesticide use reached 1.1 billion pounds in 2007, the latest year for which EPA has released records (U.S. Envrionmental Protection Agency 2007). Pesticides are widely used in agriculture, on rangelands, woodlands and other natural areas, waterways, golf courses, residential lawns and gardens, sports fields, roadsides, and on street trees. Pesticides are applied as granules, dusts, and liquids. They are sprayed from ground rigs, planes and helicopters; from backpack sprayers or dusters; used to coat seeds; and are injected into tree trunks and soils. Within the breeding range of the monarch butterfly, most pesticide applications are made during the crop-growing season, so exposure from applications overlap the migration and breeding of monarchs. In addition, exposure to persistent pesticides occurs well after applications are made, extending risk throughout the monarch's residence time in the United States. In some cases, pesticides are active for multiple years.

Insecticides

Since the active ingredients of most compounds are optimized to kill insects, and monarchs are in the class Insecta, they are vulnerable to many insecticides. Furthermore, since many insecticides were designed to control lepidopteran crop pests, they are especially toxic to many butterflies, which are in the Order Lepidoptera.

Larvae of a variety butterflies have proven to be extremely sensitive to insecticides used in agriculture (Groenendijk et al. 2002). A risk analysis in the Netherlands showed that butterflies in field margins were at risk from insecticide use on nearby crops (Ibid.). Butterflies and moths can be indirectly affected by drift from pesticides applied aerially (Sinha et al. 1990).

Although the U.S. Environmental Protection Agency regulates pesticide use in order to attempt to minimize impacts to non-target organisms such as monarchs, its regulations do not provide adequate protection. Currently, pesticide companies are not required to evaluate non-target effects of new pesticides on butterflies before registering their product. Incidents of harm to non-target organisms from pesticides are common, both from legal (following label directions) and illegal (not following label directions) applications (Mineau and Palmer 2013, Hopwood et al. 2012, 2013, also *see* Habitat Loss Due to Pesticide Drift section of this petition). Incidents that involve wild organisms such as butterflies are undoubtedly greatly underreported. Sub-lethal impacts to insects are unlikely to be recognized or reported at all, even when impacts are severe.

Insecticides of particular concern that directly impact monarchs include, but are not limited to, the increasingly used neonicotinoid insecticides, organophosphates, and pyrethroids.

Neonicotinoid insecticides

Neonicotinoids are a relatively new class of insecticides, introduced in the 1990s, which irreversibly block post-synaptic nicotinic acetylcholine receptors (nAChRs) in the central nervous system of insects and other animals (Jeschke and Nauen 2008, Jeschke et al. 2011). They are lethal to insects and other arthropods at very low doses, and cause serious sub-lethal impacts at even lower exposures (Hopwood et al. 2012, 2013, Goulson 2013, Mason et al. 2013, Van der Sluijs et al. 2013).

Neonicotinoids include imidacloprid, clothianidin, thiamethoxam, acetamiprid, thiacloprid,and dinotefuran. New insecticides that are not in the neonicotinoid class, but that have the same mode of action continue to be registered, such as sulfoxaflor (Cutler et al. 2012). Although they share a common mechanism of action, specific neonicotinoids differ in solubility, degree of persistence in soil and water, types of insects that can be killed at particular concentrations, and some other properties (Fishel 2005, Jeschke and Nauen 2008).

Neonicotinoids are applied as seed coatings to many crops such as corn and soybeans, before planting, are used in agriculture and landscaping as soil drenches and trunk injections, spread as granules in pastures and turf, added to irrigation water, and are sprayed on leaves of crops and ornamentals (Jeschke et al. 2011).

These chemicals pose a significant threat to monarchs for the following reasons: (adapted from Hopwood et al. 2012, 2013):

- Neonicotinoids, especially imidacloprid, clothianidin, dinotefuran, and thiamethoxam (four of the most widely used neonicotinoids) are highly toxic to a variety of insects. Some of the breakdown products are just as toxic.

- Sub-lethal levels of neonicotinoids can damage the ability of insects to function. This includes the ability to fly, navigate, and learn new tasks, which can impair their foraging ability and in the case of monarchs may impair migration.

- These products have a systemic mode of action: they translocate into every part of the plant including nectar and pollen. For monarchs this means they can be negatively impacted as both larvae (feeding on plant tissue) and as adults feeding on nectar.

- Neonicotinoids can persist for long periods of time in plants and soil. They can persist in soil for months or years after a single application. Also untreated plants may absorb chemical residues in the soil from the previous year. Measurable amounts of residues were found in woody plants up to six years after a single application.

- Neonicotinoids are now one of the most widely used classes of agricultural chemicals in this country.

- The toxic nature of these products, the mode of action that allows for these products to build up in plants, the fact that they are so long-lived in the environment, and that they are used across such large geographic areas and in such large quantities makes these chemicals a considerable threat to monarchs.

It is notable that the monarch decline has occurred during the same time period that the use of neonicotinoid insecticides in the key monarch breeding areas has dramatically increased, although, to our knowledge no one has tested the hypothesis that neonicotinoid use is a significant driver of monarch population dynamics, in addition to habitat loss.

The specific toxicity of each neonicotinoid insecticide to the monarch butterfly has not been investigated, but it is likely that monarchs are vulnerable to one or more of these compounds as larvae or adults, or possibly even as eggs or pupae, given the toxicity of neonicotinoids to so many other butterfly species. Several lepidopteran pests of crops and trees are on the lists of specific insects that can be controlled by neonicotinoid applications. For example, sampling a few product labels, imidacloprid applied in CoreTect Tree and Shrub Tablets controls pine tip moth larvae (Bayer CropScience 2007), and Gaucho 600 Flowable seed treatment controls black cutworm (Bayer CropScience 2010); acetamiprid applied in TriStar 30 SG foliar spray controls caterpillars of gypsy moth, tobacco bud worm, fall army worm, southern army worm, cabbage looper, and diamondback moth (Cleary Chemical Corporation 2006). Since neonicotinoids are the most widely applied insecticides in the world (Jeschke et al. 2011) and their use overlaps with monarch breeding areas, there is an urgent need to investigate the lethal and sub-lethal toxicity of these compounds to monarchs.

In the Midwestern Corn Belt, neonicotinoid use skyrocketed in the last decade, mainly as a result of almost all corn and most soybean seeds being sold having been pre-treated with neonicotinoid coatings (Krupke et al. 2012), despite questionable efficacy (Stevens and Jenkins 2014). Figures 25 through 29 illustrate this dramatic increase.

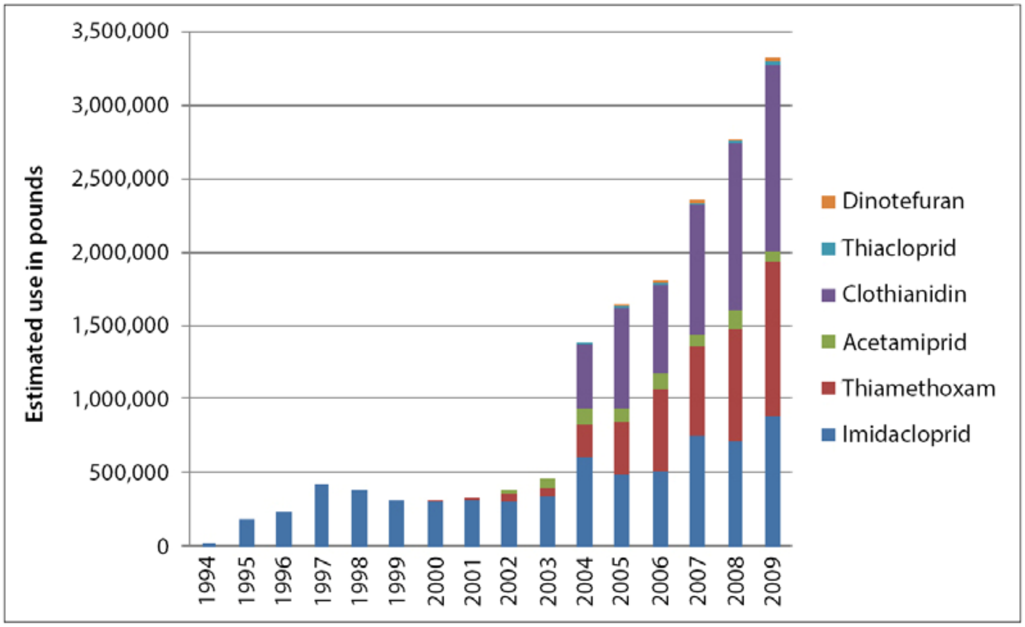


Figure 25. Estimated annual agricultural use in pounds of neonicotinoids in the United States, 1994-2009 (Data from: Stone, W.W. 2013. Estimated annual agricultural pesticide use for counties of the conterminous United States, 1992–2009. U.S. Geological Survey Data Series 752.

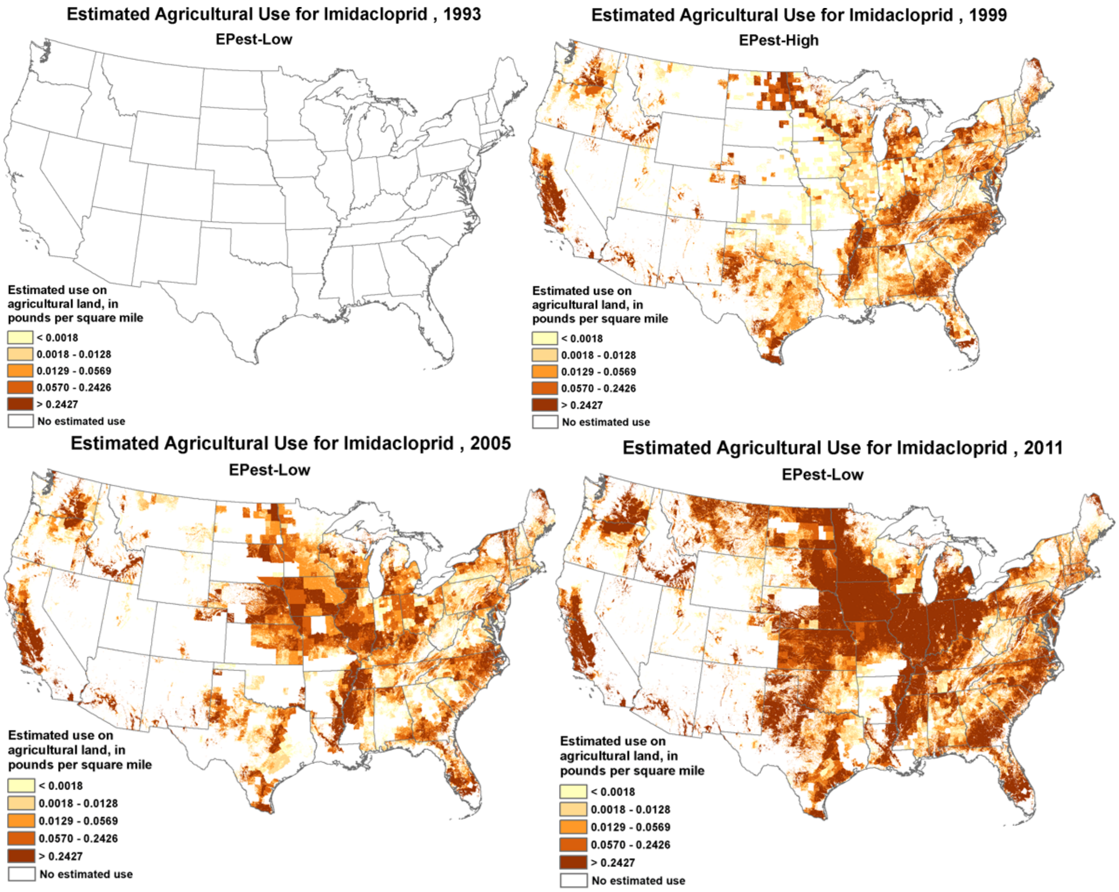


Figure 26. Increasing imidacloprid use in the United States in 1993, 1999, 2005, and 2011. Data from the USGS Pesticide National Synthesis Project, available from: http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=1992&map=IMIDACLOPRID&hilo=L

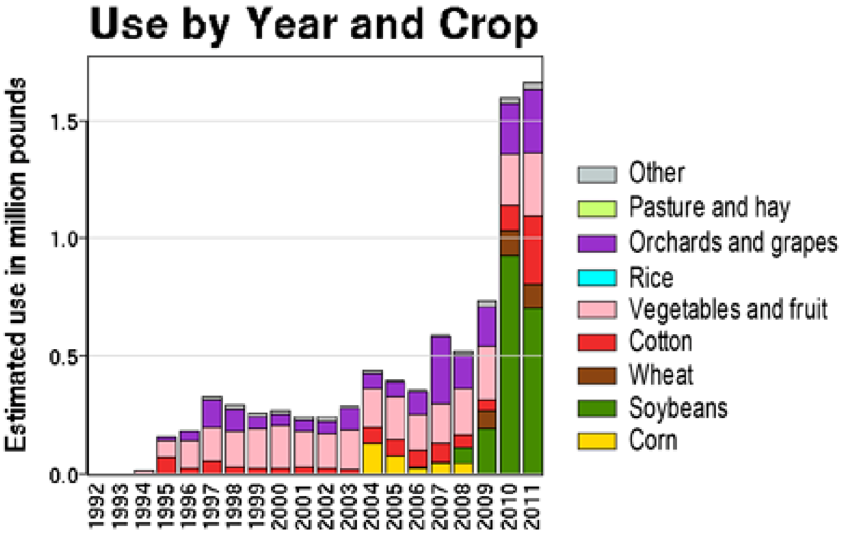


Figure 27. Imidacloprid use by crop from 1992-2011 in the United States. Data from: http://water.usgs.gov/nawqa/pnsp/usage/maps/

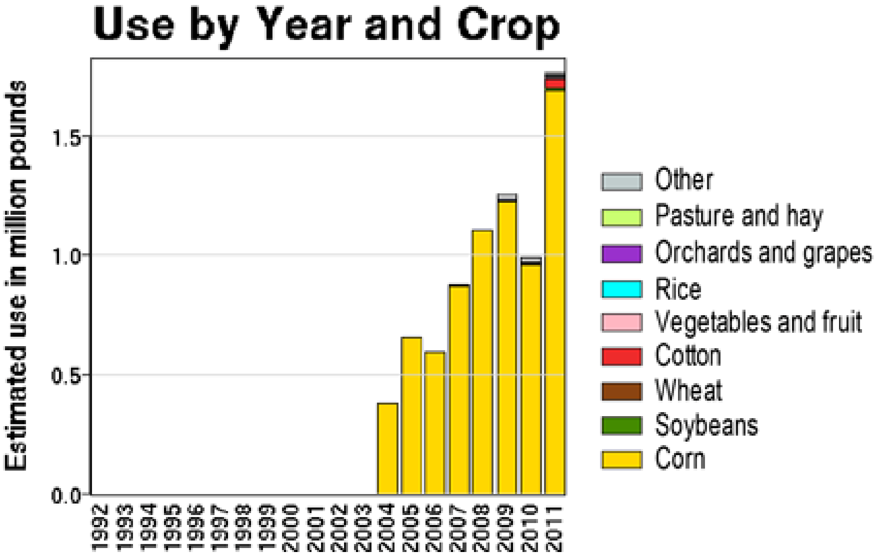


Figure 28. Clothianidin use by crop from 1992-2011 in the United States. Data from: http://water.usgs.gov/nawqa/pnsp/usage/maps/

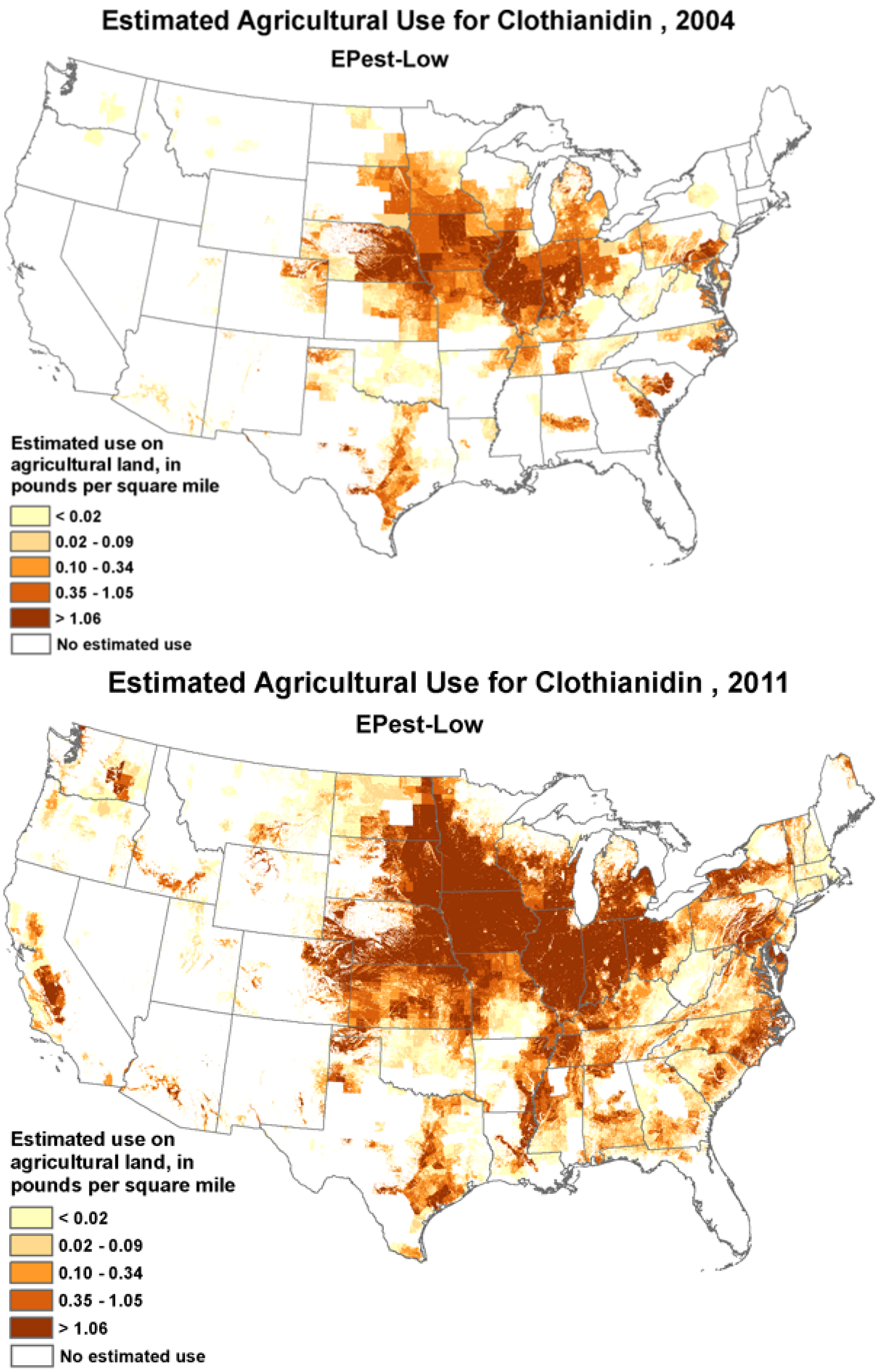


Figure 29. Increasing clothianidin use in 2004 and 2011 in the United States. Data from: USGS Pesticide Synthesis Project, *see*: http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=2011&map=CLOTHIANIDIN&hilo=L&disp=Clothianidin

Increasing neonicotinoid use is of particular concern to monarchs in the East because their main breeding range is coincident with the area of greatest neonicotinoid use in the Corn Belt.

Seeds of other crops, such as cotton, which is a significant crop in many states where monarchs breed (including Texas, Arizona and California), are also now pre-treated with neonicotinoids. After leaving overwintering sites in Mexico, many first-generation monarchs breed in Texas, and thus quality and quantity of habitat in that state is extremely important to the size of the monarch population.

Monarchs can be exposed to neonicotinoids in a variety of ways, and at different stages of their lifecycle. In brief, monarch adults can be exposed via direct contact with spray, residues on plants and other surfaces, particles released during the planting of treated seeds, contaminated water; and neonicotinoid-containing pollen, floral and extra-floral nectar and guttation liquid. Larvae can be exposed by direct contact with spray and residues, and also by eating milkweed tissues that have been contaminated, either by overspray or drift directly onto leaves, or by milkweed taking up insecticide from contaminated soil and/or water (Hopwood et al. 2012).

In more detail, systemic movement of neonicotinoid insecticides increases the number of routes by which monarchs can be exposed. Neonicotinoids are taken up by plants and move through the vascular system to all tissues and organs, including flower buds, pollen, nectar, roots, leaves, and stems. They are then slowly metabolized within plant tissues, and some of the metabolites are also toxic; residues and metabolites kill insect pests for weeks, months, or sometimes for years (Oliver et al. 2010, Goulson 2013). Thus, if host milkweed plants take up neonicotinoids from adjacent treated crops (as described below), monarch larvae will be exposed. Adult monarch butterflies feed on a wide variety of flowering plants, and if they sip nectar or guttation liquids or eat pollen from treated plants, they can also be exposed to systemic neonicotinoids.

As with most pesticides, only a fraction of neonicotinoid applications generally end up on or in targeted plants (Sur and Stork 2003, Goulson 2013), depending on the type of application. Also, a portion of neonicotinoids that does enter target plants is released into the environment as those plants decay. Environmental contamination with neonicotinoids occurs via several routes and thus poses risks to monarchs in different contexts:

- Neonicotinoids that do not contact or are not taken up by the plants during applications leach or run off directly into soil and water, where residues and metabolites can persist, remaining active for months to years (e.g. Huseth and Groves 2014). They regularly contaminate ground and surface waters near treated fields, impacting natural areas some distance from application sites at concentrations high enough to reduce insect populations (Mineau and Palmer 2013, Main et al. 2014). Monarchs can drink contaminated water, consume milkweed plants that have taken up neonicotinoids from contaminated soil and water, or drink nectar from a wide variety of plants that have taken up neonicotinoids from contaminated soil or water.

- Seed coatings form dust during planting as abraded seed tissues mix with talc or other carriers and are expelled from planting machines (Krupke et al. 2012, Tapparo et al.

2012, Nuyttens et al. 2013). This dust can contact monarch larvae and adults directly during the planting operation. Dust also settles on plants, soil and water in and around fields, where it can expose monarchs (both larvae and adults) after planting.

- Unharvested plant material from crops that have taken up neonicotinoids from foliar sprays, seed treatments, soil drenches, or other application methods contains residues and metabolites that can be released into soil (Hopwood et al. 2013) and water as the roots, stalks, and other plant parts decay, adding to environmental contamination.

Given the widespread use of neonicotinoid insecticides, especially as seed treatments, it can be assumed that milkweeds and nectar plants in monarch habitats could be contaminated with neonicotinoids. According to Goulson (2013, p. 981): "Given their persistence and accumulation in soils, we might predict hedgerow plants and trees, field margin vegetation and naturally regenerating fallows to take up neonicotinoids."

Very low concentrations of neonicotinoids and other pesticides have been shown to cause sub-lethal effects in other insects. For example, studies show sub-lethal impacts of pesticides on bee species that include changes in foraging behavior, navigation ability, reduced reproduction, and many other processes (Blacquière et al. 2012, Bryden et al. 2013, Goulson 2013), as well as increased susceptibility to pathogens (Pettis et al. 2013). Sub-lethal effects of neonicotinoids on fruit flies include a disruption of mating behavior (Charpentier et al. 2014). These types of effects are of obvious relevance to monarch populations.

Several studies suggest that levels of neonicotinoids in milkweed and nectar plants that have been exposed to contaminated soil, water, dust, or spray drift may reach concentrations that are toxic to monarchs in some situations, based on studies so far:

> The evidence presented here [in this review] suggests that the annually increasing use of neonicotinoids may be playing a role in driving these declines [of farmland insects and other taxa]. The concentrations accumulating in soil (1 to >100 ppb), waterways (often in excess of 1 ppb, sometimes up to 200 ppb), field margin plants (1–9 ppb) and nectar and pollen of flowering crops (1–50 ppb) exceed levels in crop tissues needed to control pest insects (5–10 ppb) and overlap with LC50 values for a range of non-target insects. They would appear to be sufficient to cause both direct mortality in the more sensitive nontarget species and chronic sublethal effects in many more. The groups most at risk are likely to include soil-dwelling insects, benthic aquatic insects, granivorous vertebrates and pollinators. Herbivorous insects feeding on field margin and hedgerow plants may also be exposed (Goulson 2013, p. 985).

Monarchs are in the "pollinator" risk category as adults, and the "herbivorous insects feeding on field margin and hedgerow plants" risk category as larvae. Milkweeds have largely been eradicated from corn and soybean fields, but thelands enrolled in the Conservation Reserve Program and roadsides where common milkweed now hosts most monarch larvae and where nectaring occurs are largely within agroecosystems where neonicotinoids are widely used.

New research shows that neonicotinoids are common in streams and rivers of the Midwest (Hladik et al. 2014), where they have been found in a number of samples at levels associated with toxicity to insects, and thus may be a threat to monarchs in this central breeding region. In one of the first major investigations of water contamination from multiple neonicotinoids in the United States, Hladik et al. (2014) sampled surface waters in corn and soybean regions centered in Iowa and found that neonicotinoids are mobile and that they persist in the environment. The amounts and kinds of neonicotinoids applied, timing of their use, and precipitation events determined the pattern of neonicotinoids in streams (p. 191). Neonicotinoids were detected at all of the sites sampled, including large and small watersheds draining regions with different percentages of corn and soybeans (p. 192). Small watersheds with large percentages of row crops had the highest levels of neonicotinoids in surface waters. Summarizing the results (p. 189), "[m]aximum and median concentrations (maxiumum:median) across all sites and samples followed the same pattern as detection frequencies with clothianidin (257 ng/L; 8.2 ng/L) > thiamethoxam (185 ng/L; < 2 ng/ L) > imidacloprid (42.7 ng/L; < 2 ng/L) (Table 2). Multiple neonicotinoids were common, with three neonicotinoids detected in 23% of the samples." Many samples had levels that are in the range known to be toxic to insects (e.g. Goulson 2013, p. 905: 5 - 10 ppb neonicotinoids in crop tissues control insect pests), and at levels that are associated with declining bird populations in Holland (Hallman et al. 2014: greater than 20 ppb imidicloprid in surface water is correlated with 3.5% annual decline in birds).

Another threat from neonicotinoids to monarchs comes from some nursery-grown milkweeds and nectar plants purchased from garden centers. As public awareness of the plight of monarchs grows, increasingly monarchs are being encouraged to lay eggs and sip nectar in butterfly-attracting gardens, both as a conservation measure and as a source of entertainment. Neonicotinoids have been detected in approximately half of nursery-grown plants tested (Brown et al. 2014), and there are anecdotal accounts of monarch larvae not surviving on nursery-grown milkweed plants, consistent with toxicity from systemic insecticides.

In California alone, where the state's Department of Pesticide Regulation collects detailed pesticide use data, 2,447 pounds of imidacloprid were applied to nursery plants in 2012 (California Department of Pesticide Regulation 2014, p. 414-415). These products are also widely used around homes, and products approved for home and garden use may be applied to ornamental and landscape plants, as well as turf, at significantly higher rates (up to 32 times higher) than those approved for agricultural crops (Hopwood et al. 2012).
Taken together, the cumulative impacts of these exposures to neonicotinoids throughout the monarch's habitat, particularly in their main breeding range, pose a significant ongoing and increasing threat.

Mosquito Control Programs

Insecticides are used in many areas of North America to attempt to manage mosquito larvae and adults, often in response to mosquito-borne diseases such as West Nile virus and dengue fever, or to control nuisance populations. Some models suggest that higher global temperatures will extend the geographic ranges of some mosquitos that vector diseases (Reiter 2001), which will likely lead to an increased use of insecticides targeting mosquitos. Mosquito control is done using agents that kill the adult (adulticides) or immature (larvicides) forms of the insect. The most commonly used adulticides are organophosphate (e.g., malathion, naled) and pyrethroid (e.g., pyrethrin, permethrin, resmethrin, sumithrin, prallethrin) insecticides (Mazzacano and Black 2013). These compounds have broad -spectrum toxicity and can cause severe impacts to non-target animals including butterflies.

General losses of biodiversity in insect communities that affect a wide range of orders and families have been noted by some researchers in areas where mosquito adulticides are sprayed (Eliazar and Emmel 1991, Kwan et al. 2009). Multiple studies have also shown negative impacts of mosquito treatments specifically on butterfly populations. Barrier treatments, in which pesticide applied as a spray to foliage forms a coating that kills adults that come into contact with it, can have lethal and sub-lethal effects on adult or immature butterflies.

The decline of the federally endangered Schaus swallowtail butterfly (*Heraclides aristodemus ponceanus*), endemic to southern Florida, has been linked to pesticide applications for mosquito control (Eliazar and Emmel 1991), as has the decline of the Miami blue butterfly (*Cyclargus thomasi bethunebakeri*) (USFWS 2012, 77 FR 20948). Mosquito-control pesticides are also considered to be a contributing factor in the extinctions of the Florida zestos skipper (*Epargyreus zestos)* and rockland grass skipper (*Hesperia meskei pinocayo*) (*see*: http://www.fws.gov/southeast/news/2013/032.html).

In areas that are being treated for mosquitoes, monarchs can be exposed to the insecticides at the larval stage if the insecticides are over-sprayed or drift onto milkweed hosts, or as adults if butterflies are flying or visiting nectar plants during or after applications.

Researchers at the University of Minnesota investigated toxicity to monarchs of two insecticides often used to control mosquitos (Oberhauser et al. 2006, Monarch Joint Venture 2014), and found that monarchs did have higher mortality when exposed:

The University of Minnesota conducted research on how monarch larvae and adults were affected by exposure to insecticides commonly used in mosquito control (resmethrin and permethrin). These pyrethroids can be sprayed as ultra-low volume treatments or as barrier treatments. Ultra-low volume treatments intended to affect insects as they are flying, whereas the barrier treatments remain on leaves, providing a barrier to mosquitoes that may not be out foraging during the day. Both the ultra-low resmethrin study and the barrier permethrin study showed negative impacts on monarch larvae and adults. Leaves from the barrier treatments resulted in higher mortality to monarch larvae than control leaves up to 3 weeks after the initial application (Monarch Joint Venture 2014).

Increased mortality of monarchs from mosquito control programs is thus a significant potential threat, although impacts have not been assessed.

Grasshopper Control on Rangelands in the Western United States

Insecticides are commonly used in rangeland areas across many western states to control native grasshoppers that compete with cattle for forage. When grasshopper numbers are high, the Animal Plant Health Inspection Service (APHIS) routinely facilitates spraying of insecticides to control Mormon crickets and grasshoppers on public and private lands. APHIS lists three pesticides commonly used for Mormon cricket and grasshopper control: diflubenzuron (Dimilin), carbaryl (spray and granular formulations), and malathion (USDA APHIS 2002).

All pesticides that can be used to control native grasshoppers are thought to be highly toxic to all life stages of the monarch butterfly, since they are broad-spectrum insecticides, with the exception of diflubenzuron which is primarily toxic to the larval stage. Carbaryl is a carbamate insecticide that inhibits the action of the enzyme acetyl cholinesterase (AChE) that is an essential component of insect, bird, fish, and mammal nervous systems. Carbaryl has "very high" toxicity levels for terrestrial invertebrates (Cox 1993), including butterflies. Malathion is an organophosphate insecticide and is highly toxic to a broad range of insects including butterflies. Dimilin is the trade name for the pesticide diflubenzuron. Dimilin acts as an insect growth inhibitor by arresting chitin synthesis, i.e., the formation of an insect's exoskeleton. Dimilin is lethal to lepidoptera caterpillars at extremely small quantities (Martinat et al. 1987). Dimilin caused 100 percent mortality of Douglas-fir tussock moth larvae up to seven weeks following application (Robertson and Boelter 1979). Another study found residue on foliage 21 days after application (Martinat et al. 1987). Sample et al. (1993) found that after Dimilin spraying, the number of lepidoptera larvae was reduced at treated sites.

Herbicides

In addition to indirect effects of herbicides on the monarch population via loss of milkweeds, as described in the Modification and Curtailment of Habitat section of this petition, some herbicides also exert toxic lethal and sub-lethal effects against butterflies (Russell and Shultz 2009).

Herbicides may directly harm exposed insects, such as monarchs. Some herbicides have been shown to leave residues that cause lepidopteran larvae to stop feeding on herbicide- exposed plants, and also some herbicides directly inhibit enzymes within the exposed insects (Russell and Shultz 2009, Bohnenblust et al. 2013). For example, glufosinate may have direct effects on lepidopteran pollinators when larvae eat glufosinate-containing pollen, nectar or leaves, either after direct over-spray or from drift. Glufosinate is one of the herbicides utilized on several currently grown genetically engineered, herbicide-resistant crops, and several new genetically engineered crops resistant to glufosinate and oher herbicides are slated for introduction in the coming years (Table 1); should these crops be approved for planting, glufosinate use could rise significantly.

Laboratory experiments with the skipper butterfly (*Calpodes ethlias)* showed that larvae fed glufosinate-coated leaves were injured or killed by inhibition of glutamine synthase, at doses comparable to the amount that might realistically be acquired by feeding on GLA [glufosinate]-treated crops. These studies were done with the active ingredient, not a full formulation, and so may have underestimated field toxicity (Kutlesa and Caveney 2001). Although monarchs will not use these crops as host plants for larvae, glufosinate may accumulate in nectar, pollen and guttation liquid of treated crops and be consumed by monarch butterflies. Also, glufosinate may drift onto milkweeds, exposing immature stages of monarchs to residues.

In sum, a plethora of pesticides used in a variety of applications threaten monarch adults and larvae across their range.

Global Climate Change

The monarch butterfly and its habitat are threatened by global climate change which will have significant physiological and ecological ramifications for monarchs (York and Oberhauser 2002, p. 297, Oberhauser and Peterson 2003, p. 14063, Zalucki and Rochester 2004, Batalden et al. 2007, Stevens and Frey 2010, Saenz-Romero et al. 2012). Global climate change threatens monarchs and their habitat due to increasing temperatures, increased frequency and intensity of severe drought and storm events, and curtailment of both summer and winter range due to changes in vegetation and climatic conditions.

The terms ‘‘climate’’ and ‘‘climate change’’ are defined by the Intergovernmental Panel on Climate Change (IPCC). The term ‘‘climate’’ refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2013a). The term ‘‘climate change’’ thus refers to a change in the mean or variability of one or more measures of climate (for example, temperature or precipitation) that persists for an extended period, typically decades or longer (Ibid.).

Climatic conditions influence monarch population dynamics with weather conditions directly affecting monarch reproductive success (York and Oberhauser 2002, Zalucki and Rochester 2004, Batalden et al. 2007). Zipkin et al. (2012) identify climate as a major driver of monarch population dynamics. Monarch butterfly recruitment is constrained by both regional temperatures and milkweed distribution (Zalucki and Rochester 2004). Prolonged cold and rainy conditions can reduce egg-laying and increase development time, but prolonged dry, hot conditions can reduce fecundity and adult lifespan (Zalucki 1981). Climate change poses a significant threat to long-term monarch survival because of the profound influence that climate has on monarch phenology and fecundity (Zalucki and Rochester 2004).

Climate can directly affect adult activity and larval development, or indirectly impact monarchs by reducing the growth and vitality of milkweed, nectar sources, and/or the forests monarchs use to overwinter (Zalucki and Rochester 2004, Zipkin et al. 2012, p. 3041). As climatic changes affect habitats, monarchs will have to adjust their seasonal movement patterns to attempt to accommodate changing conditions as currently suitable locations for breeding, nectaring, and overwintering are lost (Batalden et al. 2007, p. 1371).

Climate change models predict an increase in summer mean temperatures across the United States (IPCC 2013b). Increasing summer temperatures directly threaten monarchs and their habitat. Monarch summer breeding range is likely to be curtailed due to increasingly hot temperatures and loss of milkweed. High temperatures limit monarch reproductive success, and temperature rises expected from global climate change could reduce the area of suitable breeding habitat available for monarchs. Climate change models predict that annual mean maximum temperature is expected to increase across the continental United States, with mean predicted increases ranging from 3.6˚F to 9.0˚F (Alder and Hostetler 2013).

Increased temperatures threaten monarchs with direct mortality and with reduced reproductive success. Constant temperatures between 31°C and 35.5°C (88-96°F) are lethal for monarch larvae in laboratory conditions (Rawlins and Lederhouse 1981, Zalucki 1982). Exposure to temperatures above 29˚C (84°F) can be detrimental to the development of monarch larvae, with effects being dependent on length of exposure (York and Oberhauser 2002, p. 290). Increasing lengths of constant exposure to high temperatures result in increasingly higher mortality, longer development time, and lighter adult mass (Ibid.). Increasing temperatures threaten to disrupt the monarch migration. Larvae could be subjected to high-temperature conditions of longer duration which could compromise fitness by increasing pre-adult mortality, increasing development time, or decreasing adult size (York and Oberhauser 2002, p. 297). Generally speaking, areas south of Ohio are already too warm to support optimal larval growth during summer months (Malcolm et al. 1987; Batalden et al. 2007). Increasingly high temperatures and more frequent, more intense, and longer duration heat waves threaten monarchs in both their eastern and western range (Christensen et al. 2007, IPCC 2013b). Increasing temperatures could make the monarch's current summer habitat unsuitable (Batalden et al. 2007, p. 1371).

In addition to threatening the migratory populations in North America, climate change could eradicate the peripheral monarch populations that are not part of the main eastern or western migrations such as the stationery population in south Florida and populations found outside the United States on Pacific Islands and in Australia. In Miami, Florida, for example, the mean monthly maximum temperature recorded at the Miami airport from 1961–1990 (April to September) was 31.7°C (Knight and Brower 2009, p. 821). This mean temperature is already high enough to have direct negative effects on monarch larvae (Rawlins and Lederhouse 1981, Zalucki 1982, York and Oberhauser 2002), and global climate change is expected to cause an increase in mean maximum temperatures throughout Florida (Alder and Hostetler 2013). From 2050-2074, the annual mean maximum temperature in Miami-Dade County is expected to increase by 4.1˚F, with models predicting mean temperature increases of 2.3˚F - 5.9˚F (Alder and Hostetler 2013). This increase would render the area unsuitable for monarchs and could eradicate the non-migratory resident monarch population. In many parts of Florida, temperatures may already often exceed the threshold that is lethal to developing monarchs (Knight and Brower 2009, p. 821). In Gainesville, for example, the mean monthly maximum temperature from 1961–1990 from April to September was 32.6°C (Ibid.). Even increases at the lowest end of predictions would make the Gainesville area unsuitable for breeding monarchs, as temperatures in Alachua County are expected to increase by a mean of 5.0˚F, with models predicting increases ranging from 2.5˚F-7.4˚F (Ibid). Other outlying monarch populations could also be wiped out by climate change impacts. Australia, for example, has suffered from a decade-long severe drought and climate change is predicted to increase drought conditions on the continent (Van Dijk et al. 2013). In addition to threats from rising temperatures, island populations are likely to decrease in size as rising seas eliminate habitat.

Increasing temperatures threaten monarchs with direct mortality, and also threaten to alter the distribution of milkweed, the monarch's sole host plant. Due to increasing temperatures, the distribution of common milkweed will likely shift northward, but the plant may not be able to colonize northward as rapidly as monarchs will require if they are displaced from the southern parts of their range due to increasing temperatures (Batalden et al. 2007, p. 1371). Southern species of milkweeds generally become less nutritious or die back during summer and so are unsuitable host plants for the summer generations of butterflies, including those that will migrate in the fall. Monarch breeding and migration are coordinated with and dependent on milkweed availability (Cockrell et al. 1993, Malcolm et al. 1993, Brower 1995, Howard and Davis 2004), making disruption in milkweed distribution a dire threat to their survival and reproductive success.

Climate change is also expected to cause increased frequency and intensity of drought, which threatens monarchs in several ways. Climate change models predict increasing drought and reduced water availability across much of temperate western North America by 2050 (Christensen et al. 2007; IPCC 2013b). Moreover, it is generally expected that the duration and intensity of droughts will increase in the future (Glick et al. 2011, p. 45). Drought has already been identified as a primary contributing factor in population declines of western monarchs (Stevens and Frey 2004, Stevens and Frey 2010, p. 733). Stevens and Frey (2010) found that variation in moisture availability (as measured by Palmer's drought severity index) predicted monarch abundance patterns across the western United States, and determined that moisture regimes act as a strong bottom-up driver of monarch population dynamics; essentially, years of severe drought across the western monarch breeding range were associated with the lowest monarch population estimates in the western United States (p. 731). Stevens and Frey (2010) suggest that drought reduces the abundance and quality of milkweed, thus leading to lower monarch populations. Milkweed quality for developing larvae deteriorates at high temperatures (Batalden et al. 2007, p. 1365). Drought reduces milkweed germination, survivorship, growth, and seed production (Stevens and Frey 2010, p. 740). Reduced water availability can also cause changes in the properties of milkweed plants. Milkweed plants with low water availability may cause declines in larval survival because the latex is more viscous and can make leaf-eating more difficult (Stevens and Frey 2010, p. 740).

Climate change also threatens monarchs in their winter ranges in California and Mexico. Monarchs east of the Rockies migrate to Mexico each fall where they overwinter in conifer forests in the Trans-Mexican Volcanic Belt. The monarchs require very specific habitat conditions in these forests so that they do not freeze or become too warm and break diapause. The climate change models for the monarch's overwintering habitat predict that the currently occupied habitat will become unsuitable for monarchs by the end of the century.

Saenz-Romero et al. (2012) found that, by the end of the century, the climate will no longer support the forested habitat conditions upon which monarchs depend for overwintering in Mexico. In this study, the authors projected the monarch's contemporary Mexican overwintering climate niche into future climates provided by three General Circulation Models and two greenhouse gas emission scenarios and found that the area occupied by the niche will diminish rapidly over the course of the century. They predicted a decrease of suitable conditions of 69.2 percent by the decade surrounding 2030, a decrease of 87.6 percent for that surrounding 2060, and a decrease of 96.5 percent by 2090 (p. 98). In Mexico by the end of the century, temperatures are expected to increase by an average of 3.7°C, and precipitation is expected to decrease by 18.2 percent (Ibid.). By 2100, suitable habitat for the monarch butterfly may no longer occur inside the Monarch Butterfly Biosphere Reserve (Ibid.). Drought is already causing tree loss and increased susceptibility to forest diseases within the Reserve (Saenz-Romero et al. 2012, p. 99).

Oberhauser and Peterson (2003) projected current monarch overwintering distribution onto future climate scenarios (Hadley Centre climate models) and found that conditions are likely to become inadequate to support monarchs across their entire current winter range in Mexico, particularly owing to increased cool-weather precipitation that could cause increased mortality (Oberhauser and Peterson 2003, p. 14063). For example, a winter storm in 2002 killed an estimated 468-500 million monarchs representing colony losses of 75 percent (Brower et al. 2004, p. 162). Oberhauser and Peterson (2003) predict that climate change effects will cause current overwintering sites to become considerably less suitable for monarchs by 2050; in fact, when current oyamel fir forest distribution was included in models to be projected to future climates, none of the present overwintering sites were predicted to be suitable in 50 years (Oberhauser and Peterson 2003, p. 14067).

Increased occurrence of severe weather events also threaten monarchs in their overwintering habitat where they cluster together in small areas, and the frequency of severe winter precipitation events that could kill monarchs is expected to increase with climate change (Brower et al. 2012a, p. 98). Barve et al. (2012) report a regional climate change signal in Mexican overwintering areas that is trending consistently toward conditions that are inimical to monarch survival including downward temperatures that put butterflies at risk of freezing during winter storms which are expected to increase in frequency (p. 820, 821). Shrinking of forested habitat areas due to logging, drought, and tree diseases further increases the risk of exposure of overwintering monarch clusters to hazardous weather conditions (Brower et al. 2011, p. 28).

Extreme weather events can kill large numbers of monarchs, as discussed in detail in the petition section Other Factors—Severe Weather and Stochastic Events, below. A recent compilation of climate change models predicts that the southern United States will become drier and that extreme events such as heavier storms, heat waves, and regional droughts, may become more frequent across the United States (Glick et al. 2011, p. 7, IPCC 2013b).

In contrast to the findings of other authors, in a recent population model Flockhart et al. (2014) assume that climate change in Mexican overwintering habitat will reduce mortality levels on the overwintering grounds, but some assumptions behind the model are likely to result in an underestimate of climate change threats (discussed further in the Population Status section of this petition). The model assumes that increasing overall temperatures will benefit monarchs by reducing the risk of freezing, but fails to take into account increased risk of stochastic weather events due to climate change, ongoing degradation of the monarch's forest habitat in Mexico which will alter microhabitat conditions, and climate change impacts which will harm forest health and decrease the climatic suitability of the habitat. The model also underestimates climate risk because it uses temperatures from weather stations that are on average 274 m (~900 ft) below the elevation at which butterflies cluster (Flockhart et al. 2014 supporting materials, p. 30). The model also fails to take into account the influence of predicted warmer temperatures on lipid depletion during overwintering which decreases monarch fitness and reproductive success.

In sum, climate change is a primary threat to monarch butterflies throughout their range. Climate change exacerbates the threat posed to monarchs from drought and other severe weather events, and the threat is heightened even further in light of drastically reduced population size due to recent population declines.

Severe Weather and Catastrophic Events

Periodic extreme weather conditions and catastrophic events have been identified as a primary threat to monarch butterflies (Slayback et al. 2007, p. 38, Brower et al. 2012a, p. 95, Vidal et al. 2013, p. 178). Monarchs are threatened by severe weather conditions and catastrophic events including high and low temperatures, drought, winds, storms, fires, and flooding. To complete their multi-generational migration, monarchs depend on moderate temperature conditions during the various stages of their life cycle, and aberrant temperatures can kill larvae and adults. Severe cold threatens the survivorship of overwintering monarchs, and spring and summer weather that is too cold or too hot lowers breeding season survivorship and fecundity and alters larval growth rates (York and Oberhauser 2002, p. 294, Brower et al. 2012a, p. 97).

Milkweed host plants are also sensitive to temperature extremes. Late frosts can kill milkweed shoots during the early breeding season for monarchs (Brower 2009). Droughts also harm milkweed both by resulting in fewer milkweed plants and by causing plants to be of lower quality (e.g. Craig, as quoted in Mulvaney 2013; *see also* Climate Change section of this petition, *supra*).

A series of severe weather conditions in recent years demonstrates the significant threat that stochastic weather poses to monarch survival, especially in light of drastically reduced population sizes due to other threat factors. For example, above normal temperatures in Texas in spring 2009 reduced first-generation migrating monarch numbers. Then below normal temperatures in the Midwest limited numbers of summer generations produced in the Corn Belt region. Combined, these aberrant climate factors severely reduced the number of butterflies in the migrating fall generation (Brower et al. 2012a, p. 97). Already at reduced numbers, the 2009-2010 overwintering monarch population in Mexico was subjected to record-breaking precipitation levels and heavy winds which blew down hundreds of oyamel fir trees in the core of the Monarch Reserve. In addition to habitat loss from flooding, landslides, and freezing temperatures, large numbers of butterflies were killed by the winter storms (Brower et al. 2012a, p. 98).

During winter when monarchs are clustered, stochastic events can kill the vast majority of the population. Calvert et al. (1983), Brower et al. (2004), and Brower et al. (2012a) document storm events that killed very large numbers of overwintering butterflies. A winter storm in 2002 killed an estimated 468-500 million monarchs representing colony losses of 75 percent (Brower et al. 2004, p. 162). When considering that a single winter storm event killed more than 450 million butterflies, it is important to note that the 2013-2014 eastern monarch overwintering population numbered only 35 million butterflies. The drastically reduced current population size of monarchs now makes the species even more vulnerable to catastrophic events.

Stochastic weather events kill monarchs directly and cause habitat degradation. Vidal et al. (2013) found that 115 ha of monarch overwintering grounds in Mexico were degraded by floods, winds, droughts, and fires from 2009-2011 (p. 182). Extreme drought in the monarch reserve from 2008-2011 is thought to have contributed to greater susceptibility to forest diseases and parasitic plants (Ibid.).

Drought has also contributed to declining abundance of monarch's west of the Rockies. Stevens and Frey (2010) attribute declining western monarch populations to increasing drought conditions in the western United States (p. 733). They found that variation in moisture availability, as measured by Palmer's drought severity index (PDSI), across the western region predicted monarch abundance patterns, and that moisture regimes act as a strong bottom-up driver of monarch abundance via resource availability in the western United States (p. 731). Furthermore, climate change models predict that drought severity will increase in large areas of temperate western North America, with 10-30 percent less precipitation and water availability by 2050 (Stevens and Frey 2010, p. 732).

Extreme weather conditions that impact monarchs have become much more frequent and intense in recent years and have contributed to significant reductions in monarch population size (Vidal et al. 2013, p. 179). Moreover, the frequency of severe weather events is expected to increase with climate change (Brower et al. 2012a, p. 98). Barve et al. (2012) used ecological niche estimates and future climate projections to estimate future monarch overwintering distributions and predicted that regional climate change in the monarch's overwintering grounds would result in increased monarch winter mortality because climate conditions in Mexican overwintering areas are trending consistently toward conditions inimical to monarch survival and extreme events appear to be increasing in frequency (Barve et al. 2012, p. 820). Models developed by Oberhauser and Peterson (2003) also predict increased winter season mortality and a likelihood of the monarch's entire current winter range becoming climatically unsuitable habitat for monarchs (Oberhauser and Peterson 2003, p. 14063).

Invasive Species

The spread of invasive species also poses a threat to monarch butterflies. Invasive fire ants prey on monarch eggs and larvae (Calvert 1996), as discussed above in the petition section on predation. Invasive exotic plants threaten monarchs by acting as a sink when oviposition occurs on plants that are unsuitable for larval development, and when invasive plants displace milkweeds.

Tropical or scarlet milkweed (*Asclepias curassavica*) is a non-native milkweed that is often planted in backyard gardens. In parts of the southern United States, *A. curassavica* has become naturalized and is considered invasive (Harvey et al. 2009). Its leaves do not die back at the end of summer as do native milkweeds, and this can have several negative effects on monarchs (McCord and Davis 2010, p. 415, Monarch Joint Venture 2014).

When migrating monarchs encounter tropical milkweed in the fall, they may stop migrating, break diapause and lay eggs, a common occurrence in Florida where tropical milkweed is continuously available (Knight and Brower 2009). Another negative consequence of tropical milkweed is that in the absence of winter dieback, spores of the parasite *Ophryocystis elektroscirrha* accumulate on leaves over time and spread infections to monarch larvae (Altizer et al. 2004). The non-migratory south Florida monarch population is thus heavily infected with the parasite (Altizer et al. 2000).

Invasive swallow-wort species also threaten monarchs by outcompeting and displacing native plant species, including milkweed, and by acting as a sink for monarch oviposition. There are two highly invasive swallow-wort species that are widely distributed in the United States—black swallow-wort (*Vincetoxicum nigrum*, synonym *Cynanchum louiseae L.)* and pale swallow-wort (*V. rossicum*, synonym *C. rossicum*). Black swallow-wort is found from Maine through Kansas and in California. Pale swallow-wort is discontinuously distributed from the Great Lakes through New England and the Mid-Atlantic States. Both swallow-wort species out compete milkweed and also serve as dead-end hosts for monarch oviposition because monarchs lay eggs on them due to chemical cues similar to milkweeds, but larvae do not survive (DiTommaso and Losey 2003, p. 205, Casagrande and Dacey 2007, p. 632, 635).

The threat posed to monarchs by invasive species is likely to be exacerbated by climate change, which is expected to facilitate the spread of exotic species (e.g. Dukes and Mooney 1999).

Mortality at Solar Energy Facilities

Monarch butterflies are threatened by mortality from solar arrays, particularly in southern California and the southwestern United States. In a study of bird mortality at three solar energy facilities in California, Kagan et al. (2014) documented significant monarch mortality at a solar site in Ivanpah, California (p. 2). The authors observed "hundreds upon hundreds" of dead butterflies and concluded that it appears that Ivanpah acts as a "mega-trap" for insects and in turn, insect-eating birds (p. 2, 20). Some butterfly carcasses were singed. Researchers deduced that the butterflies were attracted to a brightly lit area around the boiler at the top of facility (p. 20). Based on the large numbers of monarch carcasses observed at the facility, the authors conclude that solar power towers could have a significant impact on monarch populations in the desert southwest (p. 21). The threat posed to monarchs from solar facilities will likely increase in the future as more facilities are constructed.

Electromagnetic Noise

Monarchs may potentially be threatened by electromagnetic noise. Recent research has demonstrated that monarchs possess an internal magnetic compass, located in their antennae, which may help guide their migration (Guerra et al. 2014). In a recent paper, Guerra et al. (2014) note the possibility that electromagnetic noise emitted from various electronic devices could possibly impair the monarch's migratory ability:

> Taken as a whole, our study reveals another fascinating aspect of monarch butterfly migratory behaviour. Greater knowledge of the mechanisms underlying the fall migration may well aid in its preservation, currently threatened by climate change and by the continuing loss of milkweed and overwintering habitats. Another vulnerability to now consider is the potential disruption of the magnetic compass in monarchs by human-induced electromagnetic noise, which can apparently disrupt geomagnetic orientation in a migratory bird (Engels et al. 2014) (Guerra et al. 2014).

Electromagnetic noise from AM radio signals and some electronic equipment can disrupt the magnetic compasses that migratory birds use to navigate (Engels et al. 2014). Human-induced electromagnetic noise presents a potential threat to the monarch migration and should be further investigated.

SIGNIFICANT PORTION OF RANGE

As explained in detail above, the monarch butterfly, *Danaus plexippus plexippus*, is threatened range-wide with extinction in the foreseeable future due to loss and curtailment of habitat and range, disease, predation, other factors including climate change and pesticide use, and the lack of existing regulations to safeguard the butterfly. North American populations have declined precipitously and are threatened by all five listing factors. Populations outside of North America are also threatened with extinction due to a variety of factors including small population size, host plant eradication, development, disease, global climate change, stochastic weather events including drought and excessive heat, and sea-level rise. The monarch butterfly thus warrants listing due to range-wide threats. Should the Service conclude, however, that the monarch is not threatened range-wide, then the Service must examine whether the monarch is threatened in a significant portion of its range (SPR). The best available scientific information indicates that the monarch plainly is threatened with extinction in the foreseeable future in a significant portion of its range.

On July 1, 2014, the Service issued a Final Policy on Interpretation of the Phrase ‘‘Significant Portion of Its Range’’ in the Endangered Species Act’s Definitions of ‘‘Endangered Species’’ and ‘‘Threatened Species’’ (79 FR 37578). According to the policy, a portion of the range of a species is “significant” if its contribution to the viability of the species is so important that, without the members in that portion, the species would be in danger of extinction, or likely to become so in the foreseeable future, throughout all of its range.

As an initial matter, this definition violates the Endangered Species Act and relevant judicial precedent. In a case concerning the flat-tailed horned lizard (*Phrynosoma mcallii*), the Ninth Circuit Court of Appeals specifically rejected a definition of Significant Portion of Range that requires risk of extinction to the species as a whole, stating:

> If, however, the effect of extinction throughout ‘a significant portion of its range’ is the threat of extinction everywhere, then the threat of extinction throughout ‘a significant portion of its range’ is equivalent to the threat of extinction throughout all its range. Because the statute already defines ‘endangered species’ as those that are ‘in danger of extinction throughout all ... of [their] range,’ the Secretary's interpretation of ‘a significant portion of its range’ has the effect of rendering the phrase superfluous. Such a redundant reading of a significant statutory phrase is unacceptable. *Defenders of Wildlife, et al. v. Norton*, 258 F.3d 1136, 1145 (9th Cir. 2001).

In essentially defining the significant portion of range language out of existence, the Service’s new policy undercuts a critical component of the Act. Indeed, Congress expressly noted that the “significant portion of its range” provision marked “a significant shift in the definition in existing law which considers a species to be endangered only when it is threatened with worldwide extinction” (H.R.Rep. No. 412, 93rd Cong., 1 Sess. (1973).

The monarch is a case in point. As this petition demonstrates, the monarch is at risk of extinction in North America, but also occurs as an introduced species in a number of other parts of the world, including Europe, Australia and a number of island nations. A conclusion by the Service that the entire North American range of an iconic species like the monarch is not significant would provide the clearest of examples of the fact that the policy is fundamentally at odds with the purposes of the Endangered Species Act to protect species before they are at risk of “worldwide extinction” and to conserve the ecosystems upon which species depend.

Even under the overly restrictive revised policy, however, the North American monarch population qualifies as significant, and warrants listing as a threatened species. The policy describes the threshold for “significant” in terms of an increase in the risk of extinction for the species based on the principles of conservation biology using the concepts of redundancy, resiliency, and representation. The North American population of the monarch butterfly meets this standard of significance, because North America is the core of the monarch’s range and its loss would cause imperilment everywhere due to the exacerbated risk of extinction to the species if it were only represented by the peripheral, introduced, and vulnerable non-migratory populations found outside continental North America.

The North American monarch population is significant because without it, the redundancy, resiliency, and representation of the species would be so impaired that the monarch would have an increased vulnerability to threats to the point that the overall species would be likely to become endangered in the foreseeable future. The loss of the North American portion of the monarch’s range clearly would increase the vulnerability to extinction of the entire species. Monarch populations outside of North America are relatively small and less genetically diverse and already at risk of extinction from stochastic weather events, climate change, habitat loss from development and intentional host plant eradication, disease, sea-level rise, and other factors as discussed in Appendix A. The monarch population in North America is the heart of the species range and if it were to be lost, the species would be vulnerable to extinction on a global scale. In other words, the hypothetical loss of the North American monarch population would cause the species to become endangered, for several reasons: without the North American population, which harbors the vast majority of all monarchs, the population in the remainder of the monarch’s range would not be large enough to be resilient to environmental catastrophes or random variations in environmental conditions; the spatial structure of the entire species would be disrupted and only isolated tangential populations would remain; potentially important elements of genetic diversity would be lost; the overall redundancy, resiliency and representation of the species would be severely compromised.

Redundancy (having multiple populations distributed across the landscape; abundance, spatial distribution) provides a margin of safety for a species to withstand catastrophic events. Resiliency (abundance, spatial distribution, productivity) describes the characteristics of a species that allow it to recover from periodic disturbance. Representation (the range of variation found in a species; spatial distribution, diversity) ensures that a species’ adaptive capabilities are conserved. Redundancy, resiliency, and representation are not independent of each other, and some characteristic of a species or area may contribute to all three. For example, distribution across a wide variety of habitats is an indicator of representation, but it may also indicate a broad geographic distribution contributing to redundancy (decreasing the chance that any one event affects the entire species), and the likelihood that some habitat types are less susceptible to certain threats, contributing to resiliency (the ability of the species to recover from disturbance).

The North American monarch population is biologically significant because without it, the redundancy of the species would be drastically curtailed. North America is the core of the monarch's range and the North American population as recently as the mid-1990s numbered nearly one billion butterflies. The loss of milkweed due to increased spraying of particular herbicides and development and the degradation of overwintering sites has reduced the population to approximately 35 million butterflies as of winter 2013-2014. The migratory populations in eastern and western North America still represent the vast majority of all monarchs in the world. Though monarchs are found in relatively small, peripheral, and introduced populations in tropical and subtropical locations such as Bermuda, the Canary Islands, and Australia (*see* Appendix A), these non-migrating populations cannot conserve the spatial distribution of the species over the core of its range in North America, and are limited in population growth potential such that they cannot substitute for the abundance of the continental North American population.

In terms of resiliency, the North American monarch population is biologically significant because if it were to be lost, the resiliency of the species would be so reduced that the monarch would be at risk of extinction. North America is home to nearly all monarchs. Within North America, the population from east of the Rockies that overwinters in the mountains of Mexico is the largest monarch population in the world representing by far the majority of all monarchs. Within the eastern population, in the spring most monarchs breed in Texas, Oklahoma, Arkansas, and Kansas. Summer breeding occurs mainly in the Corn Belt states (Iowa, Illinois, Indiana, northern Missouri, Ohio), the eastern portions of the Northern Plains states (Kansas, Nebraska, South Dakota), and the southern parts of the Lake States (Minnesota, Michigan and Wisconsin) (Wassenaar and Hobson 1998, Miller et al. 2011, Flockhart et al. 2013). The Corn Belt states are particularly important for production of butterflies that will overwinter (Wassenaar and Hobson 1998, p. 15439). In population models, Flockhart et al. (2014, p. 15) found that at a regional scale total monarch abundance was most sensitive to changes in vital rates in this central eastern breeding region, and in the Corn Belt in particular (p. 18). They concluded (Flockhart et al. 2014, p. 16) that the loss of milkweed due to the increased use of pesticides on herbicide-resistant crops in the Midwest has increased the current and future extinction probability for monarchs. The Corn Belt region is pivotal to monarch resiliency because it is a source population for monarchs in other regions including along the East Coast and Florida, and also provides genetic influx to the western monarchs that migrate to Mexico in lieu of overwintering in California, and presumably to many of the peripheral populations (Appendix A).

Numerous scientific studies have identified the importance of the eastern monarch population in supporting other monarch populations in North America. Miller et al. (2011, p. 43) used isotope measurements to estimate natal origins of monarchs collected from 17 sites along the East Coast and found that 88 percent of the coastal monarchs had originated in the Midwest and Great Lakes regions before completing a west to east longitudinal migration across the Appalachian mountains. The Florida monarch population is also apparently supplemented by monarchs with Midwestern origins. Though non-migratory monarchs reside in southern Florida throughout the year, this population too receives an influx of individuals each fall from the eastern migratory population (Knight 1997, Altizer 2001). In addition, the demographic success of monarchs in the Corn Belt region is directly linked to overwintering population size in Mexico (Wassenaar and Hobson 1998, Oberhauser et al. 2001, Brower et al. 2012a, b; Flockhart et al. 2013, Pleasants and Oberhauser 2012). There is also strong evidence for significant mixing of eastern monarchs with the western monarch population in California (Lyons et al. 2012, p. 3341). The productivity of monarchs as a species is thus largely dependent on the monarchs in the eastern North American population.

Monarchs from the east, and some from the west, overwinter in a small area in the mountains of central Mexico where they are highly vulnerable to severe weather events and predation from birds and mice. In fact, winter storms and predation in some years have killed the majority of overwintering monarchs. If the overwintering population were lost due to stochastic events, climate change, or high levels of predation, the majority of the monarch's habitat in North America would be unoccupied the following summer, as the entire breeding range east of the Rockies would not be repopulated by remigration. The western population and resident southern populations are likely too small to provide this function, and are themselves vulnerable to development, disease, climate change, and other factors. Also, non-migrating populations in southern areas are not subject to environmental cues that would cause them to migrate long distances in spring to re-populate the full range (e.g. Guerra and Reppert 2013).

Moreover, there is no question that the resiliency of monarchs as a species would be at risk if the North American population overall were to be lost. Without the North American population, the survival of monarchs as a species would be dependent on isolated, introduced, vulnerable populations that are themselves threatened with extinction. In Australia, for example, the monarch population has declined below the 1960s population size and is threatened by coastal development, active removal of milkweed by ranchers, severe drought, and record heat waves. Monarchs have narrow thermal tolerance, and populations in tropical and sub-tropical areas are vulnerable to rising temperatures from climate change and also to severe storm events, drought, and sea-level rise.

In terms of representation, the North American monarch population is biologically significant because the spatial distribution and diversity of the species would be severely disrupted without it. The continental North American population harbors high genetic diversity and the migrations and intermingling of the eastern and western populations maintain genetic diversity that has been lost in peripheral and isolated populations from other areas. For example, Hawaiian monarchs are smaller than North American migratory monarchs, and microsatellite markers show that Hawaiian monarchs are genetically distinct from those in North America and New Zealand (Pierce et al. 2014, p. 2). The range of variation, spatial distribution, and diversity of monarchs as a species are dependent on the survival of North American monarchs. The overall North American population of monarchs is biologically significant, and within this population, the eastern migratory population is also biologically significant. The redundancy, resiliency, and representation of the monarch species would be gravely compromised without North American monarchs.

After determining that the North American monarch population constitutes a significant portion of the species' range, the Service must then examine whether the North American SPR is threatened by any of the five listing factors. As discussed in detail in previous sections of this petition *supra*, monarch butterflies in eastern and western North America have undergone precipitous decline and are threatened by modification or curtailment of habitat and range, disease and predation, overutilization, other factors including climate change, pesticides, and severe weather events, and by a lack of existing regulations which would be adequate to safeguard the species. The monarch is threatened range-wide, and in addition, there is no question that the monarch is severely threatened in the North American portion of its range.

Though the newly finalized SPR policy is overly restrictive and illegal, even under that new policy, the North American monarch qualifies as significant. In addition, when examined under the original policy, there is no doubt that the North American monarch qualifies as a significant population. The Endangered Species Act defines an endangered species as "any species which is in danger of extinction throughout all or a significant portion of its range" and a threatened species as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The language of the statute, legislative history, congressional intent, and relevant judicial precedent all instruct that a species need not be at risk of worldwide extinction to qualify for Endangered Species Act protection. Rather, as noted in the draft policy, a species can qualify as an endangered species in two ways: if it is in danger of extinction "throughout all of its range," or if it is in danger of extinction "in a significant portion of its range." In enacting this provision, Congress intended to provide a means to protect species before they are on the brink of extinction, which is of paramount importance to species conservation.

In sum, the monarch butterfly is threatened with extinction across its range and thus whether it is threatened in a significant portion of its range is ancillary. The monarch, however, is threatened with extinction in a significant portion of its range, the North American population, and meets the threshold of significance as defined in the July 2014 SPR policy and under the original interpretation of the SPR policy.

CONCLUSION

The Endangered Species Act requires that the Service promptly issue an initial finding as to whether this petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. § 1533(b)(3)(A). There is no question that under the five listing factors of the Act, protecting the monarch butterfly may be warranted. The monarch is threatened by loss or curtailment of habitat or range, disease and predation, and other factors including global climate change, pesticides, and drought. There are no existing regulatory mechanisms which are adequate to protect the monarch butterfly. The Service must act promptly to protect this iconic species and to designate critical habitat in order to reverse its precipitous decline and to plan for the monarch's long-term survival and recovery.

REQUEST FOR CRITICAL HABITAT DESIGNATION

Petitioners urge the Service to designate critical habitat for the monarch butterfly concurrently with its listing. Critical habitat as defined by Section 3 of the ESA is: (i) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) the specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species. 16 U.S.C. § 1532(5).

Congress recognized that the protection of habitat is essential to the recovery and/or survival of listed species, stating that: "classifying a species as endangered or threatened is only the first step in ensuring its survival. Of equal or more importance is the determination of the habitat necessary for that species' continued existence… If the protection of endangered and threatened species depends in large measure on the preservation of the species' habitat, then the ultimate effectiveness of the Endangered Species Act will depend on the designation of critical habitat." H. Rep. No. 94-887 at 3 (1976).

Critical habitat is an effective and important component of the ESA, without which the monarch's chance for survival diminishes. Petitioners thus request that the Service propose critical habitat for the butterfly concurrently with its proposed listing.

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WORKS CITED

Ackery, P.R., and R.I. Vane-Wright. 1984. Milkweed butterflies, their cladistics and biology, being an account of the natural history of the Danainae, a subfamily of the Lepidoptera, Nymphalidae. British Museum (Natural History). 425 pp.

Agrawal, A.A., G. Petschenka, R.A. Bingham, M.G. Weber, and S. Rasmann. 2012. Toxic cardenolides: chemical ecology and coevolution of specialized plant-herbivore interactions. New Phytologist 194:28–45. Available from http://doi.wiley.com/10.1111/j.1469-8137.2011.04049.x (accessed June 11, 2013).

Alder, J.R. and S.W. Hostetler. 2013. USGS National Climate Change Viewer. U.S. Geological Survey. Available from http://www.usgs.gov/climate_landuse/clu_rd/nccv.asp (accessed June 16, 2014).

Altizer, S., L. Brower, E. Howard, and K. Oberhauser. 2014. Concerns about Mass-rearing and Selling of Monarchs. Website. Available from http://www.learner.org/jnorth/tm/monarch/conservation_action_release.html (accessed August 20, 2014).

Altizer, S., and A.K. Davis. 2010. Populations of Monarch butterflies with different migratory behaviors show divergence in wing morphology. Evolution 64:1018–1028. Available from http://doi.wiley.com/10.1111/j.1558-5646.2010.00946.x (accessed June 11, 2013).

Altizer, S.M., and J. de Roode. 2010. When butterflies get bugs: the ABCs of lepidopteran disease. American Butterflies 18:16–27. Available from http://inst-149.mycorphosting.com/pubs/ab182/ab182diseases_of_monarchs_and_other_butterflies.pdf (accessed August 29, 2013).

Altizer, S.M., K. Oberhauser, and L.P. Brower. 2000. Associations between host migration and the prevalence of a protozoan parasite in natural populations of adult monarch butterflies. Ecological Entomology 25:125–139.

Altizer, S. M., K.S. Oberhauser, and K.A. Geurts. 2004. Transmission of the Protozoan parasite *Ophryocystis elektroscirrha* in Monarch Butterfly Populations: Implications for Prevalence and Population-Level Impacts. Pages 203 – 218 in K.S. Oberhauser and M.J. Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Anderson, J.B., and L.P. Brower. 1993. Cold-hardiness in the annual cycle of the monarch butterfly. Pages 157 – 164 in S.B. Malcolm and M.P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

Anderson, J.B., and L.P. Brower. 1996. Freeze-protection of overwintering monarch butterflies in Mexico: critical role of the forest as a blanket and an umbrella. Ecological Entomology 21:107–116. Available from http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2311.1996.tb01177.x/abstract (accessed March 24, 2014).

Arellano, A., J. I. Glendinning, J.B. Anderson, and L.P. Brower. 1993. Interspecific Comparisons of the Foraging Dynamics of Black-backed Orioles and Black-headed Grosbeaks on Overwintering Monarch Butterflies in Mexico. Pages 315 – 322 in S.B. Malcolm and M.P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

Association of American Pesticide Control Officials (AAPCO). 1999. 1999 Pesticide Drift Enforcement Survey. Available from http://www.aapco.org/documents/surveys/drift99.html (accessed August 20, 2014).

Association of American Pesticide Control Officials (AAPCO). 2005. 2005 Pesticide Drift Enforcement Survey. Available from http://www.aapco.org/documents/surveys/DriftEnforce05Rpt.html (accessed August 20, 2014).

Baldwin, F.L. 2010. Herbicide drift damaging rice. Delta Farm Press, June 7, 2010. Available from http://deltafarmpress.com/rice/herbicide-drift-damaging-rice-0607/ (accessed August 20, 2014).

Baldwin, F.L. 2011. Glyphosate drift damage to wheat extensive. Delta Farm Press, 4/20/11. Available from http://deltafarmpress.com/wheat/glyphosate-drift-damage-wheat-extensive (accessed August 20, 2014).

Bartel, R.A., K.S. Oberhauser, J.C. De Roode, and S. M. Altizer. 2011. Monarch butterfly migration and parasite transmission in eastern North America. Ecology 92:342–351. Available from http://www.esajournals.org/doi/abs/10.1890/10-0489.1 (accessed June 11, 2013).

Barve, N., A. J. Bonilla, J. Brandes, J. C. Brown, N. Brunsell, F. V. Cochran, R. J. Crosthwait, J. Gentry, L. M. Gerhart, T. Jackson, A. J. Kern, K. S. Oberhauser, Hannah L. Owens, A. T. Peterson , A. S. Reed, J. Soberón, A. D. Sundberg and L. M. Williams. 2012. Climate-change and mass mortality events in overwintering monarch butterflies. Revista Mexicana de Biodiversidad 83:817-824. Available from http://www.revistas.unam.mx/index.php/bio/article/view/26460 (accessed August 29, 2013).

Batalden, R.V., K. Oberhauser, and A.T. Peterson. 2007. Ecological Niches in Sequential Generations of Eastern North American Monarch Butterflies (Lepidoptera: Danaidae): The Ecology of Migration and Likely Climate Change Implications. Environmental Entomology 36:1365–1373.

Bayer CropScience. 2007. Core Tect Tree and Shrub Tablets Insecticide, Label.

Bayer CropScience. 2010. Gaucho 600 Flowable Insecticide, Label.

Behrens R. and W.E. Lueschen. 1979. Dicamba volatility. Weed Science 27: 486–493.

Benbrook, C. 2009. Impacts of Genetically Engineered Crops on Pesticide Use: The First Thirteen Years. The Organic Center, November 2009. Available from http://www.organic-center.org/reportfiles/GE13YearsReport.pdf (accessed August 20, 2014).

Benbrook, C.M. 2012. Impacts of genetically engineered crops on pesticide use in the U.S. - the first sixteen years. Environmental Sciences Europe 24:24. Available from http://www.enveurope.com/content/24/1/24 (accessed August 20, 2014).

Bennett, D. 2006. 2,4-D herbicide drift damage stuns east Arkansas cotton. Delta Farm Press, 8/11/06. Available from http://deltafarmpress.com/24-d-herbicide-drift-damage-stuns-east-arkansas-cotton (accessed August 20, 2014).

Bennett, D. 2008. Damaging herbicide drift can travel far. Delta Farm Press, 7/24/08. Available from http://deltafarmpress.com/damaging-herbicide-drift-can-travel-far (accessed August 20, 2014)

Bhowmik, P.C. 1994. Biology and control of common milkweed (*Asclepias syriaca*). Reviews in Weed Science 6:227 – 250.

Bilney, R.J., R. Cooke, and J.G. White. 2009. Underestimated and severe: small mammal decline from the forests of south-eastern Australia since European settlement, as revealed by a top-order predator. Biological Conservation 143:52–59.

Blackburn, L. G., and C. Boutin. 2003. Subtle effects of herbicide use in the context of genetically modified crops: A case study with glyphosate (Roundup®). Ecotoxicology 12:271–285. Available from http://link.springer.com/article/10.1023/A%3A1022515129526 (accessed May 6, 2013).

Blacquière, T., G. Smagghe, C.A. Van Gestel, and V. Mommaerts, 2012. Neonicotinoids in bees: a review on concentrations, side-effects and risk assessment. Ecotoxicology, 21(4): 973-992.

Bohnenblust E. 2014. Biotechnology and insect management in field crop agroecosystems. Ph.D. Dissertation, Department of Entomology, The Pennsylvania State University.

Bohnenblust E., J.F. Egan, D. Mortensen, and J. Tooker. 2013. Direct and indirect effects of the synthetic auxin herbicide dicamba on two lepidopteran species. Environmental Entomology 42:586–594.

Bolger, D., W. Newmark, T. Morrison, and D. Doak. 2008. The need for integrative approaches to understand and conserve migratory ungulates. Ecology Letters 11(1):63-77.

Boppré, M. 1993. The American Monarch: Courtship and Chemical Communication of a Peculiar Danaine Butterfly. Pages 29 – 41 in S. B. Malcolm and M. P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

Borland, J., C.C. Johnson, T.W. Crumpton III, M. Thomas, S.M. Altizer, and K.S. Oberhauser. 2004. Characteristics of fall migratory monarch butterflies, *Danaus plexippus*, in Minnesota and Texas. Pages 97 – 104 in K.S. Oberhauser and M.J. Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Bossard, C.C., J.M. Randall, and M.C. Hoshovsky. 2000. Invasive plants of California's wildlands. University of California Press, Berkeley.

Boutin C., and B. Jobin. 1998. Intensity of agricultural practices and effects on adjacent habitats. Ecological Applications 8:544 – 557.

Boutin, C., B. Strandberg, D. Carpenter, S.K. Mathiassen, and P.J. Thomas. 2014. Herbicide impact on non-target plant reproduction: What are the toxicological and ecological implications? Environmental Pollution 185:295-306.

Brooks, K.N., P.F. Ffolliott, H.M. Gregersen, and L.F. DeBano. 1997. Hydrology and the management of watersheds. Iowa State University Press, Ames.

Brower, A.V. Z., and M. M. Jeansonne. 2004. Geographical Populations and “Subspecies” of New World Monarch Butterflies (Nymphalidae) Share a Recent Origin and Are Not Phylogenetically Distinct. Annals of the Entomological Society of America 97:519–523. Available from http://openurl.ingenta.com/content/xref?genre=article&issn=0013-8746&volume=97&issue=3&spage=519 (accessed June 11, 2013).

Brower, A.V.Z., N. Wahlberg, J. R. Ogawa, and Boppré, M. 2010. Phylogenetic relationships among genera of danaine butterflies (Lepidoptera: Nymphalidae) as implied by morphology and DNA sequences. Systematics and Biodiversity 8:75–89. Available from http://nymphalidae.utu.fi/Ároweretal2010.pdf (accessed June 12, 2013).

Brower, L.P. 1984. Chemical defence in butterflies. Pages 109 – 134 in Vane-Wright, R.I. and P.R. Ackery, eds. The Biology of Butterflies. London: Academic Press

Brower, L.P. 1995. Understanding and misunderstanding the migration of the monarch butterfly (Nymphalidae) in North America: 1857-1995. Journal of the Lepidopterists Society 49:304–385. Available from http://images.peabody.yale.edu/lepsoc/jls/1990s/1995/1995-49(4)304-Brower.pdf (accessed August 20, 2014).

Brower, L.P. (2001) Canary in the cornfield: the monarch and the Bt corn controversy. Orion Magazine 20: 32–41.

Brower, L.P. 2009, April 9. Dr. Brower finds frozen milkweed in Florida. Available from http://www.learner.org/jnorth/tm/monarch/Brower_FL_040909.html (accessed August 20, 2014).

Brower, L. P. and W. H. Calvert. 1985. Foraging dynamics of bird predators on overwintering monarch butterflies in Mexico. Evolution (1985): 852-868.

Brower, L.P., G. Castilleja, A. Peralta, J. Lopez-Garcıa, L. Bojorquez-Tapia, S. Dıaz, D. Marmolejo, and M. Missrie. 2002. Quantitative changes in forest quality in a principal overwintering area of the monarch butterfly in Mexico, 1971–1999. Conservation Biology 2:346–359

Brower.L.P., L.S. Fink, R. Kiphart, V.M. Pocius, R.R. Zubieta-Hernández, and M.I. Ramirez. In press. The effect of the 2010 – 21011 drought on the lipid content of monarch butterflies (*Danaus plexippus* L., Danainae) migrating through Texas to their overwintering sites in Mexico. In Oberhauser, K.S. and K. Nail, editors. Monarchs in a Changing World: Biology and Conservation of an Iconic Insect. Ithaca: Oxford University Press.

Brower, L.P., L.S. Fink, A. Van Zandt Brower, K. Leong, K. Oberhauser, S. Altizer, O. Taylor, D. Vickerman, W.H. Calvert, T. Van Hook, A. Alonso-Mejia, S.B. Malcolm, D.F. Owen, and M..P.Zalucki. 1995. On the dangers of interpopulational transfers of monarch butterflies. Bioscience 45(8):540-544.

Brower, L.P., L.S. Fink, and P. Walford. 2006. Fueling the fall migration of the monarch butterfly. Integrative and Comparative Biology 46:1123–1142. Available from http://icb.oxfordjournals.org/cgi/doi/10.1093/icb/icl029 (accessed June 11, 2013).

Brower, L.P., B.E. Horner, M.A. Marty, C.M. Mofir, and B. Villa R. 1985. Mice (*Perocmyscus maniculatus, P. spicilegus, Microtus mexicanus*) as predators of overwintering monarch butterflies (*Danaus plexippus*) in Mexico. Biotropica 17(2):89-99.

Brower, L.P., D.R. Kust, E.R. Salinas, E. Garcia-Serrano, K.R. Kust, J. Miller, C.F. del Rey, and K. Pape. 2004. Catastrophic Winter Storm Mortality of Monarch Butterflies in Mexico during January 2002. Pages 151 – 166 in K. S. Oberhauser and M. J. Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Brower, L.P., K.S. Oberhauser, M. Boppré, A.V. Brower, and R.I. Vane-Wright. 2007. Monarch sex: ancient rites, or recent wrongs. Antenna, London 31:12–18. Available from https://www.monarchlab.org/Lab/app/upload/pdf/RB-4%20Brower%20at%20al%20Monarch%20Sex%20Antenna%202007.pdf (accessed June 11, 2013).

Brower, L. P., and R. M. Pyle. 2004. The Interchange of Migratory Monarchs between Mexico and the Western United States, and the Importance of Floral Corridors to the Fall and Spring Migrations. Pages 144 – 166 in G. P. Nabhan, editor. Conserving Migratory Pollinators and Nectar Corridors in Western North America. University of Arizona Press and The Arizona-Sonora Desert Museum, Tuscon.

Brower, L.P., O.R. Taylor, E.H. Williams, D.A. Slayback, R.R. Zubieta, and M.I. Ramírez. 2012a. Decline of monarch butterflies overwintering in Mexico: is the migratory phenomenon at risk? Insect Conservation and Diversity 5:95–100. Available from http://doi.wiley.com/10.1111/j.1752-4598.2011.00142.x (accessed May 31, 2013).

Brower, L.P., O R. Taylor, and E.H. Williams. 2012b. Response to Davis: choosing relevant evidence to assess monarch population trends. Insect Conservation and Diversity 5:327–329. Available from http://doi.wiley.com/10.1111/j.1752-4598.2011.00176.x (accessed May 31, 2013).

Brower, L.P., E.H. Williams, L.S. Fink, D.A. Slayback, M.I. Ramirez, M.V.L. Garcia, R.R. Zubieta, S.B. Weiss, W.H. Calvert, and W. Zuchowski. 2011. Overwintering clusters of the monarch butterfly coincide with the least hazardous vertical temperatures in the oyamel forest. Journal of the Lepidopterists' Society 65:27–46. Available from http://images.peabody.yale.edu/lepsoc/jls/2010s/2011/2011-65-1-027.pdf (accessed August 29, 2013).

Brown, T., S. Kegley, L. Archer, T. Finck-Haynes, and B. Olivastri. 2014. Gardener's beware: Bee-toxic pesticides found in "bee-friendly" plants sold at garden centers across the U.S. and Canada. Report. 65 pp. Available from http://libcloud.s3.amazonaws.com/93/3a/3/4738/GardenersBewareReport_2014.pdf (accessed August 6, 2014).

Bryden, J., R.J. Gill, R.A. Mitton, N.E. Raine, and V.A. Jansen. 2013. Chronic sublethal stress causes bee colony failure. Ecology Letters, 16(12): 1463-1469.

Butterfield, H.M. 1935. The introduction of *Eucalyptus* into California. Madrono 3:149-154.

California Department of Pesticide Regulation. 2014. Summary of Pesticide Use Report Data 2012 Indexed by Chemical. 726 pp. Available from http://www.cdpr.ca.gov/docs/pur/pur12rep/chmrpt12.pdf (accessed August 6, 2014).

California Natural Diversity Database (CNDDB). 2012. California Department of Fish and Game. Available from http://www.dfg.ca.gov/biogeodata/cnddb/ (accessed August 6, 2014).

Calvert, W. H. 1996. Fire ant predation on monarch larvae (Nyphalidae: Danainae) in a Central Texas prairie. Journal of the Lepidopterists' Society 50:149 – 151.

Calvert, W.H., L.E. Hedrick, and L.P. Brower. 1979. Mortality of the monarch butterfly (Danaus plexippus L.): avian predation at five overwintering sites in Mexico. Science 204:847 – 851.

Calvert, W. H., W. Zuchowski and L. P. Brower. 1983. The effect of rain, snow and freezing temperatures on overwintering monarch butterflies in Mexico. Biotropica 15:42-47.

Cameron, S.A., J.D. Lozier, J.P. Strange, J.B. Koch, N. Cordes, L.F. Solter, T.L. Griswold, and G.E. Robinson. 2011. Patterns of widespread decline in North American bumble bees. Proceedings of the National Academy of Sciences 108(2):662-667.

Cappiello, D. and M. Apuzzo. 2013. The secret environmental cost of U.S. ethanol policy. Associated Press, November 12, 2013.

Casagrande, R.A., and J.E. Dacey. 2007. Monarch Butterfly Oviposition on Swallow-Worts (*Vincetoxicum* spp.). Environmental Entomology 36:631–636. Available from http://openurl.ingenta.com/content/xref?genre=article&issn=0046-225X&volume=36&issue=3&spage=631 (accessed June 11, 2013).

Center for Food Safety (CFS). 2012a. Comments to EPA on Application to Register New Use of Dicamba on Dicamba and Glufosinate Resistant MON 87701 Cotton, and to Establish Tolerances for Residues of Dicamba in Cottonseed and Cotton Gin Byproducts. Available from http://www.centerforfoodsafety.org/files/cfs-science-comments-on-dicamba-use-registration-for-cotton-date-corrected_45293.pdf (accessed August 20, 2014).

Center for Food Safety (CFS). 2012b. Comments to USDA APHIS on Draft Environmental Assessment and Draft Plant Pest Risk Assessment for Dow AgroSciences Petition (09-349-01p) for Determination of Nonregulated Status of Event DAS-68416-4: 2,4-D- and glufosinate-resistant soybean. Available from http://www.centerforfoodsafety.org/files/cfs-24-d-soy-science-comments-final-9-11-12_11171.pdf (accessed August 20, 2014).

Center for Food Safety (CFS). 2012c. Comments to EPA on Notice of Receipt of Application to Register New Use of Dicamba on Monsanto's Dicamba-Resistant MON 87708 Soybean, Center for Food Safety, Sept. 21, 2012. Available from http://www.centerforfoodsafety.org/files/cfs-science-comments-on-dicamba-use-registration-for-dicamba-resistant-soybeans.pdf (accessed August 20, 2014).

Center for Food Safety (CFS). 2014a. Herbicide Resistant Crops and the Decline of Monarch Butterflies in North America. Report, in preparation.

Center for Food Safety (CFS). 2014b. Comments to USDA APHIS on Draft Environmental Impact Statement for Determination of Nonregulated Status of Herbicide Resistant Corn and Soybeans: Science Comments I, Docket APHIS-2013-0042. Available from http://www.centerforfoodsafety.org/files/cfs-enlist-draft-eis-science-comments-i_77655.pdf (accessed August 20, 2014).

Chapco, W. and G. Litzenberger. 2004. A DNA investigation into the mysterious disappearance of the Rocky Mountain grasshopper, mega-pest of the 1800s. Molecular Phylogenetics and Evolution 30:810–814.

Chaplin, S.B. and P.H. Wells. 1982. Energy reserves and metabolic expenditures of monarch butterflies overwintering in southern California. Ecological Entomology 7:249-256.

Charpentier, G., F. Louat, J.M. Bonmatin, P.A. Marchand, F. Vanier, D. Locker, and M. Decoville. 2014. Lethal and sublethal effects of imidacloprid, after chronic exposure, on the insect model *Drosophila melanogaster*. Environmental Science and Technology 48(7): 4096–4102.

Chawkins, S. 2010. Anger flutters over 'butterfly town, USA'. L.A. Times. Available from http://articles.latimes.com/2010/aug/29/local/la-me-butterflies-20100829 (accessed August 6, 2014).

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, R. Held, R. Jones, R.K. Kolli, W.K. Kwon, R. Laprise, V. Magana Rueda, L. Mearns, C.G. Menendez, J. Räisänen, A. Rinke, A. Sarr, P. Whetton, R. Arritt, R. Benestad, M. Beniston, D. Bromwich, D. Caya, J. Comiso, R. ,de Elia, and K. Dethloff. 2007. Regional climate projections , Climate Change, 2007: The Physical Science Basis. Contribution of Working group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, University Press, Cambridge, Chapter 11, ISBN: 978-0-521-88009-1 .

Clarke, A.R., and M.P. Zalucki. 2004. Monarchs in Australia: on the winds of a storm? Biological Invasions 6:123–127. Available from http://link.springer.com/article/10.1023/B%3ABINV.0000010120.29634.db (accessed June 11, 2013).

Cleary Chemical Corporation. 2006. TriStar 30 SG Insecticide, Specimen Label.

Cline, H. 2012. SJV phenoxy drift cotton damage widespread. Western Farm Press, 6/14/2012. Available from http://westernfarmpress.com/cotton/sjv-phenoxy-drift-cotton-damage-widespread (accessed August 20, 2014)..

Cockrell, B.J., S.B. Malcolm, and L.P. Brower. 1993. Time, temperature, and latitudinal constraints on the annual recolonization of eastern North America by the monarch butterfly. Pages 233 – 251 in S.B. Malcolm and M.P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

Commission for Environmental Cooperation. 2008. North American monarch conservation plan. Communications Dept. of the CEC Secretariat, Montréal, Québec. Available from http://purl.access.gpo.gov/GPO/LPS96018 (accessed June 11, 2013).

Commission for Environmental Cooperation. 2009. Monarch Butterfly Monitoring in North America: Overview of Initiatives and Protocols. Available from http://www.mlmp.org/Resources/pdf/Monarch-Monitoring_en.pdf (accessed June 11, 2013).

COSEWIC. 2010. COSEWIC assessment and status report on the Monarch *Danaus plexippus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 43 pp. Available from http://publications.gc.ca/collections/collection_2011/ec/CW69-14-597-2010-eng.pdf (accessed August 20, 2014).

Cox, C. 1993. Carbaryl. Journal of Pesticide Reform13 (1), Spring 1993. Northwest Coalition for Alternatives to Pesticides, Eugene, OR.

Cramer, G.L. and O.C. Burnside. 1980. Common milkweed - weed on the increase. Weeds Today 11: 19-20.

Cramer, G.L., and O.C. Burnside. 1981. Control of common milkweed (*Asclepias syriaca*). Weed Science 29(6):636–640. Available from http://www.jstor.org/stable/4043469 (accessed March 11, 2014).

Cutler P, R. Slater, A.J. Edmunds, P. Maienfisch, R.G. Hall, F.G. Earley, T. Pitterna, S. Pal, V-L. Paul, J. Goodchild, M. Blacker, L. Hagmann, and A.J. Crossthwaite. 2012. Investigating the mode of action of sulfoxaflor: a fourth-generation neonicotinoid. Pest Management Science 69(5): 607-619.

Davis, A.K., and M.S. Garland. 2004. Stopover Ecology of Monarchs in Coastal Virginia: Using Ornithological Techniques to Study Monarch Migration. Pages 89 – 96 in K.S. Oberhauser and M.J. Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Davis, A.K., and E. Howard. 2005. Spring recolonization rate of monarch butterflies in eastern North America: new estimates from citizen-science data. Journal of the Lepidopterists' Society 59:1–5. Available from http://images.peabody.yale.edu/lepsoc/jls/2000s/2005/2005(1)1-Davis.pdf (accessed March 25, 2014).

Davis, A.K., N.P. Nibbelink, and E. Howard. 2012. Identifying Large- and Small-Scale Habitat Characteristics of Monarch Butterfly Migratory Roost Sites with Citizen Science Observations. International Journal of Zoology 2012:1–9. Available from http://www.hindawi.com/journals/ijz/2012/149026/ (accessed August 29, 2013).

Davis, A.K., and E. Rendon-Salinas. 2010. Are female monarch butterflies declining in eastern North America? Evidence of a 30-year change in sex ratios at Mexican overwintering sites. Biology Letters 6:45–47. Available from http://rsbl.royalsocietypublishing.org/cgi/doi/10.1098/rsbl.2009.0632 (accessed March 25, 2014).

de Roode, J.C., J. Chi, R.M. Rarick, and S. Altizer. 2009. Strength in numbers: high parasite burdens increase transmission of a protozoan parasite of monarch butterflies (*Danaus plexippus*). Oecologia 161(1): 67-75.

de Roode J.C., L.R. Gold, S. Altizer. 2007. Virulence determinants in a natural butterfly–parasite system. Parasitology 134:657–668.

de Roode, J.C., A.J. Yates, and S. Altizer. 2008. Virulence-transmission trade-offs and population divergence in virulence in a naturally occurring butterfly parasite. Proceedings of the National Academy of Sciences 105(21): 7489-7494.

Dickman, C.R., 2007. A Fragile Balance. The Extraordinary Story of Australian Marsupials. Craftsman House, Melbourne.

Dingle, H., M.P. Zalucki, W.A. Rochester, and T. Armijo-Prewitt. 2005. Distribution of the monarch butterfly, *Danaus plexippus* (L.)(Lepidoptera: Nymphalidae), in western North America. Biological Journal of the Linnean Society 85:491–500. Available from http://onlinelibrary.wiley.com/doi/10.1111/j.1095-8312.2005.00512.x/full (accessed August 29, 2013).

DiTommaso, A., and J.E. Losey. 2003. Oviposition preference and larval performance of monarch butterflies (*Danaus plexippus*) on two invasive swallow-wort species. Entomologia Experimentalis et Applicata 108:205–209. Available from http://onlinelibrary.wiley.com/doi/10.1046/j.1570-7458.2003.00089.x/full (accessed June 11, 2013).

Dockx, C. 2002. Migration of the North American Monarch *Danaus plexippus* to Cuba. Ph.D. University of Florida.

Dockx, C. 2007. Directional and stabilizing selection on wing size and shape in migrant and resident monarch butterflies, *Danaus plexippus* (L.), in Cuba. Biological Journal of the Linnean Society 92:605–616. Available from http://onlinelibrary.wiley.com/doi/10.1111/j.1095-8312.2007.00886.x/full (accessed June 11, 2013).

Dockx, C. 2012. Differences in phenotypic traits and migratory strategies between eastern North American monarch butterflies, *Danaus plexippus* (L.). Biological Journal of the Linnean Society 106:717–736. Available from http://onlinelibrary.wiley.com/doi/10.1111/j.1095-8312.2012.01916.x/full (accessed June 11, 2013).

Dodds, D.M., J.T. Irby, J.A. Huff, D.B. Reynolds. 2007. Assessment of glyphosate drift on corn (*Zea mays*) utilizing multispectral aerial imagery. Abstract of presentation at the Weed Science Society of America Annual Meeting, 2007, Abstract 7. http://wssa.net/meeting/meeting-abstracts/ (accessed August 20, 2014).

Doll, J. 1998. How weeds have changed over 20 years. Proceedings of the Wisconsin Fertilizer, AgLime, and Pest Management Conference, Vol. 37: 144-147. http://fyi.uwex.edu/weedsci/1998/11/12/how-weeds-have-changed-over-20-years/.

Doll, J. D. 2001. Transgenic crops: are milkweeds and butterflies in trouble? Available from http://www.soils.wisc.edu/extension/wcmc/proceedings01/Doll-1.PDF (accessed May 31, 2013).

Doohan, D. and Mohseni-Moghadam. 2014. Response of broccoli and pepper to simulated drift of 2,4-D and dicamba. Weed Science Society of America Annual Meeting, 2014. http://wssaabstracts.com/public/22/abstract-308.html

Duke, S.O., A.L. Cerdeira, and M.B. Batallo. 2007. Herbicide effects on plant disease. Outlooks in Pest Management 18(1): 36-40.

Duke, S.O. and S.B. Powles. 2008. Glyphosate: a once-in-a-century herbicide. Pest Management Science 64: 319-325.

Dukes, J.S. and H.A. Mooney. 1999. Does global change increase the success of biological invaders? Trends in Ecology and Evolution 14(4): 135-139.

D'urban, W.S.M. 1857. Article 31. Description of four species of Canadian butterflies, continued. Canadian Naturalist and Geologist 2(5):345-355.

Egan, J.F., K.M. Barlow, and D.A. Mortensen. 2014a. A Meta-Analysis on the Effects of 2,4-D and Dicamba Drift on Soybean and Cotton. Weed Science 62:193–206. Available from http://www.bioone.org/doi/abs/10.1614/WS-D-13-00025.1 (accessed January 22, 2014).

Egan, J.F., E.Bohnenblust, S. Goslee, D. Mortensen, and J. Tooker. 2014b. Herbicide drift can affect plant and arthropod communities. Agriculture, Ecosystems & Environment 185:77–87. Available from http://linkinghub.elsevier.com/retrieve/pii/S0167880913004398 (accessed January 22, 2014).

Eliazar, P.J., and T.C. Emmel. 1991. Adverse impacts to non-target insects. Mosquito control pesticides: ecological impacts and management alternatives. In T.C. Emmel and J.C. Tucker (eds.). Mosquito Control Pesticides: Ecological Impacts and Management Alternatives, 17-19. Scientific Publishers, Inc. Gainesville, Florida. 1991. Available from http://consensus.fsu.edu/MC/naled-files/Eliazar%20and%20Emmel-Adverse%20Impacts%20adulticides%20to%20butterflies.%201991.pdf (accessed August 20, 2014).

Engels, S., N.-L. Schneider, N. Lefeldt, C.M. Hein, M. Zapka, A. Michalik, D. Elbers, A. Kittel, P.J. Hore, and H. Mouritsen..2014. Anthropogenic electromagnetic noise disrupts magnetic compass orientation in a migratory bird. Nature 509: 353–356.

Federman, A. 2008. All Aflutter: The flap over the mail order butterfly industry. Earth Island Journal: Earth Island Institute. Available from http://www.earthisland.org/journal/index.php/eij/article/all_aflutter/ (accessed August 6, 2014).

Fink, L.S. and L.P. Brower. 1981. Birds can overcome the cardenolide defence of monarch butterflies in Mexico. Nature 291:67 – 70.

Fishbein, M., D. Chuba, C. Ellison, R.J. Mason-Gamer, and S.P. Lynch. 2011. Phylogenetic Relationships of *Asclepias* (Apocynaceae) Inferred from Non-coding Chloroplast DNA Sequences. Systematic Botany 36:1008–1023. Available from http://openurl.ingenta.com/content/xref?genre=article&issn=0363-6445&volume=36&issue=4&spage=1008 (accessed July 8, 2013).

Fishel, F.M. 2005. Pesticide toxicity profile: neonicotinoid pesticides. University of Florida, IFAS. Available from: http://www.ectownusa.net/wbfi/docs/FL_Neonicotinoid_Study.pdf (June 10, 2014).

Flockhart, D.T., J.B. Pichancourt, D.R. Norris, and T.G. Martin. 2014. Unraveling the annual cycle in a migratory animal: Breeding-season habitat loss drives population declines of monarch butterflies. Supplementay Material in addition. Journal of Animal Ecology: doi: 10.1111/1365-2656.12253.

Flockhart, D.T.T., L.I. Wassenaar, T.G. Martin, K.A. Hobson, M.B. Wunder, and D.R. Norris. 2013. Tracking multi-generational colonization of the breeding grounds by monarch butterflies in eastern North America. Proceedings of the Royal Society B: Biological Sciences 280:20131087–20131087. Supplementary Material in addition. Available from http://rspb.royalsocietypublishing.org/cgi/doi/10.1098/rspb.2013.1087 (accessed August 29, 2013).

Frankham, R. 2008. Genetic adaptation to captivity in species conservation programs. Molecular Ecology 17(1): 325-333.

Franz, J.E., M.K. Mao, and J.A. Sikorski. 1997. Glyphosate: A Unique Global Herbicide. ACS Monograph 189. American Chemical Society, Washington, D.C.

Fraser, K. 2013. Glyphosate resistant weeds - intensifying. Stratus Research, January 25, 2013. http://www.stratusresearch.com/blog/glyphosate-resistant-weeds-intensifying, last visited 6/12/14.

Freeman, S.N., R.A. Robinson, J.A. Clark, B.M. Griffin, and S.Y. Adams. 2008. Changing demography and population decline in the Common Starling Sturnus vulgaris: a multisite approach to Integrated Population Monitoring. Ibis 149:587-596.

Frick, B. and A.G. Thomas. 1992. Weed surveys in different tillage systems in southwestern Ontario field crops. Can. J. Plant Sci. 72: 1337-1347.

Frick, W.F. Frick, W.F., J.F. Pollock, A.C. Hicks, K.E. Langwig, D.S. Reynolds, G.G. Turner, C.M. Butchkoski, and T.H. Kunz. 2010. An emerging disease causes regional population collapse of a common North American bat species. Science 329: 679-682.

Glendinning, J.I. 1993. Comparative feeding responsed of the mice *Peromyscus melanotis, P. aztecus*, *Reithrodontomys sumichrasti*, and *Microstus mexicanus* to overwintering monarch butterflies in Mexico. Pages 323 – 333 in S.B. Malcolm and M.P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

Glendinning, J.I., A.A. Mejia, and L.P. Brower. 1988. Behavioral and ecological interactions of foraging mice (*Peromyscus melanotis*) with overwintering monarch butterflies (*Danaus plexippus*) in Mexico. Oecologia 75(2): 222-227.

Glick, P, B.A. Stein, and N.A. Edelson, eds. 2011. Scanning the conservation horizon: a guide to climate change vulnerability assessment. National Wildlife Federation, Washington, D.C., USA. Available from http://www.nwf.org/~/media/pdfs/global-warming/climate-smart-conservation/nwfscanningtheconservationhorizonfinal92311.ashx (accessed August 20, 2014).

Goehring, L., and K.S. Oberhauser. 2004. Environmental factors influencing postdiapause development in monarch butterflies. Pages 187 – 196 in K.S. Oberhauser and M.J. Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Goulson, D. 2013. Review: An overview of the environmental risks posed by neonicotinoid insecticides. Kleijn D. (Ed). Journal of Applied Ecology 50: 977-987.

Gove B., S.A. Power, G.P. Buckley, and J. Ghazoul. 2007. Effects of herbicide spray drift and fertilizer overspread on selected species of woodland ground flora: comparison between short-term and long-term impact assessments and field surveys: Herbicide and fertilizer impacts on woodland plants. Journal of Applied Ecology 44:374–384.

Greenberg, R. and S. Droege. 1999. On the decline of the Rusty Blackbird and the use of ornithological literature to document long-term population trends. Conservation Biology 13(3): 553–559.

Griffiths, J. 2012. The tree is dead, long live the tree: Do monarchs prefer or simply use Eucalyptus for overwintering roosts? Presentation at Monarch Biology and Conservation Meeting, Chanhassen MN. Available from http://www.monarchlab.org/mn2012/Admin/upload/68.pdf (accessed March 2013).

Griffiths, J., and F. Villablanca 2013. Management of monarch butterfly (*Danaus plexippus*) overwintering habitat: Recommendations based on patterns of tree use. Monarch Alert, California Polytechnic State University, San Luis Obispo, CA. Available from http://monarchalert.calpoly.edu/pdf/Griffiths and Villablanca 2013 Eucalyptus White Paper.pdf (accessed May 28, 2014).

Griffiths, J.L. and F.X. Villablanca. Tree use by western monarch butterflies in core overwintering habitat. (in preparation).

Groenendijk, D., M. Van Mannekes, M. Vaal, and M. Van den Berg. 2002. Butterflies and insecticides: a review and risk analysis of modern Dutch practice. In Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society (NEV) 13:9-34.

Guerra, P.A., R.J. Gegear, and S.M. Reppert. 2014. A magnetic compass aids monarch butterfly migration. Nature Communications 5(4164): 2041-1723.

Guerra, P.A., and S.M. Reppert. 2013. Coldness Triggers Northward Flight in Remigrant Monarch Butterflies. Current Biology 23:419–423. Available from http://linkinghub.elsevier.com/retrieve/pii/S0960982213000870 (accessed June 11, 2013).

Guiney, M., and K. Oberhauser. 2009. Insects as flagship conservation species. Terrestrial Arthropod Reviews 1:111–123. Available from http://booksandjournals.brillonline.com/content/10.1163/187498308x414733 (accessed August 29, 2013).

Haeger, J. F., D. Jordano, and M. L. Meléndez. 2011. Status and conservation of *Asclepiadaceae* and *Danaus* in southern Spain. Journal of Insect Conservation 15:361–365. Available from http://link.springer.com/10.1007/s10841-010-9354-7 (accessed June 11, 2013).

Hallmann, C.A., R.P. Foppen, C.A. van Turnhout, H. de Kroon, and E. Jongejans. 2014. Declines in insectivorous birds are associated with high neonicotinoid concentrations. Nature doi:10.1038/nature13531

Hartzler, R.G. 2010. Reduction in common milkweed (*Asclepias syriaca*) occurrence in Iowa cropland from 1999 to 2009. Crop Protection 29:1542–1544. Available from http://linkinghub.elsevier.com/retrieve/pii/S0261219410002152 (accessed June 11, 2013).

Hartzler, R.G., and D.D. Buhler. 2000. Occurrence of common milkweed (*Asclepias syriaca*) in cropland and adjacent areas. Crop Protection 19:363–366. Available from http://www.sciencedirect.com/science/article/pii/S0261219400000247 (accessed June 11, 2013).

Harvey, R.G., P.L. Howell, C. Morgenstern, and F.J. Mazzotti. 2009. Native Habitats for Monarch Butterflies in South Florida, WEC266. University of Florida. Available from http://edis.ifas.ufl.edu/UW311 (accessed June 11, 2013).

Hebert, V. 2004. Regional off–target movement of auxin–type herbicides. Proceedings of the International Conference on Pesticide Application for Drift Management, Kona, Hawaii.

Henderson, A.M., J.A. Gervais, B. Luukinen, K. Buhl, and D. Stone. 2010. Glyphosate Technical Fact Sheet; National Pesticide Information Center, Oregon State University Extension Services. http://npic.orst.edu/factsheets/glyphotech.html.

Hill, B.D., K.N. Harker, P. Hasselback, et al. 2002. Phenoxy herbicides in Alberta rainfall: Potential effects on sensitive crops. Canadian Journal of Plant Science 82:481–484.

Hill Jr, H.F., A.M. Wenner, and P.H. Wells. 1976. Reproductive behavior in an overwintering aggregation of monarch butterflies. American Midland Naturalist (1976): 10-19.

Hladik, M.L., D.W. Kolpin, and K.M. Kuivila. 2014. Widespread occurrence of neonicotinoid insecticides in streams in a high corn and soybean producing region, USA. Environmental Pollution 193(2014): 189-196.

Holterman, H.J., J.C. Van De Zande, H.A J. Porskamp, and J.F.M. Huijsmans. 1997. Modeling spray drift from boom sprayers. Computers and Electronics in Agriculture 19(1):1-22.

Hopwood J, S.H. Black, M. Vaughn, E. Lee-Mäder. 2013. Beyond the Birds and the Bees: Effects of Neonicotinoid Insecticides on Agriculturally Important Beneficial Invertebrates. The Xerces Society for Invertebrate Conservation. Available from http://www.xerces.org/wp-content/uploads/2013/09/XercesSociety_CBCneonics_sep2013.pdf (accessed August 20, 2014).

Hopwood J, and M. Shepherd. 2012. Neonicotinoids in Your Garden.: Effects of Neonicotinoid Insecticides on Agriculturally Important Beneficial Invertebrates,The Xerces Society for Invertebrate Conservation. Wings, Fall 2012: 22.

Hopwood J, M. Vaughan, M. Shepherd, D. Biddinger, E. Mäder, S.H. Black, C. Mazzacano. 2012. Are Neonicotinoids Killing Bees? A Review of Research into the Effects of Neonicotinoid Insecticides on Bees, with Recommendations for Action. The Xerces Society for Invertebrate Conservation. Available from http://www.xerces.org/wp-content/uploads/2012/03/Are-Neonicotinoids-Killing-Bees_Xerces-Society1.pdf (accessed August 20, 2014).

Howard, E., and A.K. Davis. 2004. Documenting the Spring Movements of Monarch Butterflies: Journey North, a Citizen Science Program. Pages 105 – 114 in K.S. Oberhauser and M.J.

Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Howard, E., and A.K. Davis. 2008. The fall migration flyways of monarch butterflies in eastern North America revealed by citizen scientists. Journal of Insect Conservation 13:279–286. Available from http://link.springer.com/10.1007/s10841-008-9169-y (accessed August 29, 2013).

Huseth A.S., and R.L. Groves. 2014. Environmental Fate of Soil Applied Neonicotinoid Insecticides in an Irrigated Potato Agroecosystem Salice CJ (Ed). PLoS ONE 9: e97081. doi: 10.1371/journal.pone.0097081

International Environmental Law Project and The Xerces Society for Invertebrate Conservation. 2012. The legal status of monarch butterflies in California. Available from http://www.xerces.org/wp-content/uploads/2008/09/legal-status-of-california-monarchs.pdf (accessed October 12, 2012).

International Survey of Herbicide Resistant Weeds (ISHRW). 2014. Weeds Resistant to EPSP synthase inhibitors (G/9). Available from http://www.weedscience.org/Summary/MOA.aspx?MOAID=12. Note: glyphosate is the only EPSP synthase inhibitor. The cited numbers of glyphosate-resistant weed populations and species and states where they occur are current as of 5/31/14.

IPCC (Intergovernmental Panel on Climate Change). 2013a. Annex III: Glossary [Planton, S. (ed.)]. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (Intergovernmental Panel on Climate Change). 2013b. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

Jepsen, S. and S.H. Black. In press. Understanding and conserving the western North American monarch population. In Oberhauser, K.S. and K. Nail, editors. Monarchs in a Changing World: Biology and Conservation of an Iconic Insect. Ithaca: Oxford University Press.

Jeschke P, and R. Nauen. 2008. Neonicotinoids-from zero to hero in insecticide chemistry. Pest Management Science 64:1084-1098.

Jeschke, P., R. Nauen, M. Schindler, and A. Elbert. 2011. Overview of the status and global strategy for neonicotinoids. Journal of Agricultural and Food Chemistry 59:2897-2908.

Johal, G.S. and J.E. Rahe. 1984. Effect of soilborne plant-pathogenic fungi on the herbicidal action of glyphosate on bean seedlings. Phytopathology 74(8): 950-955.

Johnson, B. and S. Leer. 2006. Specialist: Get ready for weeds in early Roundup Ready corn. Purdue University Agriculture News, March 30, 2006. Available from http://www.purdue.edu/uns/html3month/2006/060330.Johnson.roundup.html (accessed August 20, 2014).

Johnson Q. and M. VanGessel. 2012. Considerations for herbicide use in pastures. Weed Facts WF-17. University of Delaware Cooperative Extension, 2012.

Kagan, R.A., T.C. Viner, P.W. Trail, and E.O. Espinoza. 2014. Avian mortality at solar energy facilities in Southern California: A Preliminary Analysis. Draft Report. National Fish and Wildlife Forensics Laboratory. 28 pp. Available from http://alternativeenergy.procon.org/sourcefiles/avian-mortality-solar-energy-ivanpah-apr-2014.pdf (accessed August 20, 2014).

Keiman, A.F. and M. Franco. 2004. Can't see the forest for the butterflies: the need for understanding forest dynamics at the monarch's overwintering sites. In: K. Oberhauser & M. Solensky (ed.), The monarch butterfly: biology & conservation, pp 135-140. Cornell University Press, Ithaca, New York, USA.

Kilman, S. 2010. Superweed outbreak triggers arms race. Wall Street Journal, 6/4/10. Available from http://www.gmwatch.org/latest-listing/1-news-items/12263 (accessed August 8, 2014).

Knight A. 1998. A Population study of monarch butterflies in North-centraland South Florida. M.S. Thesis, University of Florida.

Knight, A., and L. P. Brower. 2009. The Influence of Eastern North American Autumnal Migrant Monarch Butterflies (*Danaus plexippus* L.) on Continuously Breeding Resident Monarch Populations in Southern Florida. Journal of Chemical Ecology 35:816–823. Available from http://link.springer.com/10.1007/s10886-009-9655-z (accessed June 11, 2013).

Koch, R. 2005. Minnesota Milkweed Survey Data: 2003-2005. Minnesota Department of Agriculture, 2005.

Kohler H-R, and R. Triebskorn. 2013. Wildlife Ecotoxicology of Pesticides: Can We Track Effects to the Population Level and Beyond? Science 341: 7591765. doi: 10.1126/science.1237591

Krupke, C.H., G.J. Hunt, B.D. Eitzer, G. Andino, and K. Given. 2012. Multiple Routes of Pesticide Exposure for Honey Bees Living Near Agricultural Fields, Smagghe, G. (Ed). PLoS ONE 7: e29268. doi: 10.1371/journal.pone.0029268

Kutlesa, N.J., and S. Caveney. 2001. Insecticidal activity of glufosinate through glutamine depletion in a caterpillar. Pest Management Science 57:25-32.

Kwan, J.A., M.G. Novak, T.S. Hyles, M.K. Niemela. 2009. Mortality of nontarget arthropods from an aerial application of pyrethrins. Journal of the American Mosquito Control Association 25(2):218-20.

La Marca, E., et al. 2005. Catastrophic population declines and extinctions in neotropical harlequin frogs (Bufonidae:Atelopus). Biotropica 37(2): 190-201.

Lane, J. 1984. The status of monarch butterfly overwintering sites in Alta California. Atala 9:17-20.

Lane, J. 1993. Overwintering Monarch Butterflies in California: Past and Present. Pages 335 – 344 in S.B. Malcolm and M.P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

Lavoie, B., and K.S. Oberhauser. 2004. Compensatory feeding in *Danaus plexippus* (Lepidoptera: Nymphalidae) in response to variation in host plant quality. Environmental Entomology 33:1062–1069. Available from http://www.bioone.org/doi/abs/10.1603/0046-225X-33.4.1062 (accessed August 29, 2013).

Lee, E.H., C.A. Burdick, and D.M. Olszyk. 2005. GIS-based risk assessment of pesticide drift case study: Fresno County, California. EPA/600/R-05/029.

Leong, K.L.H. 1989. Final report: monarch lane butterfly survey.

Leong, K.L.H. 1990. Microenvironmental factors associated with the winter habitat of the monarch butterfly (Lepidoptera: Danaidae) in Central California. Annals of the Entomological Society of America 83:907-910.

Leong, K.L.H. 1999. Restoration of an overwintering grove in Los Osos, San Luis Obispo County, California. Pages 221 – 218 in 1997 North American Conference on the Monarch Butterfly. Eds. J. Hoth, L. Merino, K. Oberhauser, I. Pisanty, S. Price, and T. Wilkinson.

Leong, K.L.H., D.F. Frey, A. Brenner, S. Baker, and D. Fox. 1991. The use of multivariate analyses to characterize the monarch butterfly (Lepidoptera: Danaidae) winter habitat. Annals of the Entomological Society of America 84:263-267.

Leong, K.L.H., W.H. Sakai, W. Bremer, D. Feuerstein, and G. Yoshimura. 2004. Analysis of the pattern of distribution and abundance of monarch overwintering sites along the California coastline. Pages 177-185 in K. Oberhauser and M. Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Levin, P.S., E.E. Holmes, K.R. Piner, and C.J. Harvey. 2006. Shifts in a Pacific Ocean fish assemblage: the potential influence of exploitation. Conservation Biology 20:1181–1190.

Lindenmayer, D.B., J.T. Wood, L. McBurney, C. MacGregor, K. Youngentob, and S.C. Banks. 2011. How to make a common species rare: A case against conservation complacency. Biological Conservation 144:1663-1672.

Lockery vs. Hayter. 2006. H & H Lockrey Farms 1997 Ltd. v. Hayter, 2006 CanLII 127 (ON SC) (Can.). Available from http://caselaw.canada.globe24h.com/0/0/ontario/superior-court-of-justice/2006/01/03/h-and-h-lockrey-farms-1997-ltd-v-hayter-2006-127-on-sc.shtml (accessed August 20, 2014).

Longley, M., and N.W. Sotherton. 1997. Factors determining the effects of pesticides upon butterflies inhabiting arable farmland. Agriculture, Ecosystems & Environment 61:1–12. Available from http://www.sciencedirect.com/science/article/pii/S0167880996010948 (accessed September 17, 2012).

Lorentz, L., R. Beffa, and H. Kraehmer. 2011. Recovery of plants and histological observations on advanced weed stages after glyphosate treatment. Weed Research 51(4): 333-343.

Love, O. 2012. High cost of land, crops taking bite out of conservation acres. June 16, 2012. KRCG, Cedar Rapids, Iowa. Available from http://www.kcrg.com/news/local/high-cost-of-land-crops-taking-bite-out-of-conservation-acres-159295455.html (accessed August 20, 2014).

Loux, M.M., J.M. Stachler, and S.K. Harrison. 2001. Weed control guide for Ohio field crops: Common milkweed. Ohio State University Extension, 2001. Available from http://ohioline.osu.edu/weeds/weeds_203.html (accessed August 20, 2014).

Lynch, S.P., and R.A. Martin. 1993. Milkweed host plant utilization and cardnolide sequestration by monarch butterflies in Louisiana and Texas. Pages 107 – 123 in S.B. Malcolm and M.P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

Lyons, J.I., A.A. Pierce, S.M. Barribeau, E.D. Sternberg, A.J. Mongue, and J.C. de Roode. 2012. Lack of genetic differentiation between monarch butterflies with divergent migration destinations. Molecular Ecology 21:3433–3444. Available from http://doi.wiley.com/10.1111/j.1365-294X.2012.05613.x (accessed June 11, 2013).

Main, A.R., J.V. Headley, K.M. Peru, N.L. Michel, A.L. Cessna, and C.A. Morrissey. 2014. Widespread use and frequent detection of neonicotinoid insecticides in wetlands of Canada's Prairie Pothole Region. PLoS One 9 (3), e92821.

Malcolm, S. B., and L. P. Brower. 1986. Selective oviposition by monarch butterflies (*Danaus plexippus* L.) in a mixed stad of *Ascepius curassavica L.* and *A. incarnata* L. in south Florida. Journal of the Lepidopterists' Society 40:255–263. Available from http://images.peabody.yale.edu/lepsoc/jls/1980s/1986/1986-40(4)255-Malcolm.pdf (accessed June 19, 2013).

Malcolm, S.B., B.J. Cockrell, and L.P. Brower. 1987. Monarch butterfly voltinism: effects of temperature constraints at different latitudes. Oikos 49:77-82.

Malcolm, S. B., B. J. Cockrell, and L. P. Brower. 1993. Spring recolonization of eastern North America by the monarch butterfly: succesive brood or single sweep migration? Pages 253 – 267 in S. B. Malcolm and M. P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

Martin, A., and O.C. Burnside. 1977. G77-384-A. Common Milkweed (Revised July 1984). Historical Materials from University of Nebraska-Lincoln Extension:1491. Available from http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=2488&context=extensionhist (accessed June 11, 2013).

Martin, T.G., S. Nally, A.A. Burbidge, S. Arnall, S.T. Garnett, M.W. Hayward, L.F. Lumsden, P. Menkhorst, E. McDonald-Madden, and H.P. Possingham. 2012. Acting fast helps avoid extinction. Conservation Letters 5:274–280. Available from http://doi.wiley.com/10.1111/j.1755-263X.2012.00239.x (accessed June 11, 2013).

Martinat, P.J., V. Christman, R.J. Cooper, K.M. Dodge, R.C. Whitmore, G. Booth, and G. Seidel. 1987. Environmental fate of dimilin 25-W in a central Appalachian Forest. Bulletin of Environmental Contamination and Toxicology 39:142-149.

Mason R., H. Tennekes, F. Sanchez-Bayo, and P.U. Jepsen. 2013. Immune Suppression by Neonicotinoid Insecticides at the Root of Global Wildlife Declines. Journal of Environmental Immunology and Toxicology 1:3. doi: 10.7178/jeit.1

Masters, A.R. 1993. Temperature and thermoregulation in the monarch butterfly. Pages 147 – 156 in S.B. Malcolm and M.P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

Masters, A.R., S.B. Malcolm, and L.P. Brower. 1988. Monarch butterfly (*Danaus plexippus*) thermoregulatory behavior and adaptations for overwintering in Mexico. Ecology 69(2):458-467.

Mazzacano, C. and S.H. Black. Ecologically sound mosquito management in wetlands. Available from http://www.xerces.org/wp-content/uploads/2013/02/MosMan_Mar13_XercesSociety.pdf (accessed August 20, 2014)

McCord, J. W., and A. K. Davis. 2010. Biological Observations of Monarch Butterfly Behavior at a Migratory Stopover Site: Results from a Long-term Tagging Study in Coastal South Carolina. Journal of Insect Behavior 23:405–418. Available from http://link.springer.com/10.1007/s10905-010-9224-x (accessed August 29, 2013).

McLaughlin R.E, and J. Myers. 2007. *Ophryocystis elektroscirrha* sp. n., a Neogregarine pathogen of the monarch butterfly *Danaus plexippus* (L.) and the Florida queen butterfly *D. gilippus berenice* Cramer. Journal of Eukaryotic Microbiology 17:300–305.

Meade, D.E. 1999. Monarch butterfly overwintering sites in Santa Barbara County California. Althouse and Meade Biological and Environmental Services, November 1999. 114 pp.

Merlin, C., S. Heinze, and S.M. Reppert. 2012. Unraveling navigational strategies in migratory insects. Current Opinion in Neurobiology 22:353–361. Available from http://linkinghub.elsevier.com/retrieve/pii/S0959438811002108 (accessed August 29, 2013).

Miller, N.G., L.I. Wassenaar, K.A. Hobson, and D.R. Norris. 2010. Monarch butterflies cross the Appalachians from the west to recolonize the east coast of North America. Biology Letters 7:43–46. Available from http://rsbl.royalsocietypublishing.org/cgi/doi/10.1098/rsbl.2010.0525 (accessed June 11, 2013).

Miller, N.G., L.I. Wassenaar, K.A. Hobson, and D.R. Norris. 2012. Migratory Connectivity of the Monarch Butterfly (*Danaus plexippus*): Patterns of Spring Re-Colonization in Eastern North America. PLoS ONE 7:e31891. Available from http://dx.plos.org/10.1371/journal.pone.0031891 (accessed June 11, 2013).

Mineau P, and C. Palmer. 2013. The Impact of the Nation's Most Widely Used Insecticides on Birds. American Bird Conservancy. Available at: http://www.abcbirds.org/abcprograms/policy/toxins/Neonic_FINAL.pdf Accessed August 7, 2014.

Monarch Joint Venture. 2014. Potential risks of growing exotic milkweeds for monarchs. Available from http://monarchjointventure.org/images/uploads/documents/Oe_fact_sheet.pdf (accessed August 7, 2014).

Monroe, M., D. Frey, and S. Stevens. 2013. Western Monarch Thanksgiving Count Data from 1997-2012. Available from http://www.xerces.org/western-monarch-thanksgiving-count/ (accessed October 2012).

Monroe, M., D. Frey, and S. Stevens. 2014. Western Monarch Thanksgiving Count Data from 1997–2013. Available from http://www.xerces.org/western-monarch-thanksgiving-count/ (accessed August 20, 2014)

Monsanto. 2009. Roundup WeatherMAX Specimen Label, 2009.

Monsanto. 2010. Petition for the Determination of Nonregulated Status for Dicamba-Tolerant Soybean: MON 87708. Monsanto Company, July 6, 2010.

Monsanto. 2012. New Roundup Ready® Xtend Crop System To Extend Weed Control and Maximize Yield. Monsanto Company press release, 3/1/12.

Mortensen, D.A., J.F. Egan, B.D. Maxwell, M.R. Ryan, and R.G. Smith. 2012. Navigating a critical juncture for sustainable weed management. BioScience 62:75–84. doi: 10.1525/bio.2012.62.1.12

Mulvaney, E. 2013. Drought conditions contribute to decline in monarch populations, Houston Chronicle, March 14. Available from http://www.chron.com/news/houston-texas/houston/article/Drought-conditions-contribute-to-decline-in-4355009.php (accessed August 7, 2014).

Nabhan, G. P. 2004. Stresses on Pollinators during Migration: Is Nectar Availability at Stopovers the Weak Link in Plant-Pollinator Conservation? Pages 3 – 22 in G. P. Nabhan, editor. Conserving Migratory Pollinators and Nectar Corridors in Western North America. University of Arizona Press and The Arizona-Sonora Desert Museum, Tuscon.

Nagano, C.D., and C. Freese. 1987. A world safe for monarchs. New Scientist 1554:43-47.

Nagano, C.D., and J. Lane. 1985. A survey of the location of monarch butterfly (*Danaus plexippus* [L.]) overwintering roosts in the state of California, U.S.A.: First year 1984/1985. Report to the World Wildlife Fund-US, 71 pp.

National Council of Farmer Cooperatives (NCFC). 2014. Farm Bill: Agricultural Act of 2014, Detailed Overview. Available from http://www.ncfc.org/images/FarmBill/NCFC_2014_FarmBill_Detailed_Overview_Web.pdf (accessed August 20, 2014).

National Sustainable Agriculture Coalition (NSAC). Undated. Conservation Reserve Program. Available from http://sustainableagriculture.net/publications/grassrootsguide/conservation-environment/conservation-reserve-program/ (accessed August 20, 2014).

Nazar, N., D.J. Goyder, J.J. Clarkson, T. Mahmood, and M.W. Chase. 2013. The taxonomy and systematics of Apocynaceae: where we stand in 2012. Botanical Journal of the Linnean Society. Available from http://onlinelibrary.wiley.com/doi/10.1111/boj.12005/full (accessed July 8, 2013).

Nuyttens, D., W. Devarrewaere, P. Verboven, and D. Foqué. 2013. Pesticide-laden dust emission and drift from treated seeds during seed drilling: a review. Pest Management Science 69(5):564-575.

Oberhauser, K.S. 2004. Overview of Monarch Breeding Biology. Pages 3 – 8 in K.S. Oberhauser and M.J. Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Oberhauser, K.S. 2012. Tachinid flies and monarch butterflies: citizen scientists document parasitism patterns over broad spatial and temporal scales. American Entomologist 58. Available from http://www.monarchlab.org/Lab/app/upload/pdf/PN-1%20Oberhauser%20tachinids%20and%20monarchs%20am%20ent%202012%20preprint.pdf (accessed August 29, 2013).

Oberhauser, K.S., S.J. Brinda, S. Weaver, R.D. Moon, S.A. Manweiler, and N. Read. 2006. Growth and survival of monarch butterflies (Lepidoptera: Danaidae) after exposure to permethrin barrier treatments. Environmental Entomology 35:1626–1634. Available from http://www.bioone.org/doi/pdf/10.1603/0046-225X(2006)35[1626:GASOMB]2.0.CO;2 (accessed November 1, 2013).

Oberhauser, K.S, and D. Frey. 1997. Coercive mating by overwintering male monarch butterflies. Page 67 in 1997 North American conference on the monarch butterfly. 1999. Available from http://wwwtest.fs.fed.us/wildflowers/pollinators/Monarch_Butterfly/documents/1997_conference.pdf#page=80 (accessed August 20, 2014).

Oberhauser, K., I. Gebhard, C. Cameron, and S. Oberhauser. 2007. Parasitism of monarch butterflies (*Danaus plexippus*) by Lespesia archippivora (Diptera: Tachinidae). The American midland naturalist 157:312–328. Available from http://www.bioone.org/doi/pdf/10.1674/0003-0031(2007)157%5B312:POMBDP%5D2.0.CO%3B2 (accessed August 29, 2013).

Oberhauser, K. and A.T. Peterson. 2003. Modeling current and future potential wintering distributions of eastern North American monarch butterflies. Proceedings of the National Academy of Sciences 100(24):14063-14068.

Oberhauser, K.S., and M.J. Solensky, editors. 2004. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Oliver J.B., D.C. Fare, N. Youssef, S.S. Scholl, M.E. Reding, C.M. Ranger, J.J. Moyseenko, and M.A. Halcomb. 2010. Evaluation of a single application of neonicotinoid and multi-application contact insecticides for flatheaded borer management in field grown red maple cultivars. Journal of Environmental Horticulture 28: 135. Available from http://www.hriresearch.org/docs/publications/JEH/JEH_2010/JEH_2010_28_3/JEH%2028-3-135-149.pdf (accessed June 10, 2014).

Oyeyele, S.O., and M.P. Zalucki. 1990. Cardiac glycosides and oviposition by *Danaus plexippus* on *Asclepias fruticosa* in south-east Queensland (Australia), with notes on the effect of plant nitrogen content. Ecological Entomology 15(2):177-185.

Pelham, J.P. 2008. A catalogue of the butterflies of the United States and Canada with a complete bibliography of the descriptive and systematic literature. The Journal of Research on the Lepidoptera. Volume 40. 658 pp.

Pettis, J.S., E.M. Lichtenberg, M. Andree, J. Stitzinger, R. Rose, and D. van Engelsdorp. 2013. Crop pollination exposes honey bees to pesticides which alters their susceptibility to the gut pathogen *Nosema ceranae*. PLoS One 8(7): e70182. doi: 10.1371/journal.pone.0070182

PIER. 2011, January 16. *Calotropis procera* (PIER species info). Available from http://www.hear.org/pier/species/calotropis_procera.htm (accessed May 31, 2013).

Pierce, A.A., J.C. de Roode, S. Altizer, and R.A. Bartel. 2014. Extreme heterogeneity in parasitism despite low population genetic structure among monarch butterflies inhabiting the Hawaiian Islands. PloS one, 9(6), e100061.

Pleasants, J.M. Unpublished data provided to Bill Freese, Center for Food Safety.

Pleasants, J.M. In press. Monarch Butterflies and Agriculture, Ch. 14. In Oberhauser, K.S. and K. Nail, editors, Monarchs in a Changing World: Biology and Conservation of an Iconic Insect. Ithaca: Oxford University Press.

Pleasants, J.M., and K.S. Oberhauser. 2012. Milkweed loss in agricultural fields because of herbicide use: effect on the monarch butterfly population. Insect Conservation and Diversity 6:135–144. Available from http://doi.wiley.com/10.1111/j.1752-4598.2012.00196.x (accessed May 31, 2013).

Presidential Memorandum. 2014. Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators, June 20, 2014. Available from http://www.whitehouse.gov/the-press-office/2014/06/20/presidential-memorandum-creating-federal-strategy-promote-health-honey-b (accessed August 20, 2014).

Prysby, M.D. 2004. Natural Enemies and Survival of Monarch Eggs and Larvae. Pages 27 – 37 in K.S. Oberhauser and M.J. Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Prysby, M.D., and K.S. Oberhauser. 2004. Temporal and Geographic Variation in Monarch Densities: Citizen Scientists Document Monarch Population Patterns. Pages 9 – 20 in K.S. Oberhauser and M. J. Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Pyle, R.M., S.J. Jepsen, S.H. Black, and M. Monroe. 2012. Xerces Society policy on butterfly releases. Available from http://www.xerces.org/wp-content/uploads/2008/09/xerces-butterfly-release-policy2012.pdf (accessed August 20, 2014).

Pyle, R.M., and M. Monroe. 2004. Conservation of western monarchs. Wings Magazine, The Xerces Society for Invertebrate Conservation 27:13-17.

Rapini, A., C. van den Berg, and S. Liede-Schumann. 2007. Diversification of Asclepiadoideae (Apocynacea) in the New World. Annals of the Missouri Botanical Garden 94:407–422. Available from http://www.bioone.org/doi/abs/10.3417/0026-6493%282007%2994%5B407%3ADOAAIT%5D2.0.CO%3B2 (accessed August 29, 2013).

Rasmann, S., and A.A. Agrawal. 2011. Latitudinal patterns in plant defense: evolution of cardenolides, their toxicity and induction following herbivory. Ecology Letters 14:476–483. Available from http://doi.wiley.com/10.1111/j.1461-0248.2011.01609.x (accessed July 8, 2013).

Rasmussen, N. 2001. Plant hormones in war and peace: science, industry, and government in the development of herbicides in 1940s America. Isis 92:291 – 316.

Rawlins, J.E. and R.C. Lederhouse. 1981. Developmental influences of thermal behavior on monarch caterpillars (*Danaus plexippus*): an adaptation for migration (Lepidoptera: Nymphalidae: Danainae). Journal of the Kansas Entomological Society (1981):387-408.

Reiter, P. 2001. Climate change and mosquito-borne disease. Environmental Health Perspectives 109, no. Suppl 1:141.

Rendón-Salinas, E., and G. Tavera-Alonso. 2014. Forest surface occupied by monarch butterfly hibernation colonies in December 2013, World Wildlife Fund – Mexico report. Available from http://worldwildlife.org/publications/forest-surface-occupied-by-monarch-butterfly-hibernation-colonies-in-december-2013 (accessed August 20, 2014).

Robbins, C.S., J.R. Sauer, R.S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the Neotropics. Proceedings of the National Academy of Sciences 86(19): 7658-7662.

Robertson, C. 1928. Flowers and insects: lists of visitors of four hundred and fifty-three flowers. The Science Press Printing Company, Lancaster, PA.

Robertson, J.L., and L.M. Boelter. 1979. Toxicity of insecticides to douglas-fir tussock moth, *Orgyia pseudotsugata* (Lepidoptera: Lymantriidae): II. Residual toxicity and rainfastness. The Canadian Entomologist 111(10):1161-1175.

Russell C., and C.B. Schultz. 2009. Effects of grass-specific herbicides on butterflies: an experimental investigation to advance conservation efforts. Journal of Insect Conservation 14:53–63. doi: 10.1007/s10841-009-9224-3

Sáenz-Romero, C., G.E. Rehfeldt, P. Duval, and R.A. Lindig-Cisneros. 2012. *Abies religiosa* habitat prediction in climatic change scenarios and implications for monarch butterfly conservation in Mexico. Forest Ecology and Management 275:98–106. Available from http://linkinghub.elsevier.com/retrieve/pii/S0378112712001284 (accessed June 11, 2013).

Sakai, W. 1994. Avian predation on the monarch butterfly, *Danaus plexippus* (Nymphalidae: Danainae), at a California overwintering site. Journal of the Lepidopterists' Society 48:148–56.

Sakai, W.H. and W.C. Calvert. 1991. Statewide monarch butterfly management plan for the state of California Department of Parks and Recreation. Final Report, June 1991. Interagency Agreement No. 88-11-050 between California Department of Parks and Recreation and Santa Monica College. 160 pp.

Sample, B.E., R.J. Cooper, and R.C. Whitmore. 1993. Dietary Shifts among Songbirds from a Diflubenzuron-Treated Forest. Condor. 95:616-624.

Saunders, W. 1871. On the swarming of *Danais archippus.* Canadian Entomologist 3:156-157.

Sauer, D. and D. Feir. 1974. Population and maturation characteristics of the common milkweed. Weed Science 22(3):293-297.

Schorger, A.W., 1973. The Passenger Pigeon: Its Natural History and Extinction. University of Oklahoma Press, Norman.

Sciumbato, A.S., J.M. Chandler, S.A. Senseman, R.W. Bovey, and K.L. Smith. 2004. Determining Exposure to Auxin-Like Herbicides. II. Practical Application to Quantify Volatility. Weed Technology 18:1135-1142.

Scott, R.C. 2009. Herbicide drift problem more complex. Delta Farm Press, 3/20/09. Available from http://deltafarmpress.com/management/herbicide-drift-problem-more-complex (accessed August 20, 2014).

Scudder, S.H. 1889. The butterflies of the eastern United States and Canada with special reference to New England. Published by the author, Cambridge, Massachusetts. 1775 pp.

Scudder, S.H. and J.A. Allen. 1869. A preliminary list of the butterflies of Iowa. Transactions of the Chicago Academy of Science 1:326-337.

Seiber, J.N., L.P. Brower, S.M. Lee, M.M. McChesney, H.T.A. Cheung, C.J. Nelson, and T.R. Watson. 1986. Cardenolide connection between overwintering monarch butterflies from Mexico and their larval food plant, *Asclepias syriaca*. Journal of Chemical Ecology 12:1157–1170. Available from http://link.springer.com/article/10.1007/BF01639002 (accessed June 11, 2013).

Shephard, J.M., J.M. Hughes, and M.P. Zalucki. 2002. Genetic differentiation between Australian and North American populations of the monarch butterfly *Danaus plexippus* (L.)(Lepidoptera: Nymphalidae): an exploration using allozyme electrophoresis. Biological Journal of the Linnean Society 75:437–452.

Sinha, S.N., K.H. Lakhani, and B.N.K. Davis. 1990. Studies on the toxicity of insecticidal drift on the first instar larvae of the Large White butterfly *Pieris brassicae* (Lepidoptera: Pieridae). Annals of Applied Biology 116: 27-41.

Skerratt, L.F., L. Berger, R. Speare, S. Cashins, K.R. McDonald, A.D. Phillott, H.B. Hines, and N. Kenyon. 2007. Spread of chytridiomycosis has caused the rapid global decline and extinction of frogs. EcoHealth 4(2):125-134.

Slayback, D.A., L.P. Brower, M.I. Ramirez, and L.S. Fink. 2007. Establishing the presence and absence of overwintering colonies of the monarch butterfly in Mexico by the use of small aircraft. American Entomologist 53:28–40.

Smith, D.A., G. Lushai, and J.A. Allen. 2005. A classification of Danaus butterflies (Lepidoptera: Nymphalidae) based upon data from morphology and DNA. Zoological Journal of the Linnean Society 144:191–212. Available from http://onlinelibrary.wiley.com/doi/10.1111/j.1096-3642.2005.00169.x/full (accessed June 11, 2013).

Smith, S. 2010. Testimony before the House Domestic Policy Subcommittee of the Committee on Oversight and Government Reform," September 30, 2010. Available from http://oversight.house.gov/wp-content/uploads/2012/01/20100930Smith.pdf (accessed August 20, 2014).

Smithers, C.N. 1973. A note on natural enemies of *Danaus plexippus* (L.) (Lepidoptera: Nymphalidae) in Australia. Australian Entomological Magazine 1:37–40.

Snell-Rood, E.C., A. Espeseta, C.J. Bosera, W.A. White, and R. Smykalskia. 2014. Anthropogenic changes in sodium affect neural and muscle development in butterflies. Proceedings of the National Academy of Sciences, Early Edition. www.pnas.org/cgi/doi/10.1073/pnas.1323607111

Solensky, M.J. 2004a. Overview of Monarch Migration. Pages 79 – 83 in K.S. Oberhauser and M.J. Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Solensky, M.J. 2004b. Overview of monarch overwintering biology. Pages 117 – 120 The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Stark, J.D., X.D. Chen, C.S. Johnson. 2012. Effects of herbicides on Behr's metalmark butterfly, a surrogate species for the endangered butterfly, Lange's metalmark. Environmental Pollution 164:24-27.

Steed, B., and B. Willhite. 2011. Diagnosis and evaluation of insect and disease activity, and forest health in the Monarch Butterfly Biosphere Reserve, Final Report to IAT.

Stevens, S. and D. Frey. 2004. How the other half lives: Monarch population trends west of the Great Divide. Biological Sciences Department, California Polytechnic State University. Unpublished report. 7 pp.

Stevens, S.R., and D. F. Frey. 2010. Host plant pattern and variation in climate predict the location of natal grounds for migratory monarch butterflies in western North America. Journal of Insect Conservation 14:731–744. Available from http://link.springer.com/10.1007/s10841-010-9303-5 (accessed August 29, 2013).

Stevens, S., and P. Jenkins. 2014. Heavy Costs: Weighing the Value of Neonicotinoid Insecticides in Agriculture. Center for Food Safety Available from http://www.centerforfoodsafety.org/files/neonic-efficacy_digital_29226.pdf (accessed August 20, 2014).

Stone, W.W. 2013. Estimated annual agricultural pesticide use for counties of the conterminous United States, 1992–2009. U.S. Geological Survey Data Series 752.

Sur R. and A. Stork. 2003. Uptake, translocation and metabolism of imidacloprid in plants. Bulletin of Insectology 56:35-40.

Tapparo, A., D. Marton, C. Giorio, A. Zanella, L. Soldà, M. Marzaro, L. Vivan, and V. Girolami. 2012. Assessment of the environmental exposure of honeybees to particulate matter containing neonicotinoid insecticides coming from corn coated seeds. Environmental Science and Technology 46(5): 2592-2599.

Taylor, C. 2013. Monarch Population Status, May 29. Monarch Watch Update. Available from http://monarchwatch.org/blog/2013/05/monarch-population-status-19/ (accessed June 9, 2013).

Taylor, C. 2014. January 29. Monarch Population Status, January 29. Monarch Watch Update. Available from http://monarchwatch.org/blog/2014/01/monarch-population-status-20/ (accessed August 7, 2014).

Taylor, O. and J. Lentz. 2005. Monarchs, cold summers, jet streams, volcanoes, and more. Monarch Watch Update. January 14, 2005. Available from http://www.monarchwatch.org/update/2005/0114_teaching.html (accessed August 7, 2014).

Thelin, G.P. and W.W. Stone. 2013. Estimation of annual agricultural pesticide use for counties of the conterminous United States, 1992-2009. U.S. Geological Survey Scientific Investigations Report 2013-5009.

Tooker, J.F., P. F. Reagel, and L.M. Hanks. 2002. Nectar sources of day-flying Lepidoptera of central Illinois. Conservation Biology and Biodiversity. Annals of the Entomological Society of America 95(1):84-96.

Tuduri, L., T. Harner, P. Blanchard, Y.F. Li, L. Poissant, D.T. Waite, C. Murphy, and W. Belzer. 2006. A review of currently used pesticides (CUPS) in Canadian air and precipitation. Part 2: Regional information and perspectives. Atmospheric Environment 40:1579–1589.

Tuskes, P.M., and L.P. Brower. 1978. Overwintering ecology of the monarch butterfly, *Danaus plexippus* L., in California. Ecological Entomology 3(2):141-153.

Urquhart, F.A., and N.R. Urquhart. 1978. Autumnal migration routes of the eastern population of the monarch butterfly (*Danaus p. plexippus* L.; Danaidae; Lepidoptera) in North America to the overwintering site in the Neovolcanic Plateau of Mexico. Canadian Journal of Zoology 56(8): 1759-1764.

U.S. Department of Agriculture (USDA). 2013. Summary Report: 2010 National Resources Inventory, Natural Resources Conservation Service, Washington, DC, and Center for Survey Statistics and Methodology, Iowa State University, Ames, Iowa. Available from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1167354.pdf (accessed June 17, 2014).

U.S. Department of Agriculture (USDA APHIS). 2002. Rangeland Grasshopper and Mormon Cricket Suppression Program, Environmental Impact Statement - 2002. Available from http://www.aphis.usda.gov/import_export/plants/manuals/domestic/downloads/eis.pdf (accessed August 20, 2014).

U.S. Department of Agriculture (USDA) Census. 2012. Table 8: Land: 2012 and 2007. Summary and State Data, Vol. 1, Geographic Area Series, Part 51, Census of Agriculture 2012, U.S. Department of Agriculture, May 2014.

U.S. Department of Agriculture (USDA) CropScape. 2013. USDA National Agricultural Statistics Service Cropland Data Layer. Published corn and soybean data layer. Available from http://nassgeodata.gmu.edu/CropScape/ (accessed August 5, 2014). USDA-NASS, Washington, D.C.

U.S. Department of Agriculture Economic Research Service (USDA ERS). 2012. Agricultural Resources and Environmental Indicators, 2012 Edition. Economic Information Bulletin 98, August 2012.

U.S. Department of Agriculture Economic Research Service (USDA ERS). 2014a. Adoption of genetically engineered crops in the U.S.: 1996-2014. Available from http://www.ers.usda.gov/media/185551/biotechcrops_d.html (accessed 7/31/14).

U.S. Department of Agriculture Economic Research Service (USDA ERS). 2014b. Data Set: Genetically engineered varieties of corn, upland cotton, and soybeans, by State and for the United States, 2000-14. Available from http://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us.aspx#.U961LVawyao (accessed August 20, 2014). Note that the total percentage of herbicide-resistant crops is the sum of "herbicide-tolerant only" and "stacked gene varieties."

U.S. Department of Agriculture Economic Research Service (USDA ERS) Corn. 2014. Corn: Background. Available from http://www.ers.usda.gov/topics/crops/corn/background.aspx#.U4olNcawwVs (accessed May 31, 2014).

U.S. Department of Agriculture Economic Research Service (USDA ERS) Feed Grains. 2014. Feed Grains Database. Available from http://www.ers.usda.gov/data-products/feed-grains-database.aspx (accessed May 31, 2014). Based on data for corn: production and alcohol for fuel use.

U.S. Department of Agriculture Farm Service Agency (USDA FSA). 2014. "What is the Conservation Reserve Program?" USDA Farm Services Agency. Available from http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp (accessed May 27, 2014).

U.S. Department of Agriculture Farm Service Agency Conservation Reserve Program (USDA FSA CRP). 2014. Changes in CRP Acreage from 2007 to October 2013 by State. USDA Farm Services Agency, 2014, spreadsheet available from http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=rns-css (accessed May 28, 2014).

U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS). 1991-2008. Agricultural Chemical Use Surveys: 1990 to 2007. *See* links under "Archived Documents" at: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1560 (accessed August 20, 2014). The pesticide usage information in any given document is for the year prior to the document date.

U.S. Department of Agriculture National Agricultural Statistics Service Advisory (USDA NASS Advisory). 2006. Meeting of the Advisory Committee on Agriculture Statistics (ACAS): Summary and Recommendations, Appendix III, February 14-15, 2006. USDA National Agricultural Statistics Service. Available from http://www.nass.usda.gov/About_NASS/Advisory_Committee_on_Agriculture_Statistics/advisory-es021406.pdf (accessed August 20, 2014).

U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS). 2010. Field Crops: Usual Planting and Harvesting Dates. Agriculural Handbook No. 628, October 2010.

U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS). 2011. Agricultural Chemical Use Survey: Corn 2010. May 2011. Available from http://www.nass.usda.gov/Data_and_Statistics/Pre-Defined_Queries/2010_Corn_Upland_Cotton_Fall_Potatoes/index.asp (accessed August 20, 2014).

U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS). 2013. Agricultural Chemical Use Survey: Soybeans 2012. May 2013. *See* "Data Table" link at http://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Chemical_Use/index.asp .

U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS). 2014. Corn and soybean acres planted data. Available from http://www.nass.usda.gov (accessed August 20, 2014).

U.S. Environmental Protection Agency (US EPA). 2006. Reregistration Eligibility Decision for Dicamba and Associated Salts, List [B], Case No. 0065.

U.S. Environmental Protection Agency (US EPA). 2007. Pesticide News Story: EPA Releases Report Containing Latest Estimates of Pesticide Use in the United States. Available from http://epa.gov/oppfead1/cb/csb_page/updates/2011/sales-usage06-07.html (accessed August 6, 2014).

U.S. Environmental Protection Agency (US EPA) BEAD. 2012. BEAD Chemical Profile for Registration Review: 2,4-D Chemical Case. Biological and Economic Analysis Division, Environmental Protection Agency, May 8, 2012.

U.S. Fish and Wildlife Service (US FWS). 2012. Listing of the Miami Blue Butterfly as Endangered Throughout Its Range; Listing of the Cassius Blue, Ceraunus Blue, and Nickerbean Blue Butterflies as Threatened Due to Similarity of Appearance to the Miami Blue Butterfly in Coastal South and Central Florida; Final Rule. 77 FR 20948.

U.S. Geological Survey (USGS). 2003. USGS releases study on toxic rainfall in San Joaquin Valley. August 18, 2003. Accessed August 8, 2014, Available from http://www.usgs.gov/newsroom/article_pf.asp?ID=169 (accessed August 20, 2014).

U.S. Geological Survey (USGS). 2013. Regional Trends of Biological Resources — Grasslands Prairie Past and Present. Northern Prairie Wildlife Research Center Website. Available from http://www.npwrc.usgs.gov/resource/habitat/grlands/pastpres.htm#table1 (accessed April 18, 2014).

U.S. Geological Survey (USGS). 2014. Pesticide National Synthesis Project. National Water-quality Assessment (NAWQA) Program Annual Pesticides Use Maps. Data available from http://water.usgs.gov/nawqa/pnsp/ (accessed August 7, 2014).

Van Dijk, A.I.J.M., H. E. Beck, R.S. Crosbie, R.A.M. de Jeu, Y.Y. Liu, G.M. Podger, B. Timbal, and N.R. Viney. 2013. The millennium drought in southeast Australia (2001-2009): natural and human causes and implications for water resources, ecosystems, economy, and society. Water Resources Research 49(2):1040-1057.

Van der Sluijs, J.P., N. Simon-Delso, D. Goulson, L. Maxim, J.M. Bonmatin, and L.P. Belzunces. 2013. Neonicotinoids, bee disorders and the sustainability of pollinator services. Current Opinion in Environmental Sustainability 5(3):293-305.

Vidal, O., J. Lopez-Garcia, and E. Rendon-Salinas. 2013. Trends in deforestation and forest degradation after a decade of monitoring in the monarch butterfly biosphere reserve in Mexico. Conservation Biology 28:177-186.

Villablanca, F. 2010. Monarch Alert Annual Report: Overwintering Population 2009-2010. Available from http://monarchalert.calpoly.edu/pdf/Monarch-Alert-Report-2010.pdf (accessed October 20, 2014).

Vincent, K., 2005. Investigating the causes of the decline of the urban house sparrow *Passer domesticus* population in Britain. De Montfort University, Leicester, United Kingdom.

Wagner, M. 2011. Glyphosate drift to rice a problem for us all. Delta Farm Press, 5/12/11.

Wallander S., R. Claassen, and C. Nickerson. 2011. The Ethanol Decade: An Expansion of U.S. Corn Production, 2000-09. EIB-79, U.S. Department of Agriculture, Economic Research Service, August 2011.

Wang, M. and D. Rautmann. 2008. A simple probabilistic estimation of spray drift - factors determining spray drift and development of a model. Environmental Toxicology and Chemistry 27(12):2617-2626.

Wassenaar, L.I., and K.A. Hobson. 1998. Natal origins of migratory monarch butterflies at wintering colonies in Mexico: new isotopic evidence. Proceedings of the National Academy of Sciences 95:15436–15439. Available from http://www.pnas.org/content/95/26/15436.short (accessed June 11, 2013).

Wells, H., P.H. Wells, and S.H. Rogers. 1993. Is Mulitple Mating an Adaptive Feature of Monarch Butterfly Winter Aggregation? Pages 61 – 68 in S. B. Malcolm and M. P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

White, D.S., and O.J. Sexton. 1989. The monarch butterfly (Lepidoptera: Danainae) as prey for the dragonfly *Hagenius brevistylus* (Odonata: Gomphidae). Entomological News 100:129–32.

Wilcove, D.S. 2008. No way home. The decline of the World's great animal migrations. Washington: Island Press/Shearwater Books.

Winkler K., T.R. Gordon, A.J. Storer, and D.L. Wood. 2003. Pitch Canker. Integrated Pest Management for gardeners and Landscape Professionals. Pest Notes, University of California Davis Publication 74107.

Woods, E.C., A.P. Hastings, N.E. Turley, S.B. Heard, and A.A. Agrawal. 2012. Adaptive geographical clines in the growth and defense of a native plant. Ecological Monographs 82:149–168. Available from http://www.esajournals.org/doi/pdf/10.1890/11-1446.1 (accessed June 11, 2013).

Woodson, R.E., Jr. 1954. The North American Species of Asclepias L. Missouri Botanical Garden 41:1 – 211. Available from http://www.jstor.org/stable/2394652 (accessed May 14, 2013).

Wright, C.K., and M.C. Wimberly. 2013. Recent land use change in the Western Corn Belt threatens grasslands and wetlands. Proceedings of the National Academy of Sciences 110:4134–4139. Available from http://www.pnas.org/cgi/doi/10.1073/pnas.1215404110 (accessed June 11, 2013).

Wyatt, R. 1996. More on the southward spread of Common Milkweed, Asclepias syriaca L. Bulletin of the Torrey Botanical Club 123:68 – 69. Available from http://www.jstor.org/stable/2996307 (accessed May 23, 2013).

Wyatt, R., A. Stoneburner, S.B. Broyles, and J.R. Allison. 1993. Range extension southward in common milkweed, *Asclepias syriaca* L. Bulletin of the Torrey Botanical Club 120(2):177–179. Available from http://www.jstor.org/stable/10.2307/2996947 (accessed June 11, 2013).

Xerces Society. 2013. Western Monarch Thanksgiving Count Data: 1997 - 2012. Available from http://www.xerces.org/wp-content/uploads/2011/04/TC-Data-1997-2012-Updated-MBCG.pdf (accessed June 11, 2013).

Xerces Society. 2014. Database of western monarch overwintering locations.

York, H.A., and K.S. Oberhauser. 2002. Effects of duration and timing of heat stress on monarch butterfly (*Danaus plexippus*)(Lepidoptera: Nymphalidae) development. Journal of the Kansas Entomological Society:290–298. Available from http://www.jstor.org/stable/10.2307/25481789 (accessed August 29, 2013).

Young-Isebrand, E., Oberhauser, K.S., Bailey, K., Charest, S., Hayes, B., Howard, E., Lovett, J., Meyers, S., Mollenhauer, E., Montesinos-Patino, E.B., Ryan, A., Taylor, O.R., Treviño Ulloa, R. 2015. Environmental education and monarchs: reaching across disciplines, generations, and nations. In Oberhauser, K.S., K.R. Nail, and S.M. Altizer, eds. Monarchs in a changing world: biology and conservation of an iconic insect, Chapter 1. Cornell University Press, Ithaca, NY.

Zalucki, M.P. 1981. The effects of age and weather on egg laying in *Danaus plexippus* L.(Lepidoptera: Danaidae). Researches on Population Ecology 23(2):318-327.

Zalucki, M.P. 1982. Temperature and rate of development in *Danaus plexippus* L. and *D. chrysippus* L.(Lepidoptera: Nymphalidae). Australian Journal of Entomology 21(4):241-246.

Zalucki, M.P. 1993. Sex Around the Milkweed Patch: the Significance of Patches of Host Plants in Monarch Reproduction. Pages 69 – 76 in S. B. Malcolm and M. P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

Zalucki, M.P., and A.R. Clarke. 2004. Monarchs across the Pacific: the Columbus hypothesis revisited. Biological Journal of the Linnean Society 82:111–121. Available from http://onlinelibrary.wiley.com/doi/10.1111/j.1095-8312.2004.00322.x/full (accessed June 11, 2013).

Zalucki, M.P., and R.L. Kitching. 1982. Temporal and spatial variation of mortality in field populations of *Danaus plexippus* L. and *D. chrysippus* L. larvae (Lepidoptera: Nymphalidae)." Oecologia 53(2): 201-207.

Zalucki, M.P., and J.H. Lammers. 2010. Dispersal and egg shortfall in Monarch butterflies: what happens when the matrix is cleaned up? Ecological Entomology 35:84–91. Available from http://doi.wiley.com/10.1111/j.1365-2311.2009.01160.x (accessed May 31, 2013).

Zalucki, M.P., L.P. Brower, and M.A. Alonso. 2001a. Detrimental effects of latex and cardiac glycosides on survivial and growth of first-instar monarch butterfly larvae *Danaus plexippus* feedin on the sandhill milkweed *Asclepias humistrata*. Ecological Entomology 26:212 – 224.

Zalucki, M.P., S.B. Malcolm, T.D. Paine, C.C. Hanlon, L.P. Brower, and A.R. Clarke. 2001b. It's the first bites that count: Survival of first-instar monarchs on milkweeds. Austral Ecology 26:547–555. Available from http://onlinelibrary.wiley.com/doi/10.1046/j.1442-9993.2001.01132.x/full (accessed June 19, 2013).

Zalucki, M.P., and W.A. Rochester. 2004. Spatial and Temporal Population Dynamics of Monarchs Down Under: Lessons for North America. Pages 219 – 228 in K. S. Oberhauser and M. J. Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Zalucki, M., W. Rochester, K. Oberhauser, and M. Solensky. 2004. Spatial and temporal population dynamics of monarchs down-under: lessons for North America. Pages 219 – 228 in Monarch butterfly biology and conservation. Cornell University Press Ithaca, USA.

Zipkin, E.F., L. Ries, R. Reeves, J. Regetz, and K.S. Oberhauser. 2012. Tracking climate impacts on the migratory monarch butterfly. Global Change Biology 18:3039–3049. Available from http://doi.wiley.com/10.1111/j.1365-2486.2012.02751.x (accessed June 11, 2013).

Zollinger, R. 1998. Common milkweed control. NDSU Crop and Pest Report, North Dakota State University, July 30, 1998. Available from http://www.ag.ndsu.edu/archive/entomology/ndsucpr/Years/1998/July/30/weeds_30july98.htm (accessed August 20, 2014).

Appendix A: Non-migratory Populations of *Danaus plexippus plexippus*

Non-migratory populations of *Danaus plexippus plexippus* outside of the Americas

During the mid- to late-1800's and into the 1900's monarchs spread across the Pacific to Hawaii, New Zealand, Australia, and many islands of Oceania (Brower 1995, Zalucki and Clarke 2004, Fig. 1, p. 114; *see* Figures 1 and 2 below). During this same time period, monarchs also colonized islands across the Atlantic, such as Bermuda and the Madeira and Canary Islands, and are now resident in the Azores and coastal areas of Spain as well (Haeger et al. 2011). Various lines of evidence point to more than one introduction event in the Pacific, with populations in Hawaii and Australia likely forming independently (Shephard et al. 2002, Lyons et al. 2012), and other Pacific islands being colonized by radiation from original areas (Zalucki and Clarke 2004, Fig. 1). Introduction and spread in the Atlantic and Spain have not been as well studied, but monarchs are regularly found off-course during fall migrations as far as the United Kingdom (Vane-Wright 1993, Brower 1995, p. 354).

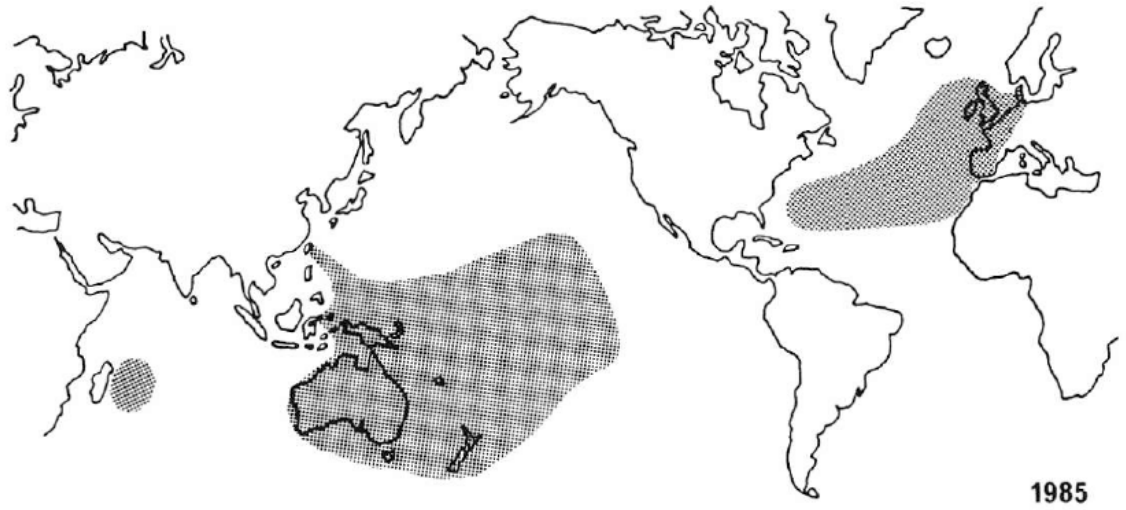

Figure 2. Current (1985) known range of *D. p. plexippus* outside the Americas. [Note: Apart from the east coast region of Spain (Edwards, 1988) monarchs are not known to breed in the British Isles or continental Europe, but they still occur as more or less occasional vagrants on western coasts (e.g. Bretherton and Chalmers-Hunt, 1982).]

Figure 1, Appendix A. 1985 Range of *Danaus plexippus plexippus* outside the Americas. Figure 2 from Vane-Wright 1993, original legend.

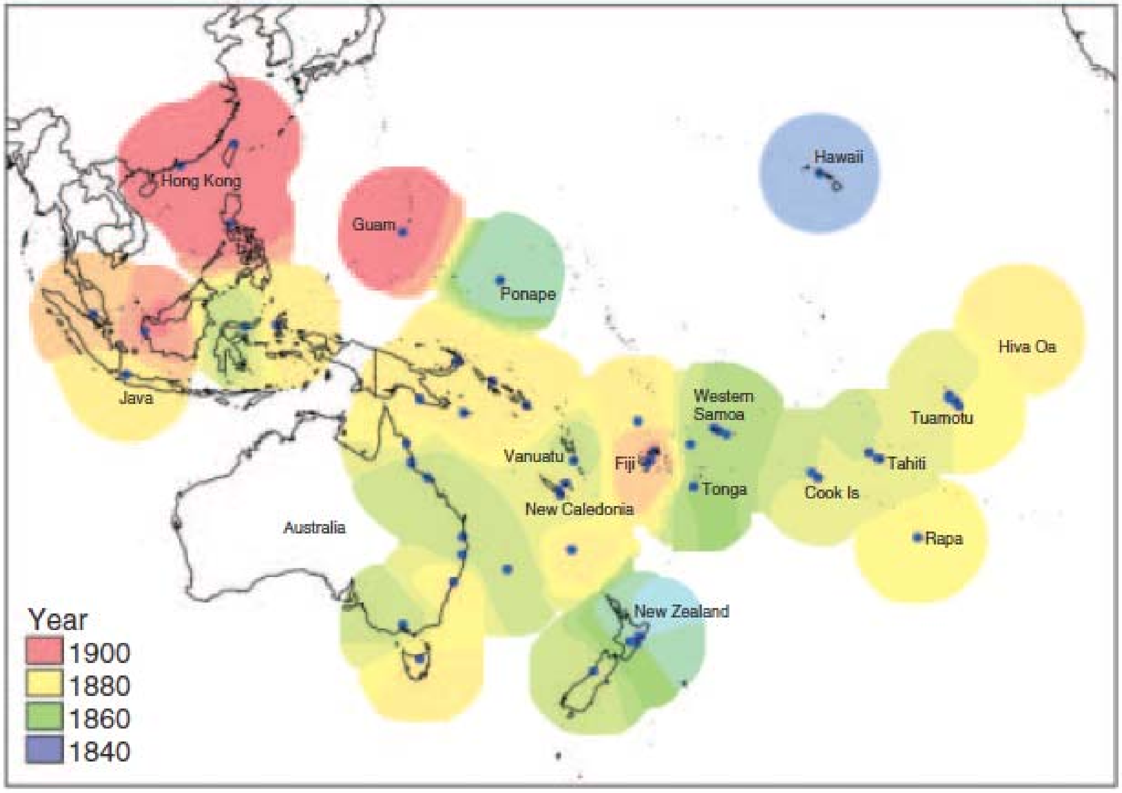

Figure 2, Appendix A. The spread of monarch butterflies, *Danaus plexippus plexippus*, across the Pacific in the 1800s. The map is generated by assuming that each new population was derived from the nearest neighboring population (in any direction) with a confirmed earlier arrival, unless an intervening island group was known to be free of the butterfly. Note that populations appear to stem from one or two incursion points in the South Pacific. Figure 1 from Zalucki and Clarke 2004, original legend.

Based on the short amount of time since these introductions of *D. p. plexippus* outside of North America, the new populations are still considered part of the subspecies. However, genetic analyses show that they have less genetic diversity than monarchs in North America (Shephard et al. 2002, Lyons et al. 2012, Pierce et al. 2014), and most are now likely to be genetically isolated from the main North American population (Lyons et al. 2012).

There is debate about how and why these dispersals occurred when they did, both east and west (Brower 1995, pp. 352 – 357). Host plants in the milkweed family had been introduced to the Pacific and Atlantic during this same time frame. Given sightings of vagrant monarchs far from North America over the years, it is plausible that some monarchs have always ventured far from their native habitat during migrations but would not have been able to establish breeding populations in the absence of suitable milkweeds. Such milkweeds were absent before colonial times.

In both the Atlantic and Pacific islands and coastal areas, non-native tropical milkweeds were introduced by colonists and travelers, intentionally as garden flowers and for medicinal uses, and unintentionally in packing materials and as seed contaminants (Brower 1995, Zalucki and Clarke

2004). These milkweeds also have become naturalized to greater or lesser extents, usually in disturbed areas such as pastures and roadsides, or along watercourses, and are now considered to be pan-tropical. The most common are *Asclepias curassavica* (tropical milkweed, scarlet milkweed) (*see*: http://www.cabi.org/isc/datasheetreport?dsid=7248), native to South America; *Gomphocarpus physocarp*a (balloon plant, giant swan plant) and *G. fruticosus* (swan plant, cotton bush), native to South Africa; and *Calotropis procera* (apple of Sodom, giant milkweed) (*see*: http://www.cabi.org/isc/datasheetreport?dsid=16848), originally from Africa, India and Southeast Asia. In addition, *C. gigantea* (crown flower, tree calotrope), also from Asia, is found in many areas of the Pacific (*see*: http://www.hear.org/pier/species/calotropis_gigantea.htm); and the non-tropical *A. incarnata* (swamp milkweed) from North America is cultivated specifically to feed monarch larvae in New Zealand (Elliot et al. 2009).

In some islands, naturalists report boom and bust cycles accompanying monarch introductions, as monarchs first thrive on and then decimate the introduced host plant populations:

> From the records of early naturalists we get a clue as to how the introductions and rapid spread may have proceeded. A number of commentators (Semper, 1873; Sturm, 1878; Walker, 1886; Collenette, 1925) point out that monarchs on some islands reached very high levels shortly after introduction. For Upolu, in the Samoan group, Semper (1873) wrote '. . . it was observed in 1869 for the first time. On Upolu the species became quickly very frequent and in 1870 it was one of the most common butterflies.' On New Caledonia, one writer reported 'millions of butterflies' (Walker, 1914). Initial 'boom' commonly appears to have been followed by 'bust', however, as large caterpillar populations appear to have eaten out their host plants, e.g. 'In New Caledonia, . . . it became very abundant some years ago, but is now comparatively scarce, owing, . . . to the destruction of nearly all the food-plant by the larvae' (Walker, 1886). Collenette (1925) reported that this butterfly had changed from being common, to rare or absent, on Hiva-Oa, Tahuata and Nuka-Hiva Islands, in the Marquesas, on Papeete, Tahiti, and on Moorea Island in the Society Islands. Diggle (Marks, 1963) went so far as to use the recently introduced (to Australia) monarch to illustrate perhaps the first ever talk on biological control using herbivorous insects (Zalucki and Clark 2004, p. 114).

Decimation of host plants results in cycles of monarch abundance, depending on the particular milkweed species and their capacity to rebound:

> Such variation in abundance still happens: on Oahu (Hawaiian archipelago) butterfly numbers fluctuate widely during the year, with periods when caterpillars are so abundant that host plants (*Calotropis* spp.) are defoliated, alternating with periods when numbers are low (M. P. Zalucki, pers. observ.; John Stimpson, University of Hawaii, pers. comm.). Thus, it appears likely that once monarchs successfully colonized an island, their populations increased rapidly until the local carrying capacity was exhausted. Subsequent outbreaks only appear to be possible with hosts that can recover relatively quickly from defoliation (e.g. *Calotropis*). Blakley & Dingle (1978) reported the virtual elimination of *A. curassavica* by monarchs on Barbados. Initial outbreaks following colonization would have resulted in high levels of non-directional local dispersion, probably resulting in high levels of population mortality, until the next island was chanced upon and the cycle repeated (Zalucki and Clarke 2004, p. 114).

Monarchs are thought to have moved between islands via favorable winds and storms, by hitchhiking on boats, and sometimes by intentional human introduction (Clarke and Zalucki 2004, Zalucki and Clarke 2004, p. 115). None of the non-North American monarch populations migrate as a regular part of their lifecycle, although they may move in response to habitat changes. There are reports and studies of migratory behavior of monarchs in Australia and New Zealand during winter from colder to warmer areas (Ramsay 1964, James 1993). These movements, however, are not comparable to the yearly two-way migrations in North America.

Establishing a population on the "next island" in this way is only possible if non-native milkweed host plants are already present when monarchs arrive. Although widespread, to our knowledge the distribution of these milkweeds, and thus the potential for resident monarch populations, is incomplete. There are surveys of milkweeds on some but not all islands in the Pacific and Atlantic, so the proportion of islands inhabited by milkweeds and that are thus potentially suitable for monarchs is unknown.

There are no published estimates of the total number of monarchs outside of North America as there have not been any comprehensive surveys or censuses. Nor are there regular studies of particular populations specifically to determine their relative status and threats. However, some information about status and threats can be gleaned from more general studies of monarch biology in various non-North American locations, both west and east of the continent.

Polynesia

Polynesia consists of more than a thousand islands scattered over the central and southern Pacific Ocean. Monarchs were first described in this region in the Hawaiian Islands in 1840's, and monarchs were reported from New Zealand then, as well. Genetic studies support the contention that these were separate introductions (Pierce et al. 2014). Monarchs are widely reported throughout Polynesia (e.g. Clarke and Zalucki 2004, Appendix), including Tonga, Vanuatu, the Marquesas, Samoa, and Tahiti, although current status on particular islands is not generally known.

Hawaii

There are resident populations of *D. p. plexippus* on all the major Hawaiian islands, and they use a variety of introduced host plants, mainly *Asclepias curassavica*, *Gomphocarpus physocarpa*, *Calotropis procera*, and *C. gigantea*. Both *Calotropis* species are planted widely around houses and in gardens. In fact, flowers of *C. gigantea* are prized and grown for leis, and were reputed to be the favorite of Queen Lili'uokalani (b. 1838 – d. 1917) (Cook 2013). All are naturalized.

Monarchs were reported in Hawaii by the mid-1800's: "…*A. curassavica* is believed to have been introduced to Hawaii in the period 1845–1850 (Wagner et al. 1990), with monarchs recorded there somewhere between 1841 and 1852, but after the milkweed (Scudder 1875)" (Zalucki and Clarke 2004, p. 114). Whether they arrived on their own or hitchhiked on a ship is not known.

Recent genetic studies using microsatellite markers show little genetic differentiation between monarchs on the four Hawaiian islands sampled, indicating that they form one admixed population (Pierce et al. 2014). The Hawaiian monarch population has fewer alleles at the loci studied than the North American population (Pierce et al. 2014), consistent with being founded by one or a few butterflies and then being separated from the main population, and in line with genetic diversity studies using allozymes (Shepard et al. 2002).

There are no estimates of numbers of monarchs in Hawaii. Numbers fluctuate, as discussed above, based on milkweed status. Threats to introduced milkweeds and monarchs in Hawaii have not been studied.

New Zealand

Monarchs were first reported in New Zealand in the 1840's (Ramsay 1964). There are no native milkweeds in New Zealand (Elliot et al. 2009, p. 603). Hosts for monarchs that have been introduced to New Zealand are *Gomphocarpus fruticosis*, *G. physocarpus*, *Asclepias curassavica*, and *A. incarnata.* These milkweeds are specifically cultivated to host monarchs because New Zealanders are so fond of these butterflies (Wise 1980, p. 157; Monarch Butterfly NZ Trust 2009, as cited in Elliot et al. 2009): "Although the monarch butterfly *D. plexippus*, is exotic in New Zealand, it is an iconic species" (Elliot et al. 2009, p. 606).

Although it appears that most monarchs are raised on garden plants, *G. fruticosus* is listed as "naturalized" in New Zealand, confined to waste places and old gardens around habitations, *see*: http://floraseries.landcareresearch.co.nz/pages/Taxon.aspx?id=_06b0c40c-3461-40bf-b826-6f3d9d5fc4cc&fileName=Flora%204.xml

There are no estimates of the monarch population size, their status, or threats.

Micronesia

Micronesia is comprised of thousands of small islands in the western Pacific Ocean, such as the Caroline Islands, including Palau, Gilbert Islands, Mariana Islands, Marshal Islands, Nauru, and Wake Island.

Monarchs are widespread, occurring on all major island or island groups with the possible exception of Kosrae (Schreiner and Nafus 1997). Monarchs were first reported in 1857, introduced from Hawaii via a shipment that contained milkweed seed (likely *A. curassavica*) to Pohnpei (Kilonia = Ponape), Caroline Islands (Scudder 1875). The main host now is *Calotropis gigantea*. There is no information on status or threats.

In Guam, monarchs seem to have reduced their original host plant population, but the effect on monarchs themselves is not noted. According to Shreiner and Nafus (1997, p. 34 – 35):

> On Pacific islands this butterfly shows up soon after host plants arrive. In 1936, Swezey noted that the weed *A. curassavica* was very abundant on Guam, forming dense stands almost acres in extent, and the butterfly was also very abundant. Possibly the butterflies provided some control of the weed, as it now never forms dense stands.

Monarchs have recently been described in Nauru (Buden and Tennent 2008) using *Calotropis gigantia*, where they are commonly found near host plants along roadsides and yards in the coastal belt. There are seasonal fluctuations in numbers of monarchs, but status and threats are unknown.

Melanesia

Melanesia is made up of islands in the western Pacific, including thousands of islands north and east of Australia to Fiji, notably Papua and West New Guinea, Fiji, Vanuatu, the Solomon Islands, and New Caledonia. Monarchs are widespread in these islands.

Australia

Monarchs are widely distributed in coastal areas of Australia:

> Since the early 1870s, *D. plexippus* has colonized most parts of eastern Australia, the Adelaide area and a small portion of Western Australia (Zalucki, 1986; James, 1993). There is a temperature-induced behavioural distinction among the Australian populations in that the majority of Queensland populations breed continuously throughout the year, whilst a range contraction occurs from southern Queensland and northern New South Wales with the onset of autumn, leading to the development of three eastern population centres: the southern Queensland/Northern New South Wales coastal strip extending up in to the tropics, the Sydney Basin/Hunter Valley region, and the Adelaide area (James, 1979; James, 1993; Zalucki & Rochester, 1999) (Shepard et al. 2002, p. 438).

Although monarchs were first noted in 1870, they were common by 1873 (Clarke and Zalucki 2004). Monarchs may have first arrived in Australia during a series of cyclones, from Vanuatu and New Caledonia where they were already established. They originally used the deliberately introduced *Asclepias curassavica* as a host plant, although *Calotropis* species were also present early:

> Calotrope is thought to have been introduced into Australia during one of the Queensland gold rushes in the late 1800s or early 1900s. It is not known exactly how it was introduced, but it may have been deliberately introduced as an ornamental or accidentally introduced in the packing of camel saddles. Calotrope was first recorded as naturalised in semi-arid northern Queensland in 1935, but was probably present for some time prior to this (Parsons & Cuthbertson 2001), *see*: http://www.environment.gov.au/cgi-bin/biodiversity/invasive/weeds/weeddetails.pl?taxon_id=2767

Monarchs currently use *Gomphocarpus fruticosus*, *G. physocarpus*, and *Calotropis procera,* in addition to *A. curassavica* (James 1993). Each of these milkweeds is considered invasive in some parts of Australia (Ward and Johnson 2013), and there are attempts at eradication (https://www.agric.wa.gov.au/declared-plants/calotropis-declared-pest).

Based on allozyme studies, Australian monarchs do not represent the full genetic diversity of the North American population (Shepard et al. 2002).

Monarchs breed year round in parts of Australia, and overwinter in other parts (Zalucki and Rochester 2004). Roughly, the population size of monarchs is Australia is estimated to be less than 250,000, much smaller than in the 1960’s (personal communication, David James to Sarina Jepsen, June 18, 2014); and monarchs may be threatened by coastal development, drought and increasing temperatures, and by eradication of milkweed from pastures due to concerns about toxicity to grazing animals (James 1983, p. 197).

Philippines

Although monarchs were reported from the Philippines in about 1900 (Vane-Wright 1993, as cited in Zalucki and Clarke 2004, p. 121), they have not been found recently.

Southeast China

Monarchs were reported in Hong Kong the 1890's (Walker 1914, as cited in Zalucki and Clarke 2004, p. 121), but recent descriptions of milkweed butterflies in Hong Kong (Wong et al. 2004) and adjacent Macau (Easton and Pun 1997) do not list *D. plexippus*.

Galapagos

The Galapagos Islands are a thousand kilometers off the coast of Ecuador. No native milkweed hosts for monarchs were present before 1905 when *Asclepias currasavica* was introduced. It now grows in gardens, and has naturalized, mainly in the agricultural areas around towns on certain islands. Monarchs were first reported in the 1920's (Roque 1998). Their population size, status and threats are unknown.

Bermuda

Bermuda consists of a cluster of islands about 1000 km east-southeast of Cape Hatteras, North Carolina. According to Hilburn (1989), *Gomphocarpus physocarpa* and *Asclepias curassavica* were introduced and became naturalized by the time the first monarchs were reported in 1850's. By the late 1800's monarchs were very abundant throughout the year, but are much less common now. Milkweeds have been displaced by intense development, resulting in a very restricted distribution (Hilburn 1989). In addition, both caterpillars and adults are preyed upon by giant toads, *Bufo marinus* L. (p. 498). In 1988, the government started a Monarch Conservation Project to encourage citizens to plant *A. curassavica* and *G. physocarpa* in gardens, and commissioned a study of monarchs in the islands (Hilburn 1989, p. 495). Total numbers of monarchs have not been determined. However, the population may be replenished by monarchs that have been seen arriving over the ocean from the north, and also leaving from the south, in September and October, presumably migrants from North America.

Macaronesia

Several islands in the North Atlantic off the coast of Europe and Africa have resident monarch populations. These have been described by Neves et al. (2001, p. 19).

Canary Islands

> …in the Canary Islands, a local monarch population has been listed at least since 1880 (Higgins and Riley 1970) or 1887 (Leestmans 1975; Baez 1998). It inhabits the entire archipelago except for Lanzarote Island, and adults are observed flying throughout the year (Baez 1998). The larvae feed on *Asclepias curassavica* L. (Lesstmans 1975; Baez 1998), *G. fruticosus* (Asclepiadaceae) and *G. arboreum* (Malvaceae) (Baez 1998).

In addition, Brandes (2005) has reported recent introductions of *Calotropis procera* in some of the Canary Islands, since the 1990's.

Madeira Islands

> In Madeira island, it was first observed in 1860 (Leestmans 1975), and after this date several observations were published (*see* Meyer 1993 for review). It has recently become resident (Sousa 1984-85, 1991), and larvae are observed through the entire year (Tatjana Anselm, Caniço, Madeira, pers. comm.). The species occurs in some numbers on Porto Santo Island (Gardner and Classey 1960; Vieira 1999).

Azores

> [In the Azores] … As *Gomphocarpus* sp. is never found in large numbers, the availability of the food plant might be a limiting factor for the increasing population of monarch in these islands (Neves et al. 2001, p. 19).

In fact, large numbers of monarch caterpillars have been observed completely defoliating *G. fruticosus* host plants in the Azores (Neves et al. 2001, pp. 22 – 23).

Spain and Portugal

Resident monarch populations have been present in southern Spain since at least the 1990's, and perhaps much longer. Monarchs have been occasionally reported in coastal Spain since the late 1800's, and now share patches of introduced milkweed, *Asclepias curassavica* and *Gomphocarpus fruticosus*, with another milkweed butterfly from Africa, *Danaus chrysippus* (Haeger et al. 2011, p. 364). Near the Strait of Gibraltar in southern Spain, these milkweeds are naturalized in moist disturbed areas, such as farmlands. In some locations, host plants are threatened by eradication campaigns:

> … both species of milkweed are included on the checklist of invasive plants of Southern Spain (Dana et al. 2005). Therefore, in the ''Natural Park of the Alcornocales'' which was part of our study area, control of these plants is occasionally undertaken and one of the biggest mixed patches of *G. fruticosus* and *A. curassavica* was cleared in 2007. In this patch *D. plexippus* was only sporadically seen, but we registered up to 45 *D. chrysippus* flying during the summer of 2009. In the National Park of Doñana (150 km to the NW of the area) both plants have been systematically uprooted. In 1983 the monarch butterfly was not included on the checklist of this National Park, but both species of *Danaus* have been detected in past years. At least one flourishing colony was eradicated in 2004 (Fernández Haeger and Jordano 2009). Nevertheless the total extinction of plants is not easy. Patches recovered in a few months after being cleared, because both species resprout easily from roots, from seed already in the soil and the arrival of seeds from surrounding patches might be frequent and germination rates of seeds are high (unpublished data). Therefore, if herbivore density and water availability does not change, recovery of patches occurs in a short period of time. In any case, there is a conflict between the conservation of these specialist butterflies and the eradication of their foodplants considered as invasive species (Haeger et al. 2011, p. 364).

Resident monarchs have also been studied in the Mediterranean coastal areas of Spain, from Málaga and Granada to Almeria in southeastern Spain. The first colony was reported in Malaga Province in 1979. Throughout the 1980's monarchs expanded along the Malaga coast. However, numbers of monarchs were extirpated from Malaga Provence in the late 1980's, perhaps due to rapid development of their breeding area and loss of host plants, or in response to cycles of drought and high temperatures (Gil-T 2006, pp. 144 – 145). Monarchs reestablished in southeastern Spain in the 2000's, and were reported to be using a new host plant, native *Cynanchum acutum,* in addition to the introduced host species (Gil-T 2006, p. 145 – 146).

There also are reports of monarchs in coastal Portugal, although their status has not been carefully studied, and they may be visiting migrants rather than residents.

Non-migratory Populations of *D. p. plexippus* in the Southeastern United States, Cuba, and elsewhere in the Caribbean

There are small populations of monarchs that have been overwintering in the United States near the Gulf of Mexico and in Florida. Populations reside in these locations year round. Since they don't migrate, some researchers classify them as *D. p. megalippe* (Smith et al. 2005). At least in the best-studied Florida locations, it appears that migratory *D. p. plexippus* individuals coming from the east coast in the fall integrate into the stationary populations (Knight and Brower 2009). Some continue to Cuba and appear to integrate into the *D. p. megalippe* population there (Dockx 2002, Dockx 2007, Dockx 2012), or continue to other Caribbean islands. Also, with the spread of non-native milkweeds in the southeastern states, more migratory individuals may be forming transient year-round populations on these more heat-tolerant milkweeds (Harvey et al. 2009). Resident populations in south Florida are threatened by development and by increasing temperatures from climate change (Knight and Brower 2009, and *see* Threats—Other Factors, Climate Change section of this petition).

There also are some monarchs that breed year round in Southern California (Urquhart et al. 1968).

Works Cited in Appendix A

Brandes, D. 2005. *Calotropis procera* on Fuerteventura. Germany, Technical University Braunschweig. Available from http://www.biblio.tu-bs.de/geobot/calotropis.pdf (accessed June 11, 2013).

Brower, L.P. 1995. Understanding and misunderstanding the migration of the monarch butterfly (Nymphalidae) in North America: 1857-1995. Journal of the Lepidopterists' Society 49:304–385. Available from http://images.peabody.yale.edu/lepsoc/jls/1990s/1995/1995-49(4)304-Brower.pdf (accessed August 20, 2014).

Buden, D.W., and W.J. Tennent. 2008. First Records of Butterflies (Lepidoptera) from the Republic of Nauru 1. Pacific Science 62:495–498. Available from http://www.bioone.org/doi/abs/10.2984/1534-

6188(2008)62%5B495:FROBLF%5D2.0.CO%3B2 (accessed June 11, 2013).

Clarke, A.R., and M.P. Zalucki. 2004. Monarchs in Australia: on the winds of a storm? Biological Invasions 6:123–127. Available from http://link.springer.com/article/10.1023/B%3ABINV.0000010120.29634.db (accessed June 11, 2013).

Dockx, C. 2002. Migration of the North American Monarch *Danaus plexippus* to Cuba. Ph.D. Thesis, University of Florida.

Dockx, C. 2007. Directional and stabilizing selection on wing size and shape in migrant and resident monarch butterflies, *Danaus plexippus* (L.), in Cuba. Biological Journal of the Linnean Society 92:605–616. Available from http://onlinelibrary.wiley.com/doi/10.1111/j.1095-8312.2007.00886.x/full (accessed June 11, 2013).

Dockx, C. 2012. Differences in phenotypic traits and migratory strategies between eastern North American monarch butterflies, *Danaus plexippus* (L.). Biological Journal of the Linnean Society 106:717–736. Available from http://onlinelibrary.wiley.com/doi/10.1111/j.1095-8312.2012.01916.x/full (accessed June 11, 2013).

Elliott, M.S., B. Massey, X. Cui, E. Hiebert, R. Charudattan, N. Waipara, and L. Hayes. 2009. Supplemental host range of Araujia mosaic virus, a potential biological control agent of moth plant in New Zealand. Australasian Plant Pathology 38:603. Available from http://link.springer.com/10.1071/AP09046 (accessed March 25, 2014).

Easton, E.R. and W.-W. Pun. 1997. New records of butterflies from Macau, Southeast China (Lepidoptera: Papilionoidea). Tropical Lepidoptera 8(2):60-66.

Erickson, J.M. 1973. The utilization of various Asclepias species by larvae of the monarch butterfly, *Danaus plexippus*. Psyche 80:230–244. Available from http://psyche.entclub.org/80/80-230.html (accessed August 29, 2013).

Gil-T, F. 2006. A new hostplant for *Danaus plexippus* (Linnaeus, 1758) in Europe. A study of cryptic preimaginal polymorphism within *Danaus chrysippus* (Linnaeus, 1758) in southern Spain (Andalusia)(Lepidoptera, Nymphalidae, Danainae). Atalanta 37. Available from http://usuarios3.arsystel.com/yofgt/pdf/text_13.pdf (accessed August 29, 2013).

Haeger, J.F., D. Jordano, and M.L. Meléndez. 2011. Status and conservation of *Asclepiadaceae* and *Danaus* in southern Spain. Journal of Insect Conservation 15:361–365. Available from http://link.springer.com/10.1007/s10841-010-9354-7 (accessed June 11, 2013).

Harvey, R.G., P.L. Howell, C. Morgenstern, and F.J. Mazzotti. 2009. Native Habitats for Monarch Butterflies in South Florida, WEC266. University of Florida. Available from http://edis.ifas.ufl.edu/UW311 (accessed June 11, 2013).

Hilburn, D.J. 1989. A Non-Migratory, Non-Diapausing Population of the Monarch Butterfly, *Danaus plexippus* (Lepidoptera: Danaidae), in Bermuda. The Florida Entomologist 72:494–499. Available from http://www.jstor.org/stable/3495188 (accessed June 1, 2013).

James, D.G. 1993. Migration Biology of the Monarch Butterfly in Australia. Pages 189 – 200 in S.B. Malcolm and M.P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

Knight, A., and L.P. Brower. 2009. The Influence of Eastern North American Autumnal Migrant Monarch Butterflies (*Danaus plexippus* L.) on Continuously Breeding Resident Monarch Populations in Southern Florida. Journal of Chemical Ecology 35:816–823. Available from http://link.springer.com/10.1007/s10886-009-9655-z (accessed June 11, 2013).

Lyons, J.I., A.A. Pierce, S.M. Barribeau, E.D. Sternberg, A.J. Mongue, and J.C. de Roode. 2012. Lack of genetic differentiation between monarch butterflies with divergent migration destinations. Molecular Ecology 21:3433–3444. Available from http://doi.wiley.com/10.1111/j.1365-294X.2012.05613.x (accessed June 11, 2013).

Monarch NZT. 2013. Monarch Butterfly New Zealand Trust. Available from http://www.monarch.org.nz/monarch/ (accessed June 1, 2013).

Neves, V.C., J.C. Fraga, H. Schäfer, V. Vieira, A. Bívar de Sousa, and P.A. Borges. 2001. The occurrence of the Monarch butterfly, *Danaus plexippus* L. in the Azores, with a brief review of its biology. Universidade dos Açores. Available from http://repositorio.uac.pt/handle/10400.3/150 (accessed June 11, 2013).

Pierce, A.A., J.C. de Roode, S. Altizer, and R.A. Bartel. 2014. Extreme heterogeneity in parasitism despite low population genetic structure among monarch butterflies inhabiting the Hawaiian Islands. PloS one, 9(6), e100061.

Ramsay, G.W. 1964. Overwintering swarms of the monarch butterfly (*Danaus plexippus* (L.) in New Zealand. New Zealand Entomologist 3:10–16. Available from http://www.tandfonline.com/doi/abs/10.1080/00779962.1964.9722821 (accessed June 11, 2013).

Roque, L. 1998. The Monarch Butterfly in the Galapagos Islands: Is It a Native or and Introduced Species? Noticias de Galapagos 59:9 – 11. Available from http://datazone.darwinfoundation.org/media/pdf/59/NG_59_1998_Roque_Monarch_Butterfly.pdf (accessed June 11, 2013).

Schreiner, L.H. and D.M. Nafus. 1997. Butterflies of Micronesia. College of Agriculture and Life Sciences, University of Guam. 30 pp.

Scudder, S.H. 1875. The Introduction of Danaida Plexippus into the Pacific Islands. Psyche 1 (15):81-84.

Shephard, J.M., J.M. Hughes, and M.P. Zalucki. 2002. Genetic differentiation between Australian and North American populations of the monarch butterfly *Danaus plexippus*

(L.)(Lepidoptera: Nymphalidae): an exploration using allozyme electrophoresis. Biological Journal of the Linnean Society 75:437–452. Available from http://onlinelibrary.wiley.com/doi/10.1046/j.1095-8312.2002.00034.x/full (accessed June 11, 2013).

Smith, D.A., G. Lushai, and J.A. Allen. 2005. A classification of Danaus butterflies (Lepidoptera: Nymphalidae) based upon data from morphology and DNA. Zoological Journal of the Linnean Society 144:191–212. Available from http://onlinelibrary.wiley.com/doi/10.1111/j.1096-3642.2005.00169.x/full (accessed June 11, 2013).

Urquhart, F.A., N.R. Urquhart, and F. Munger. 1968. A study of a continuously breeding population of *Danaus plexippus* in Southern California compared to a migratory population and its significance in the study of insect movement. Journal of Research on the Lepidoptera 7(4):169-181.

Vane-Wright, R.I. 1993. The Columbus Hypothesis: An Explanation for the Dramatic 19th Century Range Expansion of the Monarch Butterfly. Pages 179 – 187 in S.B. Malcolm and M.P. Zalucki, editors. Biology and Conservation of the Monarch Butterfly. Natural History Museum of Los Angeles County, Los Angeles, CA.

Ward, M., and S.D. Johnson. 2013. Generalised pollination systems for three invasive milkweeds in Australia. Plant Biology 15:566–572. Available from http://doi.wiley.com/10.1111/j.1438-8677.2012.00700.x (accessed June 11, 2013).

Wise, K.A.J. 1980. Monarch butterfly dispersal in New Zealand. Records of the Auckland Institute and Museum 17:157 – 173.

Wise, K.A.J. (n.d.). Food-Plants of “Monarch” Butterfly Larvae | NZETC. Available from http://nzetc.victoria.ac.nz//tm/scholarly/tei-Bio11Tuat02-t1-body-d5.html (accessed June 2, 2013).

Wong, E., P.C. Leung, P. Sze, and A. Wong. 2004. Migration and overwintering aggregation of Danaid butterflies in Hong Kong. Hong Kong Biodiversity – Agriculture, Fisheries and Conservation Department Newsletter 6:1-6.

Zalucki, M.P., and A.R. Clarke. 2004. Monarchs across the Pacific: the Columbus hypothesis revisited. Biological Journal of the Linnean Society 82:111–121. Available from http://onlinelibrary.wiley.com/doi/10.1111/j.1095-8312.2004.00322.x/full (accessed June 11, 2013).

Zalucki, M.P., and W.A. Rochester. 2004. Spatial and Temporal Population Dynamics of Monarchs Down Under: Lessons for North America. Pages 219 – 228 in K.S. Oberhauser and M.J. Solensky, editors. The Monarch Butterfly: Biology and Conservation. Cornell University Press, Ithaca, NY.

Appendix B: Proposed Rules to Facilitate Monarch Butterfly Conservation, Science, Citizen Monitoring, and Education

To avoid concerns that protecting monarchs under the ESA would curtail education about the species in classrooms as well as scientific research, citizen monitoring, and beneficial household rearing endeavors, we propose the Fish and Wildlife Service adopt a version of the following rules along with any findings on this petition and/or proposal to list the species.

If monarchs are listed as a threatened species, under Section 4(d) of the ESA the Service can create a rule exempting certain activities from the prohibitions in Section 9 when those activities are necessary and advisable for the conservation of the species. 16 U.S.C. § 1533(d). The Service should use its Section 4(d) authority to carve out limited exemptions from the prohibitions on take, transport in commerce, and transport during a commercial activity for scientific research, citizen research and rearing, and conservation education activities that are necessary and advisable for the conservation of the species.

The following is a basic outline for the rule:

§ 17.47(b) Monarchs.

(1) The provisions of § 17.31(a) apply to this species, regardless of whether members of the species are in the wild or in captivity, and also apply to the progeny of any such butterfly.
(2) Any violation of State law will also be a violation of the Act.
(3) Paragraph (b)(1) will not apply to individuals engaged in scientific research on monarchs and/or their habitat that:
    (i) is beneficial to the conservation of the species or aimed at understanding monarch biology in ways that could benefit future monarch conservation;
    (ii) does not entail collection of the species for commercial display or commercial breeding;
(4) Paragraph (b)(1) will not apply to individuals engaged in citizen monitoring designed to conserve monarchs or scientific research designed to conserve the species or better understand monarch biology that:
    (i) is overseen by a scientist, conservation organization, or other entity dedicated to the conservation of the species;
    (ii) does not require capture of members of the species for commercial display or commercial breeding;
(5) Paragraph (b)(1) will not apply to conservation education activities that enhance the survival or propagation of the species, including but not limited to:
    (i) the rearing of monarchs in school classrooms provided that the monarchs are not provided by commercial suppliers;
    (ii) the rearing of monarchs at nature centers or other facilities designed to educate the public about the ecological role and conservation needs of the species provided that the monarchs are not provided by commercial suppliers;
(6) Paragraph (b)(1) will not apply to the collection of wild members of the species and rearing of fewer than ten monarchs per year by any individual, household, or educational entity.