

The efficacy of utilizing developed space to restore and
maintain monarch butterfly habitat: A model for
conservation

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ABSTRACT

SALIBA, MATTHEW JORDAN. The Efficacy of Utilizing Developed Space to Restore and Maintain Monarch Butterfly Habitat. A Model for Conservation. (Under the direction of Dr. Gary Blank).

Danaus plexippus, the monarch butterfly, represents a conservation challenge due to its species-specific habitat requirements, migratory patterns, and food source. These vulnerabilities have exacerbated the population's decline. As with any conservation problem, land use practices have an important role to play in species management and recovery. Many non-governmental organizations are instrumental in this effort by preserving habitat or making use of existing green space to better serve ecological needs. Understanding how well these initiatives are working is vital to the conservation of the species and the implementation of any project aimed at stabilizing or improving their populations. Data collection is also invaluable to the overall picture of monarch population health and vitality. The "*Monarchs in the Rough*" golf course program initiated by Audubon International and administered through local partners is evaluated for efficacy along with a similar program associated with the chemical company BASF. Three participating local golf courses in the Triangle area were evaluated for milkweed planting efforts and monarch butterfly use. Special training and data collection support were provided by Monarch Joint Venture which helps citizen scientists collect data at monarch conservation sites and compiles that data as part of their Integrated Monarch Monitoring Program.

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DEDICATION

I dedicate this paper to Audubon International and Monarch Joint Venture.

BIOGRAPHY

Matthew Saliba currently works for Wake County Environmental Services and completed an internship with the NC Department of Environmental Quality's Water Resources Division during his graduate program. He graduated from North Carolina State University with a Bachelor of Science in Parks, Recreation and Tourism Management with an Environmental Science minor. He grew up in NC and spent several years in the real estate industry after graduating college before turning his attention to his true passion, the natural sciences. He has dreams of working in conservation wherever it may lead him.

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Introduction

The monarch butterfly has become a species of concern. Studies of its decline have underscored factors potentially affecting the butterfly population's viability and possible extinction. The United States Fish and Wildlife Service has considered listing the species as endangered but meanwhile encourages non-governmental organizations to protect and restore critical habitat and hopefully stabilize population levels. Such efforts are complicated by the species complex life history, so considering possible conservation methods requires understanding the species habits and habitat needs. This paper will address a particular approach being employed by non-governmental organizations and their partners and demonstrate how this collaborative stewardship fits the current situation facing the monarch butterfly.

Monarch Butterfly Biology

The monarch Butterfly partakes in one of the greatest migrations of any insect. Every spring, overwintering monarchs in Mexico and portions of southern California begin a multigenerational migration north to breeding and feeding grounds in the contiguous United States and Canada. The entire journey takes a whole summer to complete with at least three distinct generations each making it a little farther north. The last generation enters reproductive diapause and lives longer to make the 2,500-to-3,000-mile journey back to the overwintering habitat in central Mexico and coastal southern California. This migrating generation can live up to nine months while previous generations only live a few weeks (Monarch Joint Venture). This migration is illustrated by Figure 1.2.

The California population migrates west of the Rockies while the Mexican population migrates to the east. These are discrete populations but some cross over does occur when butterflies wander over the geographic barrier of the Rocky Mountains. Decreasing day length, temperature and biological changes in their aging milkweed food source trigger a biochemical transition in the late summer generation. That transition initiates the migration south. Studies by James Kanz (1977) and Reppert Lab (2014) have shown that monarchs use the celestial cue of the sun and the earth's magnetic field to migrate to these specific overwintering locations (Monarch Joint Venture).

Like other species of moths and butterflies, monarchs undergo complete metamorphosis. They have four life stages which include egg, larva, pupa, and adult. Female monarchs lay their eggs only on species of milkweed (genus *Asclepias*) where the resulting caterpillars (larva) feed and eventually form a chrysalis after two weeks. The caterpillars go through five molting stages called instars before their final transformation. After forming the chrysalis, an adult monarch emerges in eight to fifteen days depending on temperature (Monarch Joint Venture).

Adult monarchs can feed on a wide variety of flower nectar. The reproductive dependence on milkweeds creates a vulnerability for monarchs especially when their survival is threatened by a multitude of factors. Development, agriculture, logging, pesticide use, and climate change are all threats facing their survival according to Dr. D. Andre Green II, assistant professor of ecology and evolutionary biology at the University of Michigan. Dr. Green studies molecular and genetic triggers of monarch migration to better understand their behavior and

wrote an article on the plight of the monarch for *The Conversation*, an online publication dedicated to providing expert knowledge on a wide range of subjects in academia.

History of Decline

Experts agree that over the last two decades, the number of monarchs returning to their overwintering sites in the highlands of central Mexico has plummeted by more than 90% (Demarco 2015). “Since 1993, the area of forest covered by monarchs at their overwintering sites in Mexico has fallen from a peak of 45 acres in 1996-1997 to as low as 1.66 acres in the winter of 2013-2014” (Green 2020). The California population has also seen drastic reductions with the 2019 count being the lowest ever (Green 2020). Figure 1.1 shows the decline since data have been compiled for population.

The monarch population for eastern North America is measured by the number of acres they occupy in their overwintering habitat with densities of about 8.5 million monarchs per acre. In 1996, there were an estimated 384 million monarchs overwintering. In 2013, only about 14 million were measured. In 2019, the number was 60 million (Parham 2020). Monarch Joint Venture reported a 26% decline in the eastern North American population in 2020 from the previous year (Caldwell, Wendy). While the numbers do indicate annual fluctuation, the population trend has been in a downward direction.

Monarch population trends have been somewhat of a mystery, however. Recently published research has yielded conflicting data regarding the summer and overwintering populations. DeMarco (2015) outlines the findings of these seven studies in her article

“Monarchs Pose a Puzzle” written for the publication *Science* which highlights the confusion around monarch numbers. One study drew on 18 years of monarch sightings from citizen volunteers which showed monarchs present in all their historic eastern North American breeding range. Another study looked at hourly counts of monarchs at hundreds of summer breeding sites from 1993 to 2014 and found no statistically significant population changes. That study relied on data collected by volunteers as well. According to ecologist Leslie Reis of Georgetown University and an author of one of the studies, a possible explanation is that volunteers favored sites such as parks and protected areas leading to an under sampling of more remote locations like agricultural areas. This could have skewed the data.

One reason monarchs are thought to be on the decline is the planting of more herbicide-resistant crops in agricultural areas leading to the use of chemicals that kill milkweed. One of the recently published studies DeMarco mentions is an egg laying study which found monarch egg densities on Milkweeds have declined since 2006. Biologist and study co-author Karen Oberhauser of the University of Minnesota, Twin Cities, said those findings suggest “there aren’t enough monarchs out there to find the remaining patches” of milkweed.

Other studies have looked at the migrating populations which appear to show normal numbers in the northern U.S., but large data gaps exist in the southern part of the U.S. toward the end of their journey. Texas is of particular interest to researchers because it is a central location where the spring and fall migratory paths intersect. Ecologist Andrew Davis of the University of Georgia, Athens, is a -co-author of two studies that investigated migratory numbers in Ontario

and Michigan. The Ontario study yielded a moderate decline while the Michigan study revealed no clear trend. Davis says that could mean monarch mortality is occurring farther south.

New data is needed to better understand what is happening during the fall migration so government agencies and stakeholders can prioritize the right solutions. Perhaps certain flyways need protecting. Those findings should be added to but not replace what we already know is a problem for monarchs says ecologist Ernest Williams of Hamilton College in Clinton, New York. The iterative and migratory nature of their life cycle has complicated our understanding of monarch populations.

U.S. Fish and Wildlife Service Action

This decline has been noted by the United States Fish and Wildlife Service (USFWS) which in December of 2020, issued a decision on listing the monarch butterfly under the Endangered Species Act (ESA). The decision in the Federal Register dated December 17th, 2020 referenced ongoing threats to habitat including the critical milkweed food source, herbicide usage, and climate change as primary drivers of population loss. The North American migratory populations account for most of the world's population of monarchs. At least 29 other extant populations derived from the North American population are known but data on their numbers is weak (85 FR 81813).

The USFWS estimated the probability of monarchs reaching the point at which extinction is inevitable (pE) for each North American population. "Currently, the eastern North American population has a pE less than 10 percent over the next 10 years. The western population has a

much higher risk of extinction, with a pE of 60-68 percent over the next 10 years. Taking future conditions into account, the pE for the eastern population is estimated to be 24 percent to 46 percent in 30 years, and the pE for the western population is estimated to be 92 percent to 95 percent in 30 years. These pE estimates incorporate the primary factors that influence the populations' resiliency, including availability of milkweed and nectar resources (losses as well as gains from conservation efforts), loss and degradation of overwintering habitat, insecticides, and effects of climate change.” (85 FR 81813). The USFWS also warns that as populations dwindle, they become more vulnerable to severe weather events.

A press release just before the publication of the decision in the Federal Register outlined the agency's finding regarding adding the monarch butterfly to the list of threatened and endangered species. The USFWS found it is warranted but precluded by work on higher-priority listing actions. With this decision, the monarch becomes a candidate for listing under the ESA, and its status will be reviewed each year until it is no longer a candidate. The Director of the USFWS, Aurelia Skipwith, was quoted as saying “while this work goes on, we are committed to our ongoing efforts with partners to conserve the monarch and its habitat at the local, regional and national levels. Our conservation goal is to improve monarch populations, and we encourage everyone to join the effort.” Wendy Caldwell, Executive Director of Monarch Joint Venture, was also quoted referencing her organization's work which is “...committed to continuing its conservation efforts for monarchs. Each of our partners, and many other stakeholders, come to the monarch conservation table with different approaches, audiences, strengths, and opportunities to make a difference. There is a role for everyone in monarch conservation.” Skipwith encouraged and praised continued cooperation with non-governmental organizations

like Monarch Joint Venture at the local, regional, and national levels. Partnerships among federal, state, and non-governmental organizations amplify conservation efforts (Parham 2020).

Oberhauser et al. (2017) ran statistical analyses using a spatially explicit demographic model to better understand how certain management scenarios and land use practices affected monarch population. The model considered the iterative nature of their life cycle across different regions of eastern North America and included survival rates, fecundity and the proportion of the population migrating. The monarch range was broken up into four regions. Their model concluded that improving breeding habitat in the South or North Central region had the greatest impact on population growth when taken alone. Increasing milkweed and nectar availability and decreasing insecticide use were actions considered by the model in those regions. Combining management strategies across the monarch's entire range yielded the greatest increase in population growth. Sensitivity analyses were also conducted to investigate how much each model parameter (management action) was influencing the population trend. That analysis indicated small contributions of any one parameter to the population growth. Hence, a combination of scenarios yielded the greatest improvement. This study certainly lends merit to the practice of improving breeding habitat particularly in the regions mentioned.

Conservation practices for the monarch have largely focused on habitat restoration or preservation. Rethinking land use practices or simply using developed land for conservation purposes is a promising approach. These spaces are accessible, ubiquitous and can be monitored easily. The "*Monarchs in the Rough*" program utilizes golf courses as the developed natural areas for monarch habitat restoration; however, other developed space is also being employed in

this endeavor. The USFWS in partnership with the University of Illinois-Chicago created a program with utility companies to better adapt their rights-of-way for ecological purposes. Using rights-of-way as habitat was proposed by a working group formed at the University of Illinois-Chicago in 2015 and now includes over 200 transportation, energy, government, and non-profit organizations across the U.S. and Canada. The USFWS issues what is called an enhancement of survival permit to non-federal landowners which authorizes the incidental or accidental killing of listed species that might arise from normal activity within the utility right-of-way. To apply for the permit, the landowner (utility company) must agree to certain conservation practices which help at-risk species survive. Such agreements are called candidate conservation agreements with assurances or CCAA's. According to the USFWS "partners who enroll in the agreement through a certificate of inclusion will create, enhance and maintain habitat for monarch butterflies, as well as continue their general operations, vegetation management and maintenance and modernization activities within existing rights-of-way." These agreements are specific to energy and transportation rights-of-way and will shield these companies from having to adopt additional conservation measures if the species is listed under the ESA. It is meant to be proactive while giving utility companies peace of mind. Management actions targeted by these agreements include "adjusting the timing of mowing and other vegetation management practices to reduce impacts to monarchs, modifying and minimizing herbicide use to promote growth of milkweed and flowering plants, using local seed mixes that include a variety of flowering plants and milkweed, and monitoring the quantity and quality of monarch habitat to allow for adaptive management." These actions are meant to promote the monarch's exclusive larval food source and provide additional nectar sources for adults (USFWS "Questions and Answers: Candidate Conservation Agreement with Assurances for the Monarch Butterfly).

Similar Species Recovery Efforts

Other at-risk species have benefited from using developed space for conservation initiatives, lending merit to the concept. One such species here in North Carolina happens to be another butterfly. The Saint Francis' Satyr (*Neonympha mitchellii francisci*) is found on Fort Bragg, an extensive military installation located primarily in Cumberland and Hoke counties. This population is the only known population, making it one of the rarest butterflies in eastern North America. The species was listed as endangered in 1995 having only been discovered about a decade earlier. Not much is known about its life history, but flooded meadows where the larval stage feeds on grasses and rushes is believed to be its preferred habitat. This habitat was traditionally supported by beaver activity and wildfire but, with both less common because of human intervention; the butterfly now depends on human induced disturbance to maintain its open meadow habitat. It is thought that fires from artillery use helped keep areas on Fort Bragg hospitable for the butterfly (Vidler, Megan). More research is needed on the life cycle and habitat requirements of the Saint Francis' Satyr so reintroduction sites can be identified and managed appropriately. Their location presents a unique challenge for natural resource managers and wildlife biologists tasked with protecting the species on Fort Bragg. This is an excellent example of the potential that developed space has in serving both human and ecological needs.

Fort Bragg is also home to a population of endangered sumac called Michaux's Sumac (*Rhus michauxii*). Like the Saint Francis' Satyr, *R. michauxii* depends on natural disturbances to maintain its preferred open woodland habitat. This plant species is currently limited to 21 known extant populations in the southeast United States, almost all in North Carolina. The Department

of Defense has partnered with The Nature Conservancy and the North Carolina Natural Heritage Program in conducting surveys for this and other rare plants on Fort Bragg. Controlled growing-season burns on a 3-year cycle are used to maintain the population of *R. michauxii* on the military installation. The recovery plan for *R. michauxii* drafted by the USFWS in 1993 also mentions rights-of-way as areas where many of the extant populations are found (Murdock and Moore 1993). Once again, rights-of-way can become modes for conservation, which mirrors the utility conservation agreements put forth for monarchs. There are parallels between these species' recovery plans and the habitat recovery plan for the monarch butterfly.

The conservation programs implemented by Audubon International and BASF utilize developed open space for the enhancement of monarch survival. The multiorganizational partnership aspect is also reflected. The “*Monarchs in the Rough*” program depends on local golf courses for setting aside habitat and growing milkweed. Volunteers with Monarch Joint Venture help collect data on monarch use.

The Role of Golf Courses in Monarch Conservation

Golf courses represent an abundant opportunity for conservation initiatives. According to a 2007 report from the Golf Course Superintendents Association of America, an average 18-hole golf course comprises 150 acres. On average, 24 acres are dedicated to non-turfgrass landscapes. In the United States, an estimated 2,244,512 acres are dedicated to golf courses with 740,302 of those acres characterized as non-turfgrass landscapes (GCSAA Environmental Profile 2007). Some of these courses represent the most continuous green space in a community and they retain

the ability to provide more ecosystem benefits. “*Monarchs in the Rough*” is a great example of collaborative stewardship.

The “*Monarchs in the Rough*” program seeks to capitalize on the ecosystem benefit concept and take advantage of the ubiquitous nature of golf courses for conservation purposes. This practical strategy can make golf courses more of an ecological asset at a time when courses are becoming more aware of their ecological footprint and transforming to adopt more sustainable practices. Marcus Gray, the program manager, gave a presentation to the GCSAA in 2019 highlighting the program’s success and future goals. At the time, over 300 courses were participating in 36 states, Puerto Rico, 4 Canadian provinces and Mexico. With grant funding, the program hopes to provide 500 more golf courses with regionally appropriate milkweed and wildflower seed (Gray 2019). In the research triangle area, the Heritage and Wakefield Plantation Golf Courses participate in the program and are certified through Audubon International to meet monarch habitat requirements. North Carolina State University’s Lonnie Poole Golf Course also manages monarch habitat in partnership with the chemical company BASF through BASF’s “*Living Acres*” program. Fifty acres of the golf course were planted with milkweed and wildflowers essential to butterflies and other pollinators. Brian Green, director of golf course maintenance at Lonnie Poole, said the university has planted 750 milkweeds among different locations on the course. Golfers have noticed an increase in monarch activity since the plantings (Greene 2019).

Local Findings

Wakefield Plantation, Heritage and Lonnie Poole provide information about the efficacy of this approach toward monarch habitat restoration and management. Visits to these sites reveal differences in strategy and attention to management. However, this paper does not attempt to quantify the success of the efforts observed. For one thing, it can be difficult to measure the exact number of milkweeds present at a given site due to the plant's rhizomatous nature. One plant can send up several individual shoots that look like multiple plants. Moreover, native versus introduced milkweed species may perform differently.

At the Wakefield location, groundskeeper Todd Lawrence says he has never planted the common milkweed growing on his course. Wakefield has several areas in the roughs along the green where the common milkweed (*Asclepias syriaca*) is found. It was always present in the natural areas which are now carefully managed to prevent disturbance in the warmer months when monarchs are migrating north, and the milkweed is growing. "We just bushhog around it" he said. The grasses and other vegetation need trimming to prevent overgrowth, but the milkweeds are left intact.

The large purple flower heads called umbels stand out among the mostly green grasses and brush around them. Aside from the umbels, common milkweed is distinctive with its broad oval leaves attached to the stem by a petiole, pink midvein and younger shoots having fine white hairs with a velvety feel. We estimated about 200 individual milkweeds in total. Since the plants are allowed to mature without being cut down, Todd said the milkweeds have been reproducing via seed and spread every year. He pointed out several stands of milkweed that were not present the previous season.

During our site visit on July 10th, one monarch was seen feeding on an umbel, but no larvae or eggs were present (that we could find). Many bees were seen feeding on the umbels, which highlights the benefit of these areas for other pollinators. Todd has documented monarch use from previous seasons including reproductive activity in August which is strong evidence that the monarchs find and utilize the milkweeds at this site.

At Heritage Golf Course, only one designated area is set aside for the monarch program at the 18th hole near the pumphouse. Upon inspection, this area was found to be very overgrown with only two individual common milkweeds seen among a plethora of other native and even invasive species like Lespedeza. The site is located adjacent to the pond and golf course. Other flowers in the *Asteraceae* family (coneflower and black-eyed susan) have been planted in this area for pollinators as well. The quality of this site is reduced due to poor management of unwanted species which suffocate the desired ones and very few milkweeds. Several young sweet gum saplings were also found growing in the monarch habitat area, further crowding out and shading the other plants. No monarch larvae or eggs were present on the two milkweed plants.

Lonnie Poole's golf course is an excellent example of high-quality prairie habitat and milkweed planting efforts. The course has acres of rolling, open, grassy habitat boasting a mix of different milkweed species and wildflowers. Common milkweed stands amidst the grasses next to butterfly weed (*Asclepias tuberosa*) and whorled milkweed (*Asclepias verticillata*). Whorled milkweed has the appearance of young pine saplings with needle-like leaves and small white

flowers near the top of the stem. Flowers, including native passion vine, dot the landscape. No monarchs were seen during the site visit on July 17th but other pollinators including butterflies were found actively feeding on the mix of flowers. Due to the size of the habitat and number of milkweeds present, without meticulous surveillance of each milkweed, it is possible to miss monarch eggs or larvae. Some monarchs may have been further north at this point in the summer as well. Monarch use of the milkweed prairie habitat at Lonnie Poole is well documented however by golfers and groundskeeping staff.

Best Management Practices and Room for Improvement

Participating in a conservation program like “*Monarchs in the Rough*” or any similar initiative is a good first step for golf courses or landowners. However, without proper management, these efforts can fall short. Conservation areas should be maintained with appropriate species, manicured in such a way that does not detract from their stated purpose, and monitored regularly to track success or to catch any issues. Most milkweed species grow best in an open prairie landscape so these natural areas should be kept free of taller shrubs and trees.

All groundskeeping staff should be properly trained to identify and avoid cutting the milkweed as accidental mowing could ruin an entire growing season for the monarchs or cause direct mortality to eggs/larvae. Mowing these areas in autumn to keep them looking fresh is of no consequence because the monarchs have migrated south for winter and the milkweed dies back to the root after the first frost. Milkweed stems reemerge in the spring.

At Wakefield Plantation Golf Course, the conservation areas are carefully mowed to avoid cutting the milkweeds if the grass and brush around them starts getting overgrown. Wakefield Plantation Golf Course contains several areas of open grassy habitat where the common milkweed is doing quite well. These areas could be enhanced aesthetically and ecologically by planting a mix of wildflowers in the spring to compliment the milkweeds. Introducing other species of milkweed could also be done to add more variety and color as seen at Lonnie Poole's golf course. *Asclepias tuberosa* produces orange flowers, smaller and more slender leaves, and fuzzy stems. Adding other milkweed species provides additional food sources for adult monarchs, larvae, and other pollinators. There has even been research into which species of milkweed female monarchs prefer to lay eggs on even though they will do so on many species.

Rick Hellmich, an entomologist with the USDA's Agricultural Research Service collaborated with researchers at Iowa State University on a multi-year field study to determine which species of milkweed garnered the most attraction from female monarchs. They tested nine of the most prevalent milkweeds found in the Midwest region, including common milkweed. The team found that common milkweed and swamp milkweed (*Asclepias incarnata*) averaged the highest number of eggs. The height and number of blooms were not factors influencing the monarchs' egg laying choices. The researchers also noted that "egg-laying preference can change according to the time of season, the prevalence and habitat of the milkweed species they encounter, and the plants' robustness and maturity". For these reasons, conservators should not focus habitat restoration efforts on a single species of milkweed (Suszkiw, Jan). Hellmich's study does provide valuable insight into which species should be preferred when planning

monarch habitat areas. Depending on the site, certain milkweeds may do better than others. Soil characteristics should be considered when planning milkweed introduction. Swamp milkweed does better in boggy, wet soils and would be a great addition to golf course drainage areas or near water bodies like occur on the Heritage Golf Course conservation area.

Finally, all conservation areas should be kept free of invasive vegetation. *Microstegium vimineum* (Japanese stiltgrass), Kudzu and Lespedeza are three common invasive species found in North Carolina. All three species can rapidly spread and dominate sites, excluding desired vegetation.

Conclusion

Utilizing developed space for monarch habitat restoration is a promising approach that has yielded favorable results such as in the “*Monarchs in the Rough*” golf course program and the “*Living Acres*” program. Golf courses represent a large opportunity for conservation initiatives pertaining to pollinators including the monarch butterfly. With proper planning, implementation, and management, these developed spaces can provide ecosystem benefits while serving human communities through recreation and education. If such conservation programs are launched on all major golf courses in the United States, the monarch butterfly will gain more habitat and opportunities for reproduction during their yearly migration. Milkweed planting efforts have the added benefit of providing other pollinators with a food source as well. Reversing habitat loss should be part of a multipronged approach toward recovering the population as more research is conducted into the monarch’s decline. This model for

conservation can be applied to other at-risk species and developed spaces as seen with the right-of-way working group with likely similar results.

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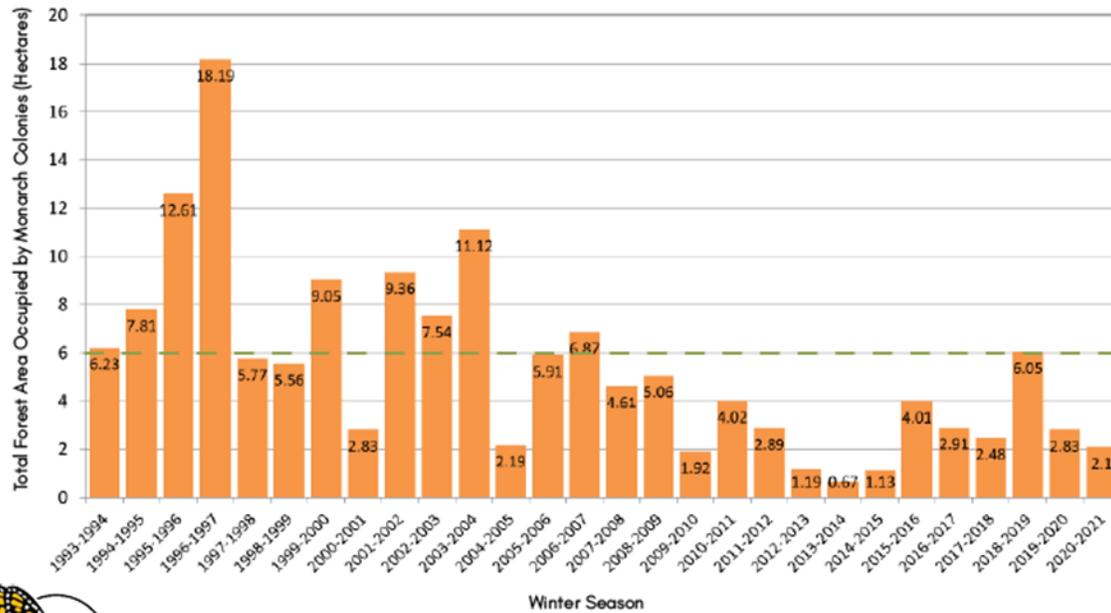
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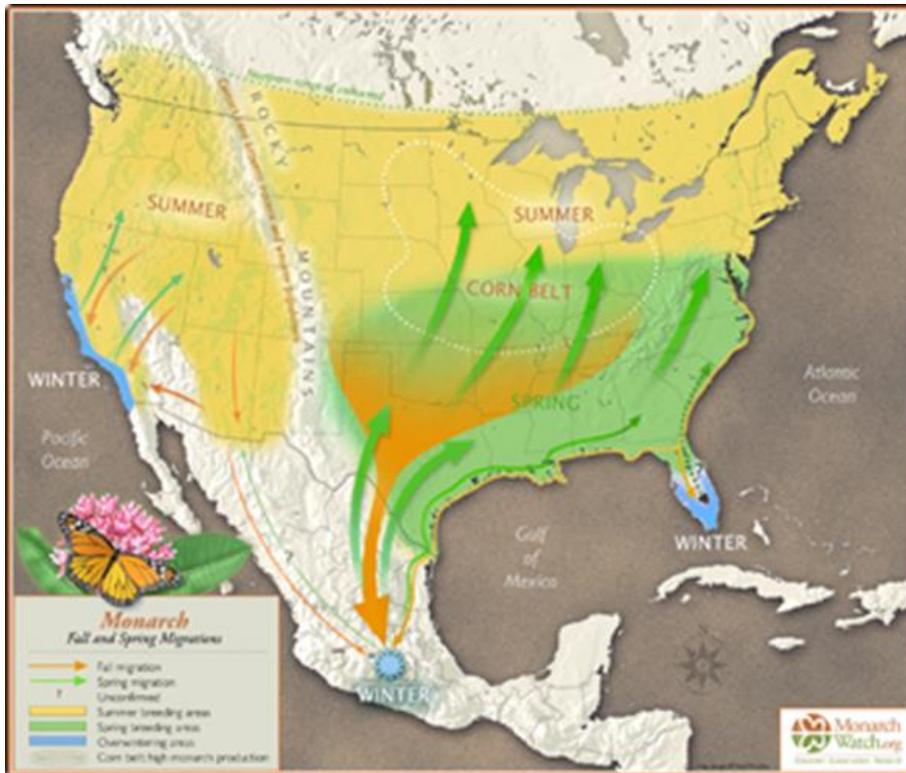
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Total Area Occupied by Monarch Colonies at Overwintering Sites in Mexico
1993/1994 - 2020/2021



Scientists estimate that a minimum of 6 hectares of overwintering monarchs is needed to sustain the eastern population (Semmens et al., 2016).

Data from 1994-2003 were collected by personnel of the Monarch Butterfly Biosphere Reserve (MBBR) of the National Commission of Protected Natural Areas (CONANP) in Mexico. Data from 2004-2021 were collected by the WWF-Telcel Alliance, in coordination with the Directorate of the MBBR. 2000-01 population number as reported by Garcia-Serrano et al. in 2004.



*Dotted white line denotes the “corn belt”, an area of high monarch reproduction