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Mapping the Migration:
A Western Monarch Butterfly Site Suitability Study

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ABSTRACT

Monarch butterfly populations have been declining at an accelerating rate. While local mitigative measures can provide some relief, the larger scale loss of habitat and lack of flyway continuity must also be addressed. This study utilized a site suitability model to rank all locations within the Western monarch migratory zone in relation to factors that collectively attribute to butterfly viability, sustainability, and functionality. The two overarching study goals were to identify flyway gaps and to compare the model outcomes with geolocated butterfly sightings. The model weighed temperature, precipitation, elevation, and land cover/use factors based on their overall impact on site suitability. In addition to these factors, wildfires, solar farms, genetically modified crops, snow/ice cover, and open water were modeled as uninhabitable zones incapable of sustaining butterfly populations. The study results illuminated the heterogeneity of the Western monarch migratory range as well as raised questions regarding possible abnormal butterfly behaviors.

KEYWORDS

Geographic Information Science, Geographic Information Systems, GIS Modeling, Migration, Site Suitability, Western Monarch Butterfly

INTRODUCTION

Species population declines have become commonplace as climate change and anthropogenic encroachment have amplified over recent decades. With concerns of extinctions and fear that the entire migratory phenomenon may be at risk (Thogmartin et al., 2017), monarch butterflies have become another candidate on a long list of threatened and endangered species. While Eastern populations have received much attention for their large-scale annual migration and population decline, Western monarchs are rapidly approaching quasi-extinction benchmarks where populations may become unrecoverable (Engen & Saether, 2000).

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This study examined physical, environmental, climatological, and anthropogenic factors that affect monarch butterfly migratory, recolonization, and overwintering behaviors. These factors were input into a geographic information system (GIS) and mapped to visualize collective migratory conditions in conjunction with geolocated butterfly sightings. The goal of this study was to identify locations where site suitability and normal butterfly behavior has been compromised and to inform Western monarch conservation agendas.

MONARCH BUTTERFLY ECOLOGY

Butterflies progress through four distinct developmental stages which carry varying implications to the viability of the overall population. While the time at each stage varies, the general rule is that monarchs will spend approximately four days in the egg stage before spending the next 9-14 days as a developing larva. The larva will consume milkweed continually until their body mass has increased by 2000-3000 times (Baumle, 2017). A final molt will transform the larva into a chrysalis in the pupal stage. After developing inside the chrysalis for an additional 9-15 days, the pupa emerges as a fully formed adult butterfly (Oberhauser, 2004). Butterflies will continue to live for an additional 2-4 weeks to complete the fourth and final stage of development where all migratory, recolonization, and overwintering activities occur.

Temperature bears a particular importance as insects metabolize using heat energy, which is a crucial element during the migration and overwinter processes. As such, monarchs must be able to function within the realm of their ectothermic limits while navigating a multitude of landscapes and atmospheric conditions.

Migration & Overwinter Sites

While Eastern and Western monarchs are genetically the same butterfly, the populations rarely intermingle due to the natural barrier provided by the Rocky Mountains (Gallou et al., 2017). Historically, the Eastern population has garnered the most awareness due to their large- scale migration which spans roughly 3000-miles from overwinter sites in Central Mexico to the summer breeding grounds in the Northern United States and Southern Canada (Solensky, 2004). However, despite the less impressive spatial scale, the Western migration encounters more flyway heterogeneity in the approximately 700-mile migration from overwinter sites along the coast of Southern California (Figure 1) to the recolonization grounds in the Pacific Northwest (Malcolm, 2018). During the overwinter months, Western monarchs roost in coastal eucalyptus (Eucalyptus spp.), Monterey pine (Pinus radiata), and Monterey cypress (Cupressus macrocarpa) in a state of reproductive diapause (Malcolm, 2018). The butterflies exit the overwinter sites during the spring months and migrate north while recolonizing throughout the journey (Baumle, 2017; Solensky, 2004).

Milkweed

Milkweed (Asclepias spp.) is vital to the survival of monarch butterfly populations and is available in multiple species that are adapted to survive in nearly all climates (United States Department of Agriculture [USDA], n.d.). As the sole food source for developing larvae, female monarchs will deposit between 500-700 eggs to the underside of milkweed leaves which provides an immediate food supply for the newly hatched larvae (Wells, 2010; Oberhauser, 2004).

While milkweed has been plentiful in the past, recent anthropogenic impacts have decreased the amount of natural milkweed occurring along migratory flyways. This issue has been complicated by the use of genetically modified crops (Pleasants & Oberhauser, 2012) as well as herbicide and pesticide use in commercial and landscaped lawns (Thogmartin et al., 2017; Pleasants & Oberhauser, 2012). To repair flyway connectivity, concerned citizens and conservationists have supported the planting of indigenous milkweed varieties as well as discouraged the use of herbicides and pesticides

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