EFFECTS OF PRESCRIBED BURNING ON BUTTERFLY POPULATIONS IN COASTAL SOUTH TEXAS

A Thesis

by

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ABSTRACT

Effects of Prescribed Burning on Butterfly Populations in Coastal South Texas

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Background: Pollination is a key biological process that enables fertilization and production of seeds for plants. Animals such as mammals, birds, and insects such as butterflies and bees serve as primary pollinators. Butterflies are an important pollinator worldwide, however, climate change and invasive species are affecting regional populations in the United States, prompting a need to manage pollinator habitat. Land managers often use prescribed burning, to mimic natural fires which provides benefits, such as removal of dead plant matter, increases in nutritional value of plants and forb diversity communities, nutrient recycling. The objective of this study was to determine effects of different seasons of prescribed burning on butterfly populations in the South Texas Coastal Marsh and Prairies ecosystem. I aimed to evaluate different burning intervals to inform management recommendations to maximize the value of rangeland for butterfly populations.

Results: Season of burn did not have a treatment effect on butterfly abundance, diversity, or family richness. This was the same across cordgrass and non-cordgrass plant communities.

Conclusion: This study site may be an appropriate burn treatment that will benefit butterfly pollinators as it has different seasons of burns, time return-intervals between burns to allow time for recolonization and areas of no-burn refugia.

Keywords: Butterflies, South Texas, fire, prescribed burning

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Contributors

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BACKGROUND AND LITERATURE REVIEW

Plants

Plants are essential parts of ecosystems, providing many uses such as food and habitat for wildlife. Arguably, every animal species requires plants in some shape. Virtually all the world's fruiting plants require pollination, where pollen transfer, depending on the plant, is mediated by very specific to loosely associated agents, such as animal pollinators. Pollinators are any species of animal that visit flowers, and in doing so transfer pollen grains to compatible flowers in the process. Ollerton et al. (2011) estimated that around 78% of temperate-zone angiosperms are animal-pollinated, making pollination an essential process in nearly all terrestrial biomes (Hoffman Black et al. 2011).

Pollinators

Pollinators provide valuable ecosystem services not only for the habitats in which they reside, but for humans as well. It is estimated that one out of every three bites of food we ingest is a result of pollination by animal pollinators (Wilson 1996). 75% of major agricultural crops depend on pollination (Klein et al. 2007), and every year pollinators provide an estimated $150-200 billion worth of services worldwide (Van Nuland et al. 2013) with $57 billion being attributed to them in the United States alone (Hallmann et al. 2017).

This chapter follows the Fire Ecology Journal format.

Out of the over 200,000 species of pollinators identified worldwide, over 99% are invertebrates, such as insects. Approximately 67% of flowering plants rely on insects for pollination, making insect pollinators, such as butterflies, vital in any terrestrial ecosystem (Tependino 1979; Harmon et al. 2011).

Butterflies as pollinators

Butterflies are members of the order Lepidoptera, named for their "scaly wings," which consist of two pairs of membranous wings, covered in scales. The scales may function as camouflage or as warning to predators, such as in the case of the monarch butterfly (*Danaus plexippus*). The bright orange and black coloration of monarch wings acts as a warning to potential predators about its toxicity due to cardenolides amassed from milkweed (*Asclepias* spp.) plants it eats as larvae (Davis et al. 2012).

There are six butterfly families and approximately 14,300 in the U.S.; 853 species of butterflies have been recorded in North America (BAMONA 2022). In Texas, 481 species have been recorded (BAMONA 2022), the most of any state, with over 300 species observed in the three southernmost counties of Hildalgo, Cameron, and Starr (Quinn and Klym 2009; BAMONA 2022).

Host Plants

Both butterflies and moths undergo a complete metamorphosis. Females will lay eggs on the larvae's food source, known as a host plant. These food sources are typically a few related species of plants unique to that butterfly species. For example, monarch caterpillars require milkweed while the American snout, (*Libytheana carienta* [Cramer]) requires hackberry (*Celtis* spp.) foliage.

Arthropod population declines

Climate change is altering ecosystems worldwide, and many species are forced to adapt to changes such as limited food resources, modifications to habitat, and changes in weather patterns (IPBES 2019). Arthropods are ideal subjects to study in relation to climate change as they have relatively short lifespans, and multiple life cycles can be studied over a short period. Arthropoda is the largest of the animal phyla and because of its vast diversity, arthropods have shown varied responses to climate change. Hallman et al. (2017) reported a decline greater than 75% in flying insect biomass in protected areas in Germany over 27 years. A related study by Hallman et al. (2019) saw declines in arthropod biomass of beetles, moths, and caddisfly in the Netherlands across 27 years.

The term "Insect Apocalypse" has been coined in multiple sources of literature to reference these insect population declines as discussed in the above studies, but that phrase is misguided. Saunders et al. (2019) argued that the expression "insect apocalypse" was exaggerated, and while many studies, such as those listed above, did report insect population declines, they were not extrapolated to a global scale, and other studies have recorded increases in insect populations. Crossley et al. (2020) reported mixed results in arthropod diversity and abundance regarding changes over time at different monitoring sites throughout the United States. While they did see some declines in species, other species experienced increases or no changes over this period. Some invasive species in North America, such as the spotted lantern fly (*Lycorma delicatula*) and emerald ash borer (*Agrilus planipennis*), have experienced rapid increases in populations, and climate change is expected to assist with their population movements and growth (Liang and Fei 2014).

It is expected that the diverse group of insect pollinators may also show varied responses to climate change. Regardless of how insect pollinators react to climate changes, they are important components of ecosystems, and should be managed, because reductions in pollinator populations may impact ecosystems through a reduction in seed production, reduced pollen, or flowering plant declines (Hanberry et al 2021).

In the case of Lepidoptera (i.e., butterflies), because of their specific life cycle requirements, habitat managers often manage for them by providing both a variety of host and year-round nectaring plants. Methods of grazing, mowing, spraying, disking, and burning may be useful for managing for butterflies (New et al. 1995; Feber et al. 1996). Managing for butterflies can benefit other pollinators, as other insect pollinators will use the nectaring species as well.

Prescribed burning

Fire has been used as a management tool in North America dating as far back as early Native Americans, historically playing a key role in shaping grasslands (Flores 1999; Allen and Palmer 2011). Fire promotes vegetation growth by removing excess organic matter, clearing out areas for new growth, and recycling nutrients needed for new plants (Brockway et al. 2002; NPS 2022). Historically, the south Texas grasslands saw fire returned to the land every 0-5 years (Stambaugh et al. 2014). Present day, this interval has increased between 0-35 years depending on the location within South Texas (Brown and Smith 2000).

With the introduction and spread of European settlers, conventional agricultural practices and a heavily instilled fire suppression regime, grasslands have become one of the most endangered ecosystems in the world (Ceballos et al. 2010). Originally covering nearly 31% of the United States, only about 60% of grasslands remain (18% of the area) today because of land-use changes, including lack of fire (Hays 1994). One potential contributor to insect population declines is the loss of this important insect habitat (Ansley and Castellano 2006).

The amount of rainfall will influence grass height, with taller vegetation occurring in wetter areas. On the eastern edge of the Great Plains of North America is the tallgrass prairies. Also referred to as "true prairies," tallgrass prairies were historically found primarily in Nebraska, North Dakota, South Dakota, Minnesota, Iowa, Kansas, and Illinois. These grasslands occur in the wettest grassland ecosystems receiving an average of 76-90 cm (30-35 in) of precipitation a year (Haukos n.d.; UC Museum of Paleontology [UCMP] n.d.). Dominant vegetation includes little bluestem (*Schizachyrium scoparium* [Michx].) Nash), big bluestem (*Andropogon gerardii* Vitman), yellow Indiangrass (*Sorghastrum nutans* [L.] Nash), and switchgrass (*Panicum virgatum* L.) (Penfound 1964).

On the western side of the Great Plains are the shortgrass prairies. Shortgrass prairies are semi-arid grasslands generally found west of the 100th meridian (Ford and McPherson 1996). They are found in the driest areas that can still support grasslands, only receiving about 25-50 cm of precipitation each year (Haukos n.d.; UC Museum of Paleontology [UCMP] n.d.). Primary species include buffalo grass (*Bouteloua dactyloides* [Nutt.] J.T. Columbus) and blue grama (*Bouteloua gracilis* [Willd. ex Kunth] Lag. ex Griffiths). Shortgrass prairies consist of species that are adapted for survival in environments with periodic fires, seasonal water deficits, and low to moderate soil fertility, making them highly resilient to disturbances (Brockway et al. 2002).

In between shortgrass and tallgrass prairies are the mixed grass prairies. Precipitation averages around 50-75 cm per year, leading these prairies to have a mixture of grasses and forbs that can be found sometimes in both tallgrass and shortgrass prairies also (Haukos n.d.; UC Museum of Paleontology [UCMP] n.d.). Common species of mixed grass prairies in Texas include: sideoats grama (*Bouteloua curtipendula* [Michx.] Torr.), blue grama, Texas wintergrass (*Nassella leucotricha* [Trin. & Rupr.] Pohl), purple threeawn (*Aristida purpurea* Nutt.), sand dropseed (*Sporobolus cryptandrus* [Torr.] A. Gray), buffalo grass, and tobosa grass (*Pleuraphis mutica* Buckley).

Mottes

In South Texas, common woody species consist of honey mesquite (*Prosopis glandulosa* Torr.), huisache (*Vachellia farnesiana* [L.] Wight & Arn.), blackbrush (*V. rigidula* [Benth.] Seigler & Ebinger), and others. These plants may grow together in groups, known as mottes. Oak mottes in southern Texas are dominated by coastal live oak (*Quercus virginiana* Mill.) and can be found in sandy soils of the coastal plain. A motte can be defined as a small stand of trees on a prairie ranging from 0.1 to over 200 acres and consisting of as few as 2 to several thousand trees (Beasom and Haucke 1975). Often these stands have a different ground cover, largely dominated by tree leaf litter, compared to the nearby vegetation. Live oaks are the larval hosts for Horace's Duskywing (*Erynnis horatius*), White M hairstreak (*Parrhasius m-ablum*), and 'Northern' Southern hairstreak (*Satyrium favonius ontario*) (Ladybird Johnson Wildflower Center 2022).

Over the years, North American prairies have evolved with fire, leading to enhanced species richness and diversity of fire-tolerant grasses and forbs. Historically, fire intervals occurred in different seasons and years, and in some parts of the prairie were as short as zero to give years Brockway et al. 2002, Stambaugh et al. 2014). These differed seasonal and yearly intervals helped promote vegetation growth and prevented fire-intolerant woody encroachment and invasive species (Brockway et al. 2002. Britton et al. 2010). Fires advance the rates of nutrient turnover needed for sustaining high primary production of prairies, especially in tall and mixed-grass prairies (Brockway et al. 2002; National Park Service [NPS] 2022).

Fire also may impact arthropod and butterfly species; however, results are dependent on arthropod order with trends indicating fire promoted Hymenoptera but was unfavorable for Lepidoptera (Carbone et al. 2019). Swengel et al. (2011) reported mixed responses of butterflies to fire with prairie specialists showing more negative responses to burning in four midwestern states in the Midwest 30-years. Van Nuland et al. (2013) saw a more positive response of butterflies to areas that had been burned in Tennessee, with higher plant visitation rates by butterflies post-fire. Hansmire et al. (1998) reported that early winter burns promoted higher forb yields on Matagorda Island, Texas, which could be beneficial for both caterpillars and butterflies. Fire-interval studies have shown that insects respond well to burns when there is ample time in between burns for recolonization and to allow their populations to rebound (Swengel et al. 2011, Panzer 2002). Regardless of their impact on arthropod and butterfly communities, prescribed burning is being reintroduced to grasslands in many places promote prairie ecosystem function, as well as to conserve arthropod communities.

Removal of fire has impacted ecosystems, and this is especially useful in grasslands with high primary production, such as tallgrass and mixed grass prairies, which accumulate more biomass than shortgrass prairies (Brockway et al. 2002; NPS 2022). The season in which fire takes places is an important consideration. Fire occurring during different times of the year promotes different vegetation growth (Britton et al. 2010).

Grasslands also support a variety of wildlife species (Johnson 1997). It is now understood that fire is important for grassland ecosystems and burning is being reintroduced to grasslands in many places to conserve them. Without fire these habitats may continue to shrink or even cease to exist.

Fire and Arthropods

Studies examining the effects of prescribed burning on butterflies and other arthropods have returned mixed results. It could be argued that grassland-dependent butterflies evolved with fire based on historically frequent fire return intervals in grassland. However, there is debate over the impact fire has on insects. Carbone et al. (2019) examined 65 studies across 21 countries worldwide investigating fire effects on pollinators and saw mixed results depending on the arthropod order; results showed fire promoted Hymenoptera but was unfavorable for Lepidoptera, especially in the case of wildfires. When examining the effects of fire on butterflies, it is important to consider that different habitats are required by different species. Swengel et al. (2011) reported mixed responses of butterflies to fire, with prairie specialists showing more negative responses to burning in four states in the Midwest: Minnesota, Wisconsin, Illinois, and Iowa over a 30-year dataset. Van Nuland et al. (2013) saw a more positive response of butterflies to areas that had been burned in Tennessee, with higher plant visitation rates by butterflies post-fire. With studies producing these mixed results, it can be inferred that there may not be one single fire management strategy that will be beneficial for every butterfly species in every location.

OBJECTIVE

The objective of this study was to determine effects of different prescribed burn seasons and time since burning on butterfly populations. Because individual species may respond differently to burning regimes, I assessed which fire management strategy had the most positive effects on butterfly diversity and abundance. With this knowledge, I hypothesized that butterflies would have the highest diversity and abundance with a longer time since burning after winter burn treatments than summer burn, a shorter time since burning, and control treatments.

Species of interest: Monarch butterfly

The monarch butterfly is a large orange and black butterfly in the family Nymphalidae, or brush-footed butterflies. Most known for their fall migration to Mexico, these threatened butterflies are found in countries all over the world. Monarchs are found in multiple areas worldwide but are most common to North America where they are divided into two major migratory populations (Agrawal 2017). West of the Rocky Mountains is the smaller population that migrates to the coast of California to overwinter. The more well-known larger population exists east of the Rocky Mountains and migrates to overwintering reserves in the Trans-Mexican Volcanic Belt in Central Mexico (Agrawal 2017; Malcolm 2018). The eastern migration is a two-month event beginning in September in northern latitudes with the first monarchs arriving in Mexico at the beginning of November. At peak in winter, the rare Oyamel Fir trees (*Abies religiosa* [Kunth.] Schltdl.&Cham.) in these mountains will be covered in thousands per tree; up to 5000 butterflies per square meter (Agrawal 2017). In spring, monarchs will begin their journey north, flying as far north as South Texas to nectar and reproduce. Their offspring will continue the journey north over four generations before the final generation returns to the wintering ground in the fall.

Since peak population estimates in the 1990s, monarch populations have declined by 90%, leading scientists to investigate the causes. Primary threats include loss of milkweed populations, loss of nectar resources from flowering plants, and degraded overwintering habitats (Malcolm 2018; Swengel et al. 2011). Originally, the decline was believed to be contributed to illegal logging practices and wildfires in Mexico. It has more recently been determined that the decline is because of what is happening in their summer habitats in the United States and Canada (Torres and Ward 2018). About 50% of eastern migrating monarchs inhabit the Midwest and Great