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Short-Term Effects of a Prescribed Burn on Butterfly Abundance and Diversity in a Restored Northeastern Ohio Prairie

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Abstract: Prescribed burns are a common management technique used across the globe and are often used to control encroaching vegetation in prairie systems. Although effective for managing vegetation, fire can have variable effects on insects such as butterflies and is generally linked to disruption of reproductive cycles and host plant use. This study was conducted to determine the effects of a prescribed burn on adult butterflies within a short time scale (3 months post-burn). Surveys were conducted in July 2013 (prior to the burn) and July 2014 (following the burn) using a combination of plot and transect surveys. Overall, both total abundance and species richness declined significantly following the prescribed burn. Responses, however, were species-specific, with three major outcomes: 1) some species were detected in the summer prior to the burn but not following it; 2) some species were detected during the summer following the burn but not prior to it; and 3) some species were found during both years. Pearl crescents (*Phyciodes tharos*), common butterflies in this area, significantly decreased in abundance following the burn. Further, great spangled fritillaries, orange/clouded sulphurs, and cabbage whites, all common generalist species, were not detected during surveys following the burn. These four common species were, however, detected in the control plot and during transect surveys. Although not all butterflies were negatively affected, fire did adversely impact the community as a whole. As insect pollinators continue to decline, prairie managers should consider using alternative methods such as haying and grazing when possible. However, when fire is used, nearby refugia and host plants should be set aside and conserved for sensitive species.

Keywords: Lepidoptera, fire, disturbance, pearl crescents, population, species richness

Introduction

Globally, insect pollinators have been in decline over the last several decades. Population losses have been linked to habitat loss and fragmentation, use of agrochemicals, the spread of pathogens, introduction of alien species, and climate change (see Potts et al., 2010 for a review). Because pollinators provide essential ecosystem services and play a key role in both the ecological landscape and human society, conservation measures to protect insect pollinators have gained increasing awareness through initiatives such as the Convention on Biological Diversity's International Pollinator Initiative (http://www.cbd.int/decision/cop/?id=7147), and through citizen science programs such as Bumble Bee Watch (http://www.bumblebeewatch.org/) and Monarch Watch (http://www.monarchwatch.org/). Although most studies have focused on the decline of the European honeybee (*Apis mellifera*), many other pollinator species are in peril, including prairie-specialist butterflies, which have shown rapid population declines over the last century (Orwig, 1992; Schlicht and Orwig, 1998).

It is estimated that approximately 98% of North American tallgrass prairie has been destroyed (primarily for agricultural use) since European establishment in North America (Drache, 2001), and this has likely been a major cause in the decline of prairie-specialist butterflies. As a result, prairie restoration projects have become common across the Midwest and are often managed by controlled burns, mowing/haying, and/or grazing to maintain prairie vegetation, prevent forest succession, and control the establishment of invasive species. Previous studies have shown that butterfly populations can benefit from prescribed burns (Huntzinger, 2003; Panzer and Schwartz, 2000) or that prescribed burns have no net effect on species diversity (Fleishman, 2000). However, even if diversity is not influenced by burning, certain species may be affected differently and some management practices may favor some butterfly species while negatively affecting others (Vogel et al., 2007). Conversely, there are several studies that show declining trends of butterfly abundance and/or diversity following a prescribed burn (Swengel, 1996; Vogel et al., 2010; Swengel et al., 2011) with recovery taking approximately three to six years or more (Swengel, 1996; Vogel et al., 2010).

In this study, we surveyed butterfly populations within a restored prairie in northeastern Ohio prior to and approximately three months after a prescribed burn. Surveys were conducted weekly during the month of July, when butterfly activity was at its peak. Additional surveys were conducted in a nearby Monarch Waystation as a control, and transect surveys were completed

in surrounding habitats post-burn to compare species presence and absence. Although the literature suggests that the effect of prescribed burns on abundance and diversity is not consistent across study sites, we predicted that burning would decrease both plant diversity and butterfly abundance and diversity in the short term.

Methods

Field site description. All butterfly surveys were conducted at the James H. Barrow Field Station, Hiram College, Portage County, Ohio (41.299521 N, -81.109085 W). This field station covers approximately 380 acres of land and is comprised of beech-maple forest, wetlands, streams, and successional old field meadows. In 2008, approximately three acres (140,000 sq. ft.) of continuously mowed grass were set aside for two major reasons: 1) to construct a zig-zag wetland to purify greywater from field station buildings and 2) to allow for natural succession of meadow vegetation. In 2011, a native tallgrass prairie mix including both grasses and forbs (packaged by Ohio Prairie Nursery) was planted in an effort to mimic the native prairies historically found in northeastern Ohio. Following the planting in 2011, native seed has been scattered and additional plugs of both grasses and forbs have been planted throughout the area. In April 2014, the first prescribed burn was completed over the entire prairie for management purposes.

In 2009, a Monarch Waystation (approximately 200 m^2 in size) was constructed and certified according to Monarch Watch's Waystation standards. Although this garden was established to attract monarchs, several flowering species have been planted to increase visitation of butterflies in general. This garden is situated approximately 70 m from the restored prairie. Due to the close proximity and the lack of disturbance during the study, this garden was used as a control site for the restored prairie.

Butterfly surveys. A 200 m^2 plot was established in the restored prairie during the summer of 2013 (equal to the size of the Monarch Waystation). Butterfly surveys were conducted weekly (N = 4 per site) throughout the month of July in both 2013 (pre-burn) and 2014 (post-burn) within both the restored prairie and the Monarch Waystation. Plots were surveyed between 10 a.m. and 4:00 p.m. on sunny days with winds no stronger than five on the Beaufort wind scale. Timed surveys were conducted using four observers stationed within the plot for a duration of 20 minutes. To catalog both abundance and diversity, butterflies were captured with butterfly nets and held in jars until the end of the survey period. Individuals not captured were identified in flight and special care was taken to estimate numbers conservatively to avoid re-counting butterflies missed by netters. All butterflies were identified to the species level and released live following surveys.

In addition to plot-style surveys, transect surveys were conducted during July 2014, on the same days as plot surveys, to allow for a larger area of coverage and with the goals of surveying as many butterfly species as possible and detecting the presence of species that may have not visited the restored prairie and/or Monarch Waystation. The transect was mapped out across the James H. Barrow Field Station in accordance to standards set by the Ohio Lepidopterists Society for long-term monitoring (http://www.ohiolepidopterists.org/bflymonitoring/instructions/default.htm). This transect represented a variety of habitats, including successional old fields, forests, and wetlands, and took approximately 45 minutes to walk at a moderate pace. All butterflies within 15 feet of the recorder were identified and counted.

Flowering plant surveys. Plant surveys were conducted twice during July 2013 within the 200 m^2 plot used for butterfly surveys in the restored prairie. In 2013, stem counts were completed for all plants that were in flower and plants were identified to species. During July 2014, a visual inspection was completed during butterfly surveys in the restored prairie to catalog species in flower and determine percent cover.

Statistical analyses. One-way ANOVAs were used to compare differences between July 2013 and 2014 for butterfly abundance and species richness, pearl crescent abundance, and flowering plant species richness (JMP 10.0.0, SAS Institute Inc., 2012). One flowering plant species was unable to be identified and was cataloged as an unknown.

Results

Butterfly surveys. Both total abundance (2013 average = 8.75 ± 2.32 [mean ± 1SE], 2014 average = 3.75 ± 0.25, ANOVA, $F_{(1,6)} = 4.58$, $P = 0.0761$) and species richness (2013 average = 2.75 ± 0.25 [mean ± 1SE], 2014 average = 3.5 ± 0.28, ANOVA, $F_{(1,6)} = 3.86$, $P = 0.0972$) were not significantly different for the Monarch Waystation between July 2013 and 2014. Although many of the species that visited the Monarch Waystation across these two summers were similar, there were some butterflies that were detected in 2013 but not in 2014 (Table 1). Following the prescribed burn, both total abundance (ANOVA, $F_{(1,6)} = 72.98$, $P < 0.0001$) and species richness (ANOVA, $F_{(1,6)} = 12.00$, $P = 0.0134$) decreased significantly (Figs. 1a and b). In addition

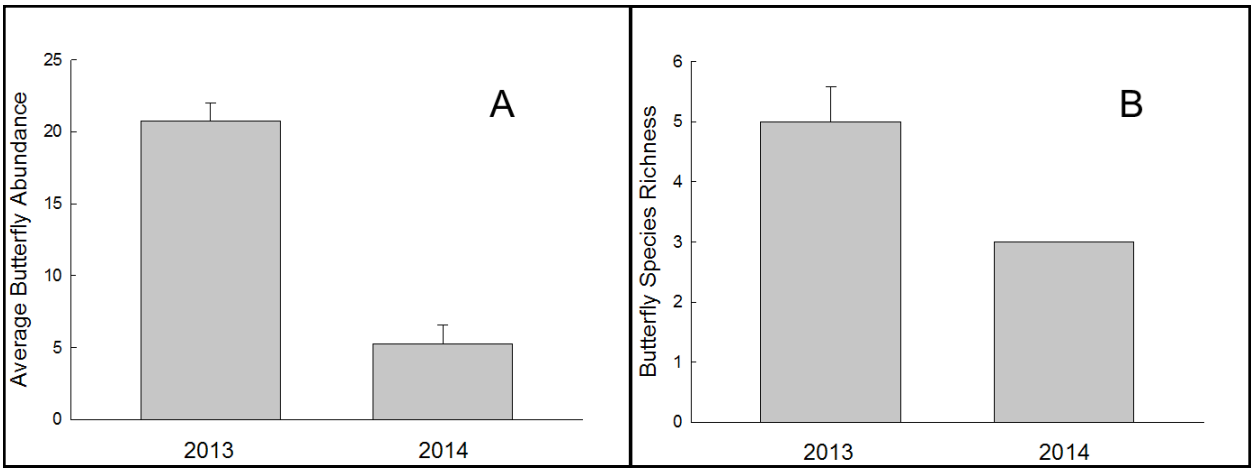

Figure 1. Average butterfly abundance (a) and species richness (b) (mean ± 1 SE) at the restored prairie from July 2013 (prior to the prescribed burn) and 2014 (following the prescribed burn) surveys.

to declines in overall abundance, pearl crescent (*Phyciodes tharos*) butterfly abundance (also an incredibly common butterfly species) decreased significantly following the prescribed burn (2013 average = 14.75 ± 1.65 [mean ± 1SE], 2014 average = 2.75 ± 1.55, ANOVA, $F_{(1,6)} = 28.10$, $P = 0.0018$). Great spangled fritillaries (*Speyeria cybele*), orange/clouded sulphurs (*Colias eurytheme*/*Colias philodice*), and cabbage whites (*Pieris rapae*) (three very common species at the James H. Barrow Field Station) were detected prior to the prescribed burn, but were not detected following the burn (Table 2). These three species were, however, detected in July 2014 in the nearby Monarch Waystation (Table 1) and during transect surveys (Table 3). Eastern tailed-blue (*Everes comyntas*) and mourning cloak (*Nymphalis antiopa*) butterflies were detected prior to the prescribed burn, but were absent from all surveys in July 2014. Although many common species were not detected following the prescribed burn, four species absent during July 2013 surveys were found in 2014: silver-spotted skipper (*Epargyreus clarus*), cobweb skipper (*Hesperia metea*), little sulphur (*Eurema lisa*), and little wood satyr (*Megisto cymela*). All but the cobweb skipper were detected during transect surveys.

Table 1. Butterfly species detected at the Monarch Waystation during July 2013 and 2014 surveys. The "X" indicates presence during that year.

Butterfly Species	July 2013	July 2014
Orange/clouded sulphur (*Colias eurytheme*/*C. philodice*)	X	X
Pearl crescent (*Phyciodes tharos*)	X	X
Great spangled fritillary (*Speyeria cybele*)	X	X
Summer azure (*Celastrina neglecta*)	X	X
Cabbage white (*Pieris rapae*)	X	X
Eastern tiger swallowtail (*Papilio glaucus*)	X	
Horace's duskywing (*Erynnis horatius*)	X	
Banded hairstreak (*Satyrium calanus*)		X
Crossline skipper (*Polites origenes*)		X
Meadow fritillary (*Boloria bellona*)		X
Edward's hairstreak (*Satyrium edwardsii*)		X
Common wood nymph (*Cercyonis pegala*)		X
Little wood satyr (*Megisto cymela*)		X
Sachem (*Atalopedes campestris*)		X
European skipper (*Thymelicus lineola*)		X

Table 2. Butterfly species detected at the restored prairie prior to the prescribed burn (July 2013) and following (July 2014). The "X" indicates presence during that year.

Butterfly Species	July 2013	July 2014
Orange/clouded sulphur (*Colias eurytheme*/*C. philodice*)	X	
Great spangled fritillary (*Speyeria cybele*)	X	
Cabbage white (*Pieris rapae*)	X	
Eastern tailed-blue (*Everes comyntas*)	X	
Mourning cloak (*Nymphalis antiopa*)	X	
Pearl crescent (*Phyciodes tharos*)	X	X
Eastern tiger swallowtail (*Papilio glaucus*)	X	X
Meadow fritillary (*Boloria bellona*)	X	X
Common wood nymph (*Cercyonis pegala*)	X	X
Silver-spotted skipper (*Epargyreus clarus*)		X
Little wood satyr (*Megisto cymela*)		X
Cobweb skipper (*Hesperia metea*)		X
Little sulphur (*Eurema lisa*)		X

Flowering plant surveys. Visual inspection during butterfly surveys indicated that red clover (*Trifolium pretense*, approximately 95% cover) and black-eyed Susans (*Rudbeckia hirta*) were the only two species present that were in flower during the month of July. Flowering plant species richness was significantly higher during July 2013 (2013 average = 8.5 ± 0.5 [mean ± 1SE], 2014 average = 2.0 ± 0, ANOVA, $F_{(1,2)} = 169.00$, $P = 0.0059$) (see Table 4 for a complete listing of plants found during 2013 survey).

Table 3. Butterfly species detected through transect surveys during July 2014.

Butterfly Species July 2014
Orange/clouded sulphur (*Colias eurytheme*/*C. philodice*)
Pearl crescent (*Phyciodes tharos*)
Great spangled fritillary (*Speyeria cybele*)
Summer azure (*Celastrina neglecta*)
Cabbage white (*Pieris rapae*)
Eastern tiger swallowtail (*Papilio glaucus*)
Meadow fritillary (*Boloria bellona*)
Common wood nymph (*Cercyonis pegala*)
Little wood satyr (*Megisto cymela*)
Silver-spotted skipper (*Epargyreus clarus*)
Little sulphur (*Eurema lisa*)
Black swallowtail (*Papilio polyxenes*)

Table 4. Flowering plants surveyed during July 2013 (prior to the prescribed burn).

Flowering Plant Species July 2013
Queen Anne's lace (*Daucus carota*)
Black-eyed Susan (*Rudbeckia hirta*)
Red clover (*Trifolium pretense*)
Oxeye daisy (*Leucanthemum vulgare*)
Prairie coneflower (*Ratibida pinnata*)
Eastern purple coneflower (*Echinacea purpurea*)
Henbit (*Lamium amplexicaule*)
Woodland sunflower (*Helianthus divaricatus*)

Discussion

Surveys from this study showed that both butterfly abundance and diversity declined following the prescribed burn. Because abundance and diversity did not differ between 2013 and 2014 in the nearby Monarch Waystation and common butterflies missing from the restored prairie were detected during transect surveys, we can conclude that the effects of fire in the short

term were an important cause of declines in the restored prairie. These results are consistent with other studies in which overall abundance declined on a short time scale following a burn (Panzer, 2002; Swengel and Swengel, 2007). However, this trend is not consistent across geographical locations and systems. Some studies show that fire can increase butterfly abundance and diversity (Taylor and Catling, 2012; Huntzinger, 2003; Verdasca et al., 2012; Scandurra et al., 2014), while sometimes it has no net effect on diversity (Fleishman, 2000). Further, responses to fire can be species-specific, with some butterfly species experiencing negative effects and others benefitting from this disturbance (Swengel, 1996; McIver and Macke, 2014). Similarly, surveys from this study also showed that butterflies can have species-specific responses to fire. Because the prescribed burn had marked effects on the flowering plant community, we suggest that this may be linked to overall declines and species-specific responses.

Cool-season fires typically favor several dominant, native, warm-season grasses, which, in turn, reduce the abundance and diversity of forbs, especially when burns are frequent (Ewing and Engle, 1988). Further, plants that grow primarily in the cool season are more likely to decline after a fire occurring in that same season (Ewing and Engle, 1988). In this study, flowering plant diversity declined drastically post-burn; red clover was the main plant in flower, along with a small number of black-eyed Susans. Since many butterfly specialists feed primarily on forb species (Davis et al., 2008), this may explain the decrease in abundance and diversity of butterflies following this cool-season prescribed burn.

In this study, four common species were found either in lower abundance following the burn (pearl crescent) or were completely absent (great spangled fritillary, orange/clouded sulphur, and cabbage white). These four species were found during surveys in other nearby locations at the James H. Barrow Field Station during 2014, suggesting that they respond negatively to fire. Pearl crescents, great spangled fritillaries, orange/clouded sulphurs, and cabbage whites are all considered to be habitat generalists with regard to both habitat use and adult nectar sources. Great spangled fritillaries and cabbage whites are known to use red clover as a nectar source and were expected visitors at this site. This reduction of generalist species is inconsistent with many studies that show that specialist species are more negatively impacted by fire management than species that are more common (see Swengel, 2011, for a review). Generalist butterfly species with broad habitat niches tend to recover more quickly following a burn than specialist butterfly species, especially if source populations and host plants are nearby (Swengel, 1996). Vagility and voltinism can affect the recovery of butterfly populations, with multivoltine species colonizing more readily following fire (Swengel 1996).

Conversely, our surveys showed that four species were found during post-burn surveys that were not detected during pre-burn surveys: silver-spotted skipper, cobweb skipper, little sulphur, and little wood satyr. Adult cobweb skippers have been found in association with burned landscapes and habitats with *Andropogon* spp., the larval host plant for this species (Shapiro, 1965). *Andropogon gerardi* (big bluestem) is prevalent throughout the restored prairie in this study and recovered quickly following the prescribed burn. Cobweb skippers are considered to be fire-adapted because the first instars feed nocturnally underground at the base of plants where they are protected from ground fires (Shapiro, 1974). Since silver-spotted skippers (Stichter, 2015) and little sulphurs (Glassberg, 1999) are well adapted to disturbances, they may have been able to recover more quickly and/or were visitors from nearby refugia. Further, the little wood satyr was found throughout the James H. Barrow Field Station in 2014, and nearby refugia likely contributed to its visitation to the prescribed burn plot.

Lastly, three species (the Eastern tiger swallowtail, meadow fritillary, and common wood nymph, all common species in northeastern Ohio) were present during surveys for both years, suggesting that the burn did not have a substantial effect on these species. Further, all three species were also found in high abundance during July transect surveys. Host plants for these species are evenly distributed throughout the James H. Barrow Field Station property and this likely accounts for their visitation to the prescribed burn plot.

Although this study showed species-specific responses, butterfly populations as a whole did not recover within a growing season, which is likely linked to decreased plant diversity and direct mortality. Swengel (1996) suggests that for populations that experience declines following a burn, recovery can take at least 3–5 years. However, it is common for newly established prairies to be burned every year and then every 3–5 years once vegetation is well established. Although fire may benefit some species, this prescription likely does not allow enough time for many butterfly species to recover. In general, fire has negative impacts on insect communities (see Swengel, 2001, for a review), but some taxa appear to recover quickly (within one to two years), especially those with high vagility (Panzer, 2002).

There is growing concern among entomologists that prairie insect species may be threatened by prescribed burning practices. Since this management tool can result in a substantial loss of insect species richness, several authors recommend that the use of prescribed burns should be minimized (Orwig, 1992; Swengel, 1996). As pollinators continue to decline, managers should consider using other methods such as haying, grazing, and brush-cutting to manage prairie plants. Areas formerly

burned may take six to eight years to become refuge habitat for butterflies (Swengel and Swengel, 2007), and using multiple methods within a landscape would likely be less harmful to butterfly populations, as species respond differently to management practices (Swengel, 1996). Further, areas should be set aside as a refuge when these management techniques are implemented. In landscapes that are burned periodically, refugia offer persistent habitat diversity where organisms adverse to fire are more likely to survive (York, 1999; Swengel and Swengel, 2007).

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