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Butterfly responses to prairie restoration through fire and grazing

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ARTICLE INFO

Article history:
Received 3 August 2006
Received in revised form
6 June 2007
Accepted 27 July 2007
Available online 18 September 2007

Keywords:
Burning
Butterflies
Grazing
Insect conservation
Restoration
Tallgrass prairie

ABSTRACT

The development of land for modern agriculture has resulted in losses of native prairie habitat. The small, isolated patches of prairie habitat that remain are threatened by fire suppression, overgrazing, and invasion by non-native species. We evaluated the effects of three restoration practices (grazing only, burning only, and burning and grazing) on the vegetation characteristics and butterfly communities of remnant prairies. Total butterfly abundance was highest on prairies that were managed with burning and grazing and lowest on those that were only burned. Butterfly species richness did not differ among any of the restoration practices. Butterfly species diversity was highest on sites that were only burned. Responses of individual butterfly species to restoration practices were highly variable. In the best predictive regression model, total butterfly abundance was negatively associated with the percent cover of bare ground and positively associated with the percent cover of forbs. Canonical correspondence analysis revealed that sites with burned only and grazed only practices could be separated based on their butterfly community composition. Butterfly communities in each of the three restoration practices are equally species rich but different practices yield compositionally different butterfly communities. Because of this variation in butterfly species responses to different restoration practices, there is no single practice that will benefit all species or even all species within habitat-specialist or habitat-generalist habitat guilds.

1. Introduction

Destruction of habitat is the most prevalent threat to butterfly and insect populations around the world (New et al., 1995). Habitat losses across the globe have resulted from the conversion of land for agriculture and development (Saunders et al., 1991; Stoner and Joern, 2004). Grassland ecosystems are especially vulnerable to losses from agricultural development and, in fact, the tallgrass prairie region of North America is one of the most endangered ecosystems on Earth (Smith, 1981; Noss et al., 1995). Given these extensive losses of habitat, the preservation of remaining habitat is of great concern. Overall conservation strategies should not only include preservation of existing habitat but also habitat restoration (Jordan, 1997).

In addition to habitat loss, grassland ecosystems have been degraded by the disruption of their natural disturbance regimes. Studies of butterflies and insects from different regions of the globe have indicated that populations respond differently to disturbances and that many species have different habitat requirements at each life stage (New et al., 1995;

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0006-3207/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.biocon.2007.07.027

Samways, 2007). In North American grasslands, as in grasslands around the world, methods used to restore habitats have included reintroducing natural disturbances such as fire and grazing.

The effects of grazing on butterflies may be moderated by the effects of grazing on their host plants. Long term studies of the skipper *Hesperia comma* in the UK have illustrated how grazing influences their grass host plant, *Festuca ovina* (Thomas et al., 1986; New, 1997). Over time, reduced grazing led to taller host plants and reduced oviposition site suitability for the species. A more recent reintroduction of grazing in the area has returned many areas to suitable habitat for *H. comma* (Thomas et al., 1986; New, 1997). Another European grassland butterfly, *Lysandra bellargus*, had larger populations on sites where grazing kept vegetation height between 1 cm and 4 cm (Thomas, 1983). In contrast, studies of many other European grassland butterflies have indicated that species richness tends to be higher where vegetation is taller from reduced disturbance intensity (Ockinger et al., 2006; Poyry et al., 2006). For one threatened butterfly in Belgium, the bog fritillary (*Procossiana eunomia*), grazing decreased butterfly populations by an estimated 74% compared to un-grazed sites (Schtickzelle et al., 2007). Differences in microclimate requirements in conjunction with the relatively small sizes of remaining habitat patches have led to the implementation of single species management in order to preserve rare insects and butterflies.

Large grazing mammals were present throughout the evolutionary history of North American prairies and are an important component of the ecosystem (Mutel, 1989). Grazing can increase plant species diversity when used in a moderate grazing regime (Soleki and Toney, 1986). Intensive grazing could have negative effects on sensitive invertebrate species (Moffat and McPhillips, 1993; Swengel and Swengel, 1999) and many prairies have likely been destroyed or degraded by improper grazing regimes (Williams, 1997).

Fire is an important component of many ecosystems around the world (Sauer, 1950; Huntzinger, 2003; Fleishman, 2000; Vieira et al., 1996) and of grassland ecosystems in particular (Collins and Gibson, 1990; Schultz and Crone, 1998). Following a period of suppression, fire has increasingly been used as a management tool for restoring native habitats (Panzer and Schwartz, 2000; Huntzinger, 2003; Hobbs and Atkins, 1990). However, some researchers have expressed concern about the response of insect species to prescribed fire in small, isolated remnants (Dana, 1991; Swengel, 1996; Panzer, 2002; Samways, 2007). Local populations of insects on fragmented preserves may not survive repeated prescribed burns (Panzer, 2002).

In the state of Iowa, USA, less than 0.01% of the original 12 million hectares of prairie remains (Sampson and Knopf, 1994). As a result, the landscape is highly fragmented with small, isolated remnants surrounded by a matrix of agricultural lands. The negative consequences of habitat fragmentation on plants and animals are numerous and have been studied extensively (e.g., Kruess and Tscharntke, 1994; Quinn, 2004; Wilsey et al., 2005; Benedick et al., 2006; Cagnolo et al., 2006). Because smaller fragments have a higher edge-to-area ratio than larger fragments (Webb, 1989; Kiviniemi and Eriksson, 2002; Benedick et al., 2006), they are more susceptible to invasion by non-native species (e.g., Kiviniemi and Eriksson, 2002; Hansen and Clevenger, 2005). In fact, invasive species such as leafy spurge (*Euphorbia esula*) and smooth brome (*Bromus inermis*) are a major threat to biodiversity in the remaining prairies of North America (Fellows and Newton, 1999; Vinton and Goergen, 2006).

The Loess Hills of western Iowa contain some the state's largest unplowed native prairies. This unique landform is composed of fine soil particles, or loess, deposited by wind that has blown over glacial melt-water silt from the Missouri River bottoms (Mutel, 1989). Many of the remaining prairies in the Loess Hills have historically been used as pastures and hay meadows (Mutel, 1989). Remnant prairies in the Loess Hills area are home to almost 100 species of butterflies (Orwig, 1990), including some rare and endangered species. The diversity of butterflies in the state of Iowa has been declining because of habitat destruction and alteration (Schlicht and Orwig, 1998). The invertebrate communities of tallgrass prairies make up a large component of the total biodiversity in the ecosystem and their survival is an important issue for conservation (Dietrich, 1998; Schlicht and Orwig, 1998).

The questions addressed in this study are:

1. How do grazing and burning restoration practices affect butterfly species richness and abundance on prairie remnants managed for biological diversity?
2. Are there distinct butterfly communities associated with burned only, grazed only, or burned and grazed restoration practices?
3. How has the vegetation responded to prescribed restoration practices and how have butterflies responded to the vegetation?

2. Methods

2.1. Study area

We conducted butterfly surveys on prairie remnants located in Plymouth County, Iowa, USA at the northern end of the Loess Hills Landform (Fig. 1). Specifically, survey sites were located on Broken Kettle Grasslands Preserve (more than 1800 ha, owned and managed by The Nature Conservancy), Five Ridge Prairie (approximately 320 ha, owned and managed by the Plymouth County Conservation Board), and on adjacent private land.

We surveyed a total of 69 sites located within 28 management units. The study area was divided into units based on the restoration practices (burned only, grazed only, or burned and grazed) they received. Management units ranged in size from approximately 10 to over 100 ha, with an average size of 40 ha (Appendix A). Burned units were managed with prescribed fires conducted during the fall and spring in 2–6 year rotations (Appendix A). Prescribed burns conducted within a management unit were designed to burn the entire area within that unit. The limited number of burned only units available ($n = 10$) restricted our ability to further divide units into categories by season or frequency of burn. Grazed units received light rotational grazing by domestic cattle with stocking rates of approximately one cow–calf pair (one Animal