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The Importance of Oak Savanna Restoration for the Endangered Karner Blue Butterfly (*Lycaeides melissa samuelis*)

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Photo: Ann B. Swengel/USFWS

Introduction

The Karner blue butterfly, *Lycaeides melissa samuelis* Nabokaov (Lepidoptera: Lycaenidae) is a federally endangered species that inhabits oak savanna and requires wild lupine, *Lupinus perennis* L.(Fabaceae), its only known larval food plant. Wild lupine historically occurred in oak savannas and pine barrens which are becoming very rare communities. Suitable habitat for the Karner blue butterfly is especially limiting since the species is restricted to sandy savannas and barrens that have populations of *L. perennis*. Historically, the butterfly occurred at northern latitudes from Minnesota to Maine (Dirig 1994). These historic limits correspond to the distribution of *L. perennis* (USFWS 2001). Populations of Karner blue currently exist in Indiana, Michigan, Minnesota, New Hampshire, New York, Wisconsin, and Ohio (USFWS 2001). The populations in these states are small and several are at risk of extinction from habitat degradation, or loss. Maintaining the preferred habitat of the Karner blue is dependent on the natural disturbance regime of oak savanna ecosystems. Restoration actions such as prescribed burns, removal of woody vegetation, and revegetation with native species, have been explored to restore and manage for the oak savanna. Examples from research and restoration projects in states supporting Karner blue populations will be examined to help determine the best management for Minnesota. The only know population of Karner blue butterfly in Minnesota exists in only one location in southeastern part of the state. The focus of this paper will be to examine habitat history and current management efforts to save this population in southeastern Minnesota.

Background

Habitat Ecology

At the time of European settlement, oak savanna once covered eleven to thirteen million hectares of the Midwest (Nuzzo 1985). Marschner's detailed map "The Original Vegetation of Minnesota" is the most widely accepted source of information about presettlement oak savanna in the state. Using this map Kratz and Jensen (1983) assessed that southeastern Minnesota was covered by nearly one million hectares of oak openings and barrens. Much of the original vegetation in this ecosystem had been eliminated or degraded by agricultural use by the mid-1850s (Lane 1999). The Minnesota Natural Heritage Program identified only five hundred hectares of savanna remaining in the state in 1985 (Nuzzo 1986). A 716 ha expanse of poor to high quality oak savanna exists at Whitewater Wildlife Management Area (WMA) in southeastern Minnesota (Lane 1999) (Figure 2).

Dry oak savanna in southeast Minnesota is dominated by tree species such as *Quercus velutina* Lam. (black oak) with *Pinus banksiana* Lamb. (Jack pine) and *Quercus ellipsoidalis* E.G. Hill (northern pin oak) occasionally occurring. The few shrubs that occur in this ecosystem include *Prunus virginiana* L. (chokecherry) and *Corylus americana* Walt. (hazelnut). The typical herbaceous species inclue: *Lupinus perenni*s L. (wild lupine), *Monarda punctata* L. (horsemint), *Euphorbia corollata* (flowering spurge), *Schizachyrium scoparium* (Michx.) Nash (little bluestem) and *Koeleria macrantha* (Ledeb.) Schultes (June grass) (Lane 1999). Similar Karner blue habitat in Minnesota and other states include dry sand prairies and pine barrens.

The savanna/barrens ecotype is a very unique and dynamic system that owes its existence to specific past and present disturbance regimes, namely wild fires. The same dynamic processes, which produced these unique botanical communities, also produced a highly specialized community of invertebrates adapted to this regime (Shuey, 1994). These systems historically had frequent fires that preserved the heterogeneous landscape of cover and openings. Dramatic decline in character and frequency of fire (coupled with absence of appropriate types and levels of grazing) in the past 150 years has led to changes in the canopy cover. There is a direct correlation between the change in canopy cover to the decline of the Karner blue (Grundel et. al. 1998b). Suppression of wildfires has produced a much different landscape for the butterfly with a more densely wooded landscape and fewer canopy openings (Nuzzo 1986).

The percentage of canopy cover is a major contributor to the behavior of the Karner blue. Grundel et al. (1998a) found that adult males used habitat under canopy openings for nearly 90-percent of their activities at the Indiana Dunes National Lakeshore. Females used openings and shaded areas more or less equally. The frequency of oviposition on wild lupine was highest under 30-60 percent canopy cover; regardless if lupine was more abundant in more open areas (Grundel et al. 1998a). Grundel (1998a) also found that larvae fed preferentially on larger lupine plants and on denser patches. This shows that there is a trade-off between lupine abundance and distribution of larval feeding and oviposition because lupines are generally larger in the shade but grow in denser clumps in the sun.

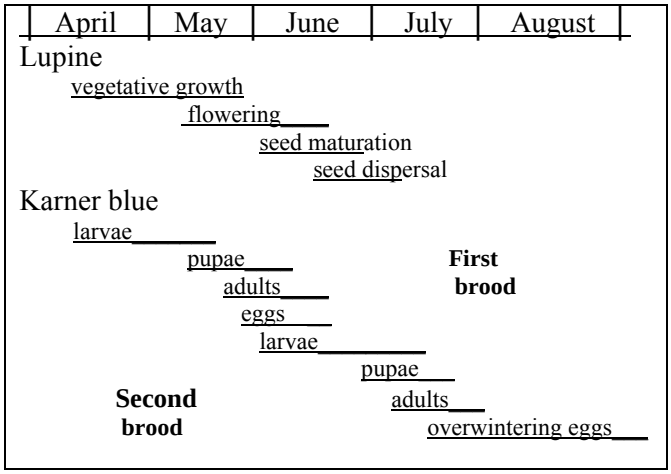
Karner Blue Butterfly Ecology

Understanding the life cycle of the Karner blue is important to its relationship with the wild lupine and oak savanna restoration. The Karner blue exclusively uses *L. perennis* for oviposition and as a larval food source, while adults depend on several other plant species as a nectar source (Bleser 1993). The Karner blue is bivoltine, which means that it completes two generations per

year. The first brood of larvae hatch from overwintered eggs in April and begin feeding on lupine. Larvae pass through four instars while feeding for about three to four weeks. Certain species of ants have a mutualistic relationship with the butterfly. They tend the late instar larvae and harvest a liquid that is beneficial to the ants. In return, the ants offer protection for the larvae. (Lane 1999). Therefore, the habitat of the local ant species is also important to consider in restoration efforts.

The larvae pupate in leaf litter, on stems and twigs, and occasionally on lupine leaves. Pupations usually take seven to eleven days with the adults emerging in late May through mid-June. Adults live an average of five days but can live as long as three weeks. These first flight adult females lay eggs primarily on lupine plants or occasionally on other plants or leaf litter near lupine.

Figure 1. Phenology of Karner blue and lupine. (USFWS 2001)



These second broods hatch in five to ten days and feeds in June and July. Second brood adults appear in mid-July to mid-August. There are usually three to four times more adults in the second brood compared to the first brood (Schweitzer 1994). First broods may be smaller due to winter mortality or larvae inability to find less abundant lupine populations.

Wild Lupine


Photo by USFWS: Joel Trick

Management of the Karner blue is directly dependent on the presence of wild lupine populations. *L. perennis* is a member of the pea family (Fabaceae). Peak bloom is typically in mid-May to late June within the range of the Karner blue. Stem density and flowering is greatest in open and partial canopied areas. Lupine is an early successional species adapted to survive on dry, relatively infertile soils. It can grow on soils low in nitrogen because of its association with the nitrogen fixing bacterium *Rhizobium lupina*. Unfortunately several species of woody vegetation are also adapted to the same soils and habitat (Nuzzo 1986). Without disturbance these trees and shrubs close the canopy and prevent lupine from reproducing. Managing for disturbance, such as prescribed burns and tree and shrub removal, are crucial to the success of the lupine.

Management Strategies

Prescribed Fires

Fire had been an important part of the natural disturbance regime in the oak savanna/barrens ecosystem until policy changed to suppress fire around 150 years ago. Prescribed burns have been the most commonly used tools for creating more open canopy habitats within the Karner blue's range. Part of this philosophy has come from the understanding that the oak savanna is a fire-dependent ecosystem and the Karner blue is a fire-sensitive species. Unfortunately, fire can have a negative impact on the success of the Karner blue. Schweitzer (1992) and Swengel (1994) both believe that fire causes some butterfly mortality during prescribed burns by putting eggs and larvae at risk, although King (2003) points out that there is no data to substantiate this theory. The problem arises if the Karner blue or wild lupines only exist in small patches and are not properly identified before the burn. To solve this problem, habitat patches should be identified outside of the burn area to allow for adult recolonization or the burns areas can be designed in a manner to provide adequate refugia for larvae of the Karner blue.

Fires have been used in Indiana Dunes National Lakeshore (IDNL) for habitat restoration over the past decade. Kwilosz (1999) found that quantifying Karner blue impacts from fire were difficult because of other variables could also affect their populations (variations in weather, habitat characteristics, and lupine and nectar plant abundance). Surveys conducted post-burn at IDNL showed some mortality to the Karner blue larvae again showing importance of site identification. Adult butterflies did not seem to be adversely affected, probably due to migration back into the more desirable habitat after the burn (Kwilosz 1999).

A study by King (2003) in the Necedah National Wildlife Refuge in Wisconsin used a combination of mowing and burning on different test sites. This study used cool burns in November and July. The timing of the burns was to take advantage of the less susceptible life stages of the butterfly. The burn was also noted to increase the numbers of nectar plants used by the adults. One conclusion of this study may be that the burning did not regulate or adversely affect Karner blue populations due to the timing of the burns.

Lupine Planting/Seeding

Kleintjes et al. (2003) used a study site in Wisconsin to study the effects of transplanting and seeding wild lupine. Plugs containing lupine where transplanted using a tree spaded from a site prior to impact by a wastewater treatment facility. These were taken to a mitigation site that was prepared using soil removed from the impact site. Other areas within the site where also seeded with grasses and forbs, including Karner blue nectar species and lupine. All of the study sites showed signs of Karner blue populations within the first few years after planting. The restoration sites benefited from having a viable population in an undisturbed adjacent conservation area, where butterflies most likely migrated into the newly establish habitat.

Other Methods

Management efforts have also included other methods including mowing, cutting, and herbicide. Most of these methods are usually used in conjunction with burning. Mowing was used by King (2003) in the Necedah site. Mowing was only done in late August with a 2.0 M wide rotary mower at a height of 0.2 M. Prior to this treatment crews removed larger shrubs and trees with chainsaws. Mowing did not have a detrimental effect on Karner blue because they were in the second brood egg stage during the mowing. Also, most eggs are laid below the height of the

blade. Mowing is also used readily in road and highway right-of-ways. In Wisconsin these areas have been found to be important dispersal and flight corridors. Some rural sites with mowing usually only in August have proven to be effective at sustaining Karner blue populations (Swengel 1994). Other sites that are mowed more often and that sometimes used herbicide treatments were found to be less viable communities due to low plant species diversity. Herbaceous treatments have been used to control woody vegetation when combined with mechanical cutting, especially to prevent re-sprouting and canopy regrowth.

A Case Study: Whitewater River Valley, MN

The only known population of the Karner blue butterfly in Minnesota is Whitewater Wildlife Management Area (WMA) in Winona County (Figure 2). Other locations in Minnesota would have historically supported wild lupine and the Karner blue. Cedar Creek Natural History Area and 50 other oak savanna/sandy soil sites were surveyed and revealed that lupine was no longer present and the Karner blue had been extirpated (Lane and Dana 1994). Whitewater WMA contains oak savanna at various successional stages in a much-dissected topography of steep ridge and bluff areas (Lane 1994). It is these areas that support the greatest populations of *L. perennis*. Of the 12 to 15 valleys that have lupine habitat, only three support the Karner blue (Edwards 2003). Other important plant species that the Karner blue were observed using for nectar sources include: *Monarda punctata*, *Campanula rotundifolia*, *Gnaphalium obtusifolium*, and *Euphorbia corollata* among others (Lane 1994). The Karner blue has set the stage for protection of a rare community type in Minnesota. The goal at Whitewater WMA is to restore enough habitats to enable development of a Karner blue metapopulation to buffer existing populations from stochastic events. Current management efforts at Whitewater WMA are: 79 hectares of brush clearing, 75 hectares of prescribed burns, and enrichment of 18 hectares of savanna/prairie openings with seed collecting and seedling planting of nectar source plants (Edwards 2003).

Figure 2. Karner blue population in MN.

Conclusion

The Karner blue was listed as a federally endangered species in 1992 (Clough 1992 and www.endangered.fws.gov). The Federal Recovery Plan (USFWS 2001) calls for establishment of viable populations across the Karner blue's current range. The plan's estimated cost is over four million dollars over a twenty-year period.

The Karner blue is primarily threatened by fire suppression practices that prevent the growth of wild lupine by stopping successional growth. Habitat modification, urbanization, and fragmentation have also caused problems for the butterfly. More research is clearly needed to determine which management strategies are most effective since current data either conflicts or is incomplete (King 2003, Swengel 1994).

Current research supports the use of prescribed burns as the most feasible management strategy for the oak savanna ecotype. A method to ensure the survival of the Karner blue during burn management would be to burn in non-colonized patches that would be recolonized by adult butterflies from unburned areas (Kwilosz 1999). Combining prescribed burn practices with other

methods of management such as mechanical removal and/or herbicide treatment of woody species on sites that have closed canopies is important in initial habitat recovery. In addition, where large populations of food source vegetation are not enough to support viable populations of the Karner blue, seeding and live planting of lupine and other nectar sources has proven to be important (Kleintjes et al 2003).

The first goal should be to protect the existing populations of Karner blue by protecting, restoring, and managing the oak savanna/barrens habitat. Protecting and managing the savanna habitat for the Karner blue also enhances habitat for other rare species, such as the frosted elfin butterfly, Blanding's turtle, and loggerhead shrike. The next step in Minnesota and across the butterfly's range is to identify additional historic Karner blue habitat for restoration. This will allow the current populations to disperse when these sites are restored. There are already several proposals that should help improve the Karner blue habitat such as the Federal Plan and the restoration plan for Whitewater WMA.

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