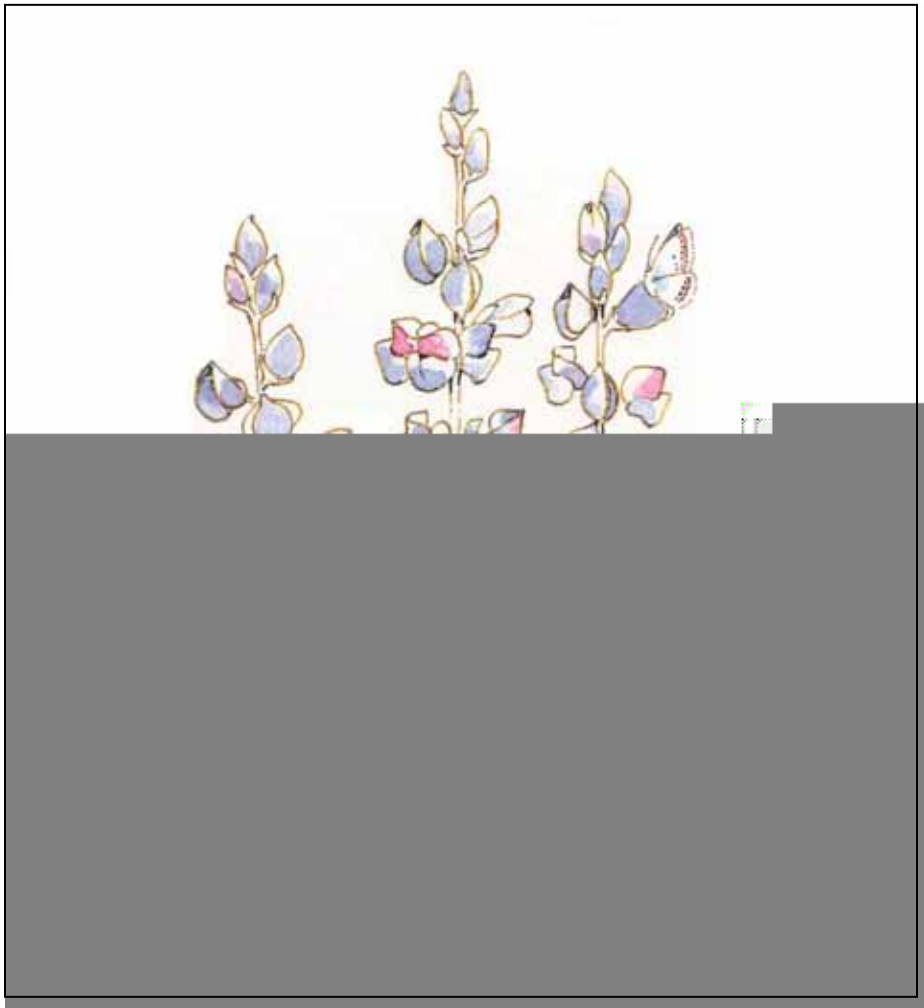
Karner Blue Butterfly Recovery Plan

(Lycaeides melissa samuelis)



September 2003

Department of the Interior
U.S. Fish & Wildlife Service
Great Lakes - Big Rivers Region (Region 3)
Fort Snelling, Minnesota

* * *

This recovery plan has been prepared by the Karner Blue Butterfly Recovery Team under the leadership of Dr. David Andow, University of Minnesota-St. Paul. Dr. John Shuey and Dr. Cynthia Lane assisted with the writing of the document. The purpose of the plan is to delineate reasonable actions needed to restore and protect the endangered Karner blue butterfly *(Lycaeides melissa samuelis)*. Recovery objectives will be attained and funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

The plan does not necessarily represent the views or official position of any individuals or agencies involved in plan formulation, other than the U.S. Fish and Wildlife Service. The plan represents the official position of the U.S. Fish and Wildlife Service only after it has been signed by the Regional Director. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

LITERATURE CITATION:

U.S. Fish and Wildlife Service. 2003. Final Recovery Plan for the Karner Blue Butterfly *(Lycaeides melissa samuelis)*. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota. 273 pp.

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ACKNOWLEDGEMENTS

The U.S. Fish and Wildlife Service recognizes that development of this draft recovery plan would not have been possible without the assistance of the many individuals who attended recovery team meetings, and contributed valuable information to the process. Special thanks goes to Mary Parkin, the Service's Region 5 Recovery Coordinator, who, while not seen but at one meeting, was ever-present as a guide and support in the evolution of this plan. Acknowledgement goes to Catherine Carnes, the Service's Karner Blue Butterfly Recovery Coordinator who oversaw and coordinated this project.

The Service also wishes to especially acknowledge the following individuals who served as technical consultants to the recovery team for their efforts on behalf of the species:

Mr. Richard King	Necedah National Wildlife Refuge, Wisconsin
Dr. Judi Maxwell	University of Wisconsin, Madison, Wisconsin
Mr. Robert Welch	Waupaca Field Station, Waupaca, Wisconsin

Thanks also to the following individuals who gave of their time and expertise to assist with this plan development:

Michael Amaral	Dave Lentz
Nancy Braker	Kim Mello
Hilda Diaz-Soltero	Amelia Orton-Palmer
Buddy Fazio	Noel Pavlovic
Anthony Frank	Chuck Pils
Ralph Grundel	Rebecca Power
Mark Heil	Gregory Smith
Bob Hess	Janet Smith
Ken Hujanen	John Staszcuk
Craig Johnson	Kathy Trudell
Randy Jurewicz	David VanLuven
Chuck Kjos	Tim Wilder
Randy Knutson	Jennifer Windus
Paul Kooiker	Mike Zeckmeister

Also, special thanks goes to David Kopitzke for the Karner blue butterfly artwork that appears on the cover and within the body of this document.

EXECUTIVE SUMMARY
Karner Blue Butterfly Recovery Plan

Current Species Status: The Karner blue butterfly, *Lycaeides melissa samuelis* Nabokov (Lepidoptera: Lycaenidae), formerly occurred in a band extending across 12 states from Minnesota to Maine and in the province of Ontario, Canada, and now only occurs in the seven states of Minnesota, Wisconsin, Indiana, Michigan, New York, New Hampshire, and Ohio. Wisconsin and Michigan support the greatest number of Karner blue butterflies and butterfly sites. The majority of the populations in the remaining states are small and several are at risk of extinction from habitat degradation or loss. Based on the decline of the Karner blue across its historic range, it was listed as endangered in 1992. Since listing, two populations have been extirpated and are being reintroduced to Concord, New Hampshire, and West Gary, Indiana. A third population is being reintroduced to Ohio.

Habitat Requirements and Limiting Factors: The Karner blue butterfly is dependent on wild lupine, *Lupinus perennis* L. (Fabaceae), its only known larval food plant, and on nectar plants. These plants historically occurred in savanna and barrens habitats typified by dry sandy soils, and now occur in remnants of these habitats, as well as other locations such as roadsides, military bases, and some forest lands. The primary limiting factors are loss of habitat through development, and canopy closure (succession) without a concomitant restoration of habitat. A shifting geographic mosaic that provides a balance between closed and open-canopy habitats is essential for the maintenance of large viable populations of Karner blue butterflies.

Recovery Objectives: The objective of this recovery plan is to restore viable metapopulations of Karner blues across the species extant range so that it can be reclassified from endangered to threatened. The long-range goal is to remove it from the Federal list of *Endangered and Threatened Wildlife and Plants.*

Recovery Criteria: The reclassification criteria will be met when a minimum of 27 metapopulations [19 viable metapopulations (supporting 3,000 butterflies each), and 8 large viable metapopulations (supporting 6,000 butterflies each)] are established within at least 13 recovery units across the butterfly's range and are being managed consistent with the recovery objectives outlined in this plan. Delisting will be considered when a minimum of 29 metapopulations (13 viable and 16 large viable metapopulations) have been established within at least 13 recovery units and are being managed consistent with the plan.

Actions Needed:

1. Protect and manage Karner blue and its habitat to perpetuate viable metapopulations.
2. Evaluate and implement translocation where appropriate.
3. Develop rangewide and regional management guidelines.
4. Develop and implement information and education program.
5. Collect important ecological data on Karner blue and associated habitats.
6. Review and track recovery progress **(includes re-evaluation of recovery goals for Wisconsin).**

Total Estimated Cost of Recovery (in $1,000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	* Total
2003	872.5	75	7	133	391	7	1,485.5
2004	964.5	55	26	63	423	27	1,558.5
2005	974	100	27	48	400	15	1,564
Total	2811	230	60	244	1,214	49	4,608

* Does not include land acquisition costs.

Date of Recovery: Full recovery of the species is anticipated to require at least 20 years, until about 2023.

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PART I. INTRODUCTION

The Karner blue butterfly (*Lycaeides melissa samuelis*) was proposed for Federal listing on January 21, 1992 [U.S. Fish and Wildlife Service (USFWS) 1992a], and on December 14, 1992 it was listed as federally endangered rangewide (USFWS 1992b). Historically, the Karner blue butterfly occurred in 12 states and at several sites in the province of Ontario. It is currently extant in seven states (New Hampshire, New York, Ohio, Indiana, Michigan, Wisconsin and Minnesota) with the greatest number of occurrences in the western part of its range (Michigan and Wisconsin). The Karner blue is considered extirpated from five states and the Canadian province of Ontario. Reintroductions are underway at three sites, Concord, New Hampshire, West Gary, Indiana, and in Ohio. The historic habitat of the butterfly was the savanna/barrens ecosystems. Much of these ecosystems has been destroyed by development, fragmented, or degraded by succession, and has not been replaced by other suitable habitat, especially in the eastern part, and along the margins of the butterfly's range. The loss of suitable habitat resulted in a decline in Karner blue locations and numbers, with some large populations lost, especially in the eastern and central portions of its range. Presently, the Karner blue butterfly occupies remnant savanna/barrens habitat and other sites that have historically supported these habitats, such as silvicultural tracts (e.g. young pine stands), rights-of-ways, airports, military bases, and utility corridors.

The ecology of the Karner blue butterfly is closely tied to its habitat which provides food resources and key subhabitats for the butterfly. The larvae feed only on one plant, wild lupine (*Lupinus perennis*). Adults require nectar sources to survive and lay sufficient eggs. Because these habitat components can be lost to succession, Karner blue butterfly persistence is dependent on disturbance and/or management to renew existing habitat or to create new habitats. The distribution and dynamics of these habitats in the establishment of viable metapopulation of this species forms the ecological basis for recovery planning.

TAXONOMY AND DESCRIPTION

Taxonomy

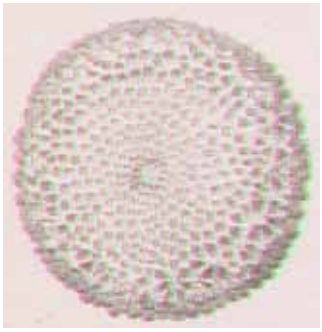
The taxonomy of the Karner blue *(Lycaeides melissa samuelis)* follows Lane and Weller (1994) who have conducted the most recent review of its taxonomy. The Karner blue is a member of the genus *Lycaeides* (Lepidoptera: Lycaenidae: Polyommatinae) (Elliot 1973, Nabokov 1943, 1949). In North America there are two species of *Lycaeides, L. idas* (formerly *L. argyrognomon*) and *L. melissa* (Higgins 1985, Lane and Weller 1994). *Lycaeides melissa* is comprised of six subspecies, *L. m. melissa, L. m. annetta*,

and the currently accepted status of the Karner blue butterfly is subspecific (Miller and Brown

each from Minnesota and Michigan) and limited number of base pairs analyzed (Robert Zink, University of MN, pers.comm. 2002).]

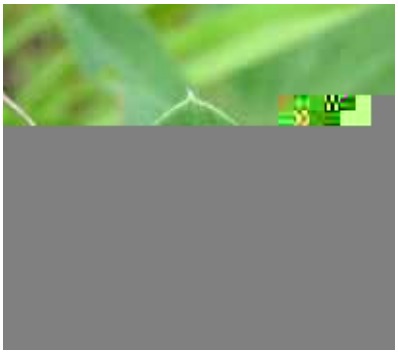
Taken as a whole, the genetic, morphological, ecological, and life history data support

Figure 1. Life stages of the Karner blue butterfly



Egg, top view
[----------]
0.7mm

Egg, side view



Egg on lupine

Larva on lupine

Larva tended by ant
Larval feeding damage on lupine

Pupae on lupine

Adult Female

Adult Male

Photo credits. Drawings of eggs from Scudder (1889); Karner blue larvae tended by ant courtesy of the Wisconsin DNR, all other photos courtesy of Paul Labus, The Nature Conservancy, Whiting, Indiana (refer also to: http://nature.org/wherewework/northamerica/states/indiana/preserves/art9126.html for additional images).

Ants are known to tend larvae during their larval stage (Figure 1). Pupae are bright green and smooth, changing to a light tan with hints of purple shortly before emergence when the adult cuticle separates from the cuticle of the pupal case.

Distinguishing Karner blue from similar species

In the eastern United States, the Karner blue butterfly can be confused readily with the eastern-tailed blue (*Everes comyntas*) and less readily with the spring azure (*Celastrina argiolus*) complex (Opler 1992, Scott 1986). Eastern-tailed blues are on average smaller than Karner blue and they have black projections or "tails" on the outer angle of the hind wings (Opler 1992, Scott 1986). These tails may be broken off but usually leave some remnant indicating their former

DISTRIBUTION

Rangewide Distribution of Karner Blues

Historically, the Karner blue butterfly occurred in a geographic band between 41^{o} and 46^{o} North latitude extending from Minnesota to Maine (Dirig 1994) (refer to Figure B-1, APPENDIX B). The butterfly is commonly found on sandy soil types that have populations of *Lupinus perennis* (the only known larval food source), and often inhabits communities similar to oak and pine savanna/barrens communities. In this recovery plan, the term "lupine" will refer to *L. perennis* to the exclusion of all other species of *Lupinus*.

Dirig (1994) reviewed all of the locality records of the Karner blue he could find, whether or not they were confirmed with vouched specimens. His work is an exhaustive summary of the reports of Karner blue occurrence. To establish a definitive historic geographic range, this recovery plan only includes locality records with confirmed specimens. Additional information from Dr. Robert Dirig, requested by the Recovery Team, was especially critical for evaluating records from Pennsylvania, New Jersey, Maine, and Wisconsin. These findings are summarized here and presented in greater detail in APPENDIX B.

The historic northern, eastern, and western limits of the butterfly correspond roughly with

State Distribution of Karner Blues

This section briefly reviews survey efforts and the distribution of the Karner blue in each state where recovery units (RUs) have been established via this recovery planning process. Survey efforts to identify additional Karner blue sites are continuing in Wisconsin, Michigan and New York, with additional Karner blue butterfly localities identified in all three states since Federal listing of the species. Several of the survey efforts are a result of formal section 7 consultations with Federal agencies including the Department of Defense (Fort McCoy) in Wisconsin and the U.S. Forest Service in Michigan (for forest management activities on the Huron-Manistee National Forest [NF] and for gypsy moth control). For a glossary of terms used in this recovery plan (Plan) refer to APPENDIX A. For information and locations on the 13 RUs and six potential RUs established by this Plan refer to APPENDIX B.

New Hampshire (Merrimack/Nashua River System RU)

No native Karner blue populations remain in New England. The last native population occurred in the Concord Pine Barrens in Concord, New Hampshire, and was extirpated in 2000. That last population, which existed in a powerline right-of-way and the grassy safeways of the

more than 10 butterflies in the annual index counts. Eight subpopulations are within the Queensbury Sandplains in Warren County, which is considered a location for recovery under the state's draft recovery plan. Five subpopulations are within Glacial Lake Albany RU, but are isolated from any expected interaction with the sites in the recovery areas. The NY DEC considers a site occupied until at least five years of adequate survey has failed to find the species. Some of the New York subpopulations are extremely small and vulnerable and will be considered extirpated if Karner blues are not found in the next year or two (Gerald Barnhart, NY DEC, in litt. 2002).

Michigan (Ionia, Allegan, Newago and Muskegon RUs)

The Karner blue butterfly is currently found in 10 of the 11 Michigan counties in which it historically occurred. Early surveys by Wilsmann (1994) noted that the Karner blue populations were reduced and highly fragmented. The majority of the Karner blue sites occur on state land (Flat River and Allegan State Game Areas [SGAs]) in the Ionia and Allegan RUs, and on Federal lands (Huron-Manistee National Forest) in the Newaygo and Muskegon RUs.

Survey efforts during 1994-1996 by the Michigan Natural Features Inventory (NFI) of 65 areas within the Ionia RU on public and private lands revealed nine extant Karner blue sites, eight within the Flat River SGA; with the exception of one site, all supported low numbers of butterflies (Cuthrell and Rabe 1996). Based on data through 1998, eight subpopulations (defined as separated by 200 meters of unsuitable habitat) have been identified at the Flat River SGA and 23 at the Allegan SGA. In addition, two other subpopulations occur on private property; one near each of these state properties (Daria Hyde, Michigan NFI, pers. comm. 1998). The Ionia RU is the least well surveyed of all the Michigan RUs with much of the area outside of the Flat River SGA developed for agriculture and other uses (Baker 1994, Wilsmann 1994). The most sizable populations in the state occur at Allegan and Flat River SGAs and most likely on the Huron-Manistee NF (Jennifer Fettinger, pers. comm. 2002).

Many locations in the Newaygo and Muskegon RUs that supported Karner blue butterfly populations 35-40 years ago have been lost to succession, agricultural conversion, forestry, and residential and commercial developments (Wilsmann 1994). The majority of Karner blue sites in these two RUs occur on the Huron-Manistee NF. As of the fall of 2002, a total of 13,792 acres of the Huron-Manistee NF were surveyed for the Karner blue, with butterflies found on 2,026 acres in 267 locations. As of 2002, 78 subpopulations (using the 200 meter criteria) were reported on the Huron-Manistee NF; these includes seven along powerline ROWs (Jennifer Fettinger, MI NFI, pers. comm. 2002). In 2002, the Michigan NFI surveyed 58 sites on the Huron-Manistee NF and found the Karner blue at 40 of these sites. Surveys on private lands within the Manistee National Forest boundary have documented an additional 56 localities on about 440 acres (Joe Kelly, pers. comm. 1998, Jennifer Fettinger, pers.comm. 2002). Some utility companies (e.g., Consumers Energy and Wolverine Power Company) in Michigan are surveying their transmission line corridors for Karner blues.

As of the fall of 2002, Michigan, excluding the Allegan SGA, supported 158 subpopulations of Karner blues (based on a 200 meter separation criteria) (Jennifer Fettinger, Michigan NFI, pers. comm. 2002). As noted above, in 1998, Allegan SGA supported 23 subpopulations of Karner blues; this number is currently under revision to reflect 2002 numbers.

Indiana (Indiana Dunes RU)

Historically, the Karner blue was reported from eight counties in Indiana. In 1990, Karner blue butterflies were identified at 10 sites out of 35 potential sites surveyed (Martin 1994). Two population clusters were identified within two counties (Lake and Porter), the majority of which was associated with medium to high quality Karner blue habitat (Martin 1994). The early surveys in Porter County (which includes the National Park Service's Indiana Dunes National Lakeshore [IDNL]) identified between 1,000 and 10,000 second brood Karner blue adults (Baker 1994). In Lake County, at the IDNL, several thousand second brood adults were estimated (Schweitzer 1992), and in other Lake County sites, the subpopulations likely number between 100-500 (John Shuey, The Nature Conservancy (TNC), pers. comm. 1998).

Currently it is estimated that 17 subpopulations of Karner blues (using the 200 meter separation criteria) occur at IDNL (Ralph Grundel and Noel Pavlovic, U.S. Geological Survey (USGS), pers. comm. 1998). In West Gary, about 21 tracts clustered into 11 individual preserves and management areas have been identified as potentially able to at least periodically support the Karner blue (Shuey, undated); these sites are associated with a remnant dune and swale complex. In 1998, four of these tracts supported Karner blues (John Shuey, pers. comm. 1998); however, by 2000, Karners were gone from all four sites. In 2001, a reintroduction project was started to restore Karner blues to West Gary (refer to PART I, Reintroduction/Translocation, Captive rearing)

Wisconsin (Morainal Sands, Glacial Lake Wisconsin, West Central Driftless, Wisconsin Escarpment and Sandstone Plateau and Superior Outwash RUs)

The Wisconsin Department of Natural Resources (WDNR) began systematic statewide surveys for the Karner blue in 1990 including surveys of 33 of the 36 known historic butterfly sites. Initial surveys by Bleser (1993) reported that only 11 of the 33 historical sites supported Karner blues, and also identified 23 previously unknown sites. Additional survey efforts were subsequently conducted by the Wisconsin DNR, the U.S. Fish and Wildlife Service (Service) [Trick 1993, Necedah National Wildlife Refuge (NWR)], Fort McCoy (Leach 1993), and other biologists (Swengel 1994, Bidwell 1996). By 1993, an estimated 150 to 170 discrete Karner blue sites were documented in Wisconsin (Baker 1994). In recent years, additional surveying has been done by partners to the Wisconsin Statewide Habitat Conservation Plan for the Karner Blue Butterfly (HCP) including eight county forest departments, several private forest and utility companies, The Nature Conservancy, and the Wisconsin Department of Transportation. Partners to the HCP routinely survey for the butterfly prior to conducting management activities in an effort to avoid adverse impacts to the Karner blue. In addition, partners monitor for Karner blues annually as part of the HCP effectiveness monitoring program coordinated by the Wisconsin DNR.

Two separate but related sources of data on the Karner blue and its habitat in Wisconsin currently demonstrate that Karner blue butterfly populations in Wisconsin are numerous and widely distributed across the state. As of April 2002, Wisconsin DNR's Natural Heritage Inventory (NHI) database noted 311 Karner blue butterfly occurrences (using a one-half mile separation criteria) across 20 counties in Wisconsin. This reflects an 815 percent increase in recorded NHI Karner blue occurrences since listing. Similarly, the HCP annual monitoring

program has documented 256 Karner blue occupied sites as of December 2002 on HCP partner lands, reflecting a 241 percent increase in Karner blue occupied sites on partner lands between 1998 and 2002 (Darrell Bazzell, WDNR, in litt. 2002). Most of the 256 Karner blue occurrences on partner lands are a subset of the NHI data (i.e. included in the 311 NHI occurrences), although further analyses is necessary to determine if some of these sites are new NHI occurrences (greater than 1/2 mile from an existing occurrence).

The number of known lupine sites on HCP partner lands in Wisconsin has also increased. About 252,299 acres of land (WDNR 2002a) are covered by the HCP, and partners implement measures that contribute to the conservation, and in some cases, recovery of the butterfly on these lands (WDNR 2000) (not all this acerage supports Karner blues). In 1998, there were 90 identified lupine sites on shifting mosaic (i.e. forestry) habitat that contained at least 25 plants or clumps of lupine at a density of 50 lupine plants/acre, or 25 lupine plants/200 meters for linear

Permanent transect counts conducted at two sites since 1992 (Cuthrell and Historic Sites) recorded peak second flight counts ranging from 0.63 to 4.00 butterflies per 1,000 square meters of transect (mean = 1.40) at the Cuthrell Site, and from 0 to 1.33 butterflies per 1,000 square meters of transect (mean = 0.60) at the Historic Site. These numbers represent relative abundance, and the relationship between numbers counted and total population size is unknown but is probably linear (Lane 1999a, Edwards 2002). Because other butterfly monitoring research has shown that only a portion of the butterflies in a sample area are counted and that in this case only a fraction of each site is surveyed, population numbers are considerably greater than the observed transect count numbers.

There are other locations in the southeastern and east-central part of the state that formerly supported lupine. The only other known location to have supported the Karner blue butterfly in Minnesota is the Cedar Creek Natural History Area (CCNHA). Surveys of 50 potentially suitable sites in Minnesota (oak savanna with sandy soil and lupine) revealed that many lupine sites were no longer present and that Karner blues had been extirpated from the CCNHA site (Lane and Dana 1994).

LIFE HISTORY AND ECOLOGY

Karner Blue Butterfly

The life history of the Karner blue butterfly has been studied by Scudder (1889), Dirig (1976, 1994), Cryan and Dirig (1978), Savignano (1990), Swengel (1995), Swengel and Swengel (1996, 1999, 2000), and Lane (1999b). The Karner blue butterfly is bivoltine, which means that it completes two generations per year (Figures 2 and 3). In typical years, first brood larvae (caterpillars) hatch from overwintered eggs in mid- to late April and begin feeding on wild lupine (*Lupinus perennis*), the only known larval food source (Figure 2). Larvae pass through four instars (developmental stages), between which the relatively soft larval exoskeleton is shed. Feeding by first and second instar larvae results in tiny circular holes in the lupine leaves while older larvae eat all but the upper or lower epidermis, creating a characteristic window-pane (Figure 1) appearance (e.g., Swengel 1995). Larvae feed for about three to four weeks and pupate (transform from larvae to adult) in late May to early June. Ants commonly tend larvae (refer to PART I, LIFE HISTORY AND ECOLOGY, Associated Ants). Mature larvae enter a wandering phase, after which the pre-pupal larvae attach themselves to various substrates with a silk thread. Karner blues are known to pupate in the leaf litter, on stems and twigs, and occasionally on lupine leaves (Dirig 1976, Cryan and Dirig 1978). Dirig (1976) reported that pupation generally lasted seven to eleven days in the field. Laboratory-reared pupae typically took seven to nine days, and sometimes up to eleven days before emerging as adults (Savignano 1990, Herms et al. 1996). First flight adults begin emerging in late May with the flight extending through late June (Swengel and Swengel 1996). At peak flight the sex ratio typically exceeds 50% males. The Swengels (1996) have reported 70 percent males at peak flight. The percent males decrease as the flight period progressess (Leach 1993, Swengel and Swengel 1996). Adults are believed to live an average of four to five days but can live as long as two to three weeks. First flight adult females lay their eggs primarily on lupine plants, often singly on leaves, petioles, or stems, or occasionally on other plants or leaf litter close to lupine plants.

Second brood eggs hatch in five to ten days, and larvae can be found feeding on wild lupine leaves and flowers from early June through late July. Typically, a larva can survive on one large lupine stem; however, the larva moves from leaf to leaf on the lupine stem, often returning to leaves fed on during earlier instars, and it may even move to other lupine stems (Lane 1999b). Larvae are found often on the lower parts of the stems and petioles. Ants also typically tend second brood larvae, but during midday on hot days tending may be reduced. Pupae are also frequently tended by ants (Cynthia Lane, pers. comm**.** 1997). Refer to Figure 1 which depicts the different life stages of the Karner blue.

Second brood adults begin to appear in early to mid-July and fly until mid to late August, and in some years into early September (Swengel and Swengel 1996). Flight phenology may be delayed because of cool wet summers and result in an adult flight period lasting through late August (Cathy Bleser, pers. comm. 1995; Cynthia Lane, pers. comm. 1995). The peak flight period usually lasts one to two weeks. Generally, there are about three to four times as many adults in the second brood compared with the first brood (Schweitzer 1994b). Maxwell and Givnish (1994) surveyed Karner blue populations at 46 locations at Fort McCoy, Wisconsin, during 1993; they found that locations with high first flight butterfly counts also had high second flight counts ($r^2 = 0.674$) and that populations were three to four times as abundant during the second flight. However, the pattern is highly variable, and in some years, the second brood is not larger than the first brood (Swengel and Swengel 1996). The first brood is usually smaller most likely due to high overwintering mortality of eggs, the inability of larvae to find lupine in the spring, or greater oviposition success of first-flight females.

It is important to note that there is a significant amount of annual variation in adult abundance relative to peak flight date and in brood timretDt.Jns aod tomyroo(Swengelring

fluctuations in abundance, 2) phenological differences among years and 3) among sites, and 4) inter-annual variation in span between spring and summer generations."

Second flight females usually land on green non-senesced lupine, crawl down the stem, and lay eggs primarily on grasses and sedges, other plant species, leaf litter near lupine stems, and occasionally on lupine (Lane 1999b). In general, insects that overwinter in the egg stage often lay their eggs on various materials close to the ground because these sites afford better winter protection (Bernays and Chapman 1994). The eggs laid by second flight females are the overwintering stage (evidence summarized by Haack 1993), and studies by Spoor and Nickles

Figure 3. Illustration of life history stages of the Karner blue.

Lupine abundance and Karner blue

Management for sufficient lupine is critically important for the Karner blue, because it is the only food plant for the larvae. Significant increases in the abundance of lupine will usually not be detrimental to the Karner blue, and may in many cases be beneficial. Lupine, however, is not the only factor limiting Karner blue butterfly subpopulations, and it is important to manage for additional factors important to the butterfly.

A positive association between lupine abundance and Karner blue abundance or persistence would indicate that lupine abundance could be a factor limiting Karner blue populations. Several researchers have found a positive correlation between lupine abundance and number of Karner blue butterfly adults in New York, Michigan, and Wisconsin (Savignano 1994b, Bidwell 1995, Herms 1996, Smallidge et al. 1996, Swengel and Swengel 1996, Lane 1999). In Wisconsin, lupine abundance and proximity to the middle of a large lupine population were correlated with adult Karner blue abundance (Swengel and Swengel 1996). Savignano (1994b) found a significant correlation between Karner blue numbers and the number of lupine rosettes in New York studies. At one site with abundant lupine but few butterflies, Savignano (1994b) suggested that a dearth of nectar plants limited the butterfly. Herms (1996) found a significant positive correlation between lupine density and Karner blue abundance at the Allegan SGA in Michigan.

The reproductive status of lupine was found to be a key in explaining butterfly numbers at Fort McCoy, Wisconsin, where Maxwell (1998) found significantly greater second brood larval densities in shady plots which had a higher proportion of non-reproductive lupine. Second brood adult abundance increased with the frequency of non-reproductive lupine plants, but declined with increasing cover of flowering plants. Maxwell (1998) also detected that lupine plants in open areas, which tended to be reproductive, senesced earlier than those in shaded areas and suggested that early senescence could result in larval starvation. However, the study year (1995) was particularly hot and studies by Lane (1999) suggest that in most years larvae are able to reach pupation before lupine senesces. In addition to the influence of lupine abundance on the

shadiest lupine patches serve as "nurseries" for second brood larvae due the greater availability of non-reproductive lupine, which are not as susceptible to mildew and remain green throughout the larval stage.

It is unlikely that a single factor, such as the density of lupine, would account for variation in abundance of the Karner blue throughout its range. In places where it does, however, such as in the Glacial Lake Albany RU in New York, and at Fort McCoy, Wisconsin, it suggests that Karner blue populations might be enhanced by increasing the amount of lupine available. In localities where there is a poor correlation between lupine abundance and adult Karner blues, such as in the Paleozoic Plateau RU in Minnesota, and possibly, the Allegan SGA in Michigan, other factors may be important such as lupine quality, microhabitat, and distance from the nearest occupied site.

Lupine quality and the Karner blue

Variation in plant quality, as influenced by nutrient composition, secondary plant chemistry, morphology, and other factors can have significant effects on Lepidoptera (Bernays and Chapman 1994). *Lupinus* species have secondary plant compounds, typically alkaloids, that influence lupine's suitability as insect food. Levels of alkaloids in *Lupinus* species vary with plant part and are highest in reproductive parts and the epidermis (Bernays and Chapman 1994). In addition, habitat differences in sun and shade may affect host plant quality by influencing host plant nutrients, secondary plant compounds, phenological state, and/or physical condition (Mattson 1980, Waterman and Mole 1989, Dudt and Shure 1994, Ravenscroft 1994).

Laboratory and field feeding studies have shown that the quality of lupine as larval food is affected by growing conditions (Grundel et al. 1998a, Maxwell 1998, Lane 1999). Grundel et al. (1998a) tested the effects of nine types of lupine on larval growth and survival. Lupine type was based on several factors including: age, reproductive/phenological status (non-flowering, flowering, seed, and senesced), percent canopy cover where lupine was growing, water status, presence of powdery mildew, and soil type. These laboratory feeding studies demonstrated that larvae fed leaves from shade grown plants that had gone to seed grew faster than larvae fed leaves from sun grown plants that had gone to seed (Grundel et al. 1998a). Lane (1999) also conducted laboratory feeding studies, using six lupine types, and found that larvae fed sun grown lupine in seed had the lowest survival rates of the lupine types tested (Lane 1999). Results from these studies are significant because during the second brood larvae feed extensively on leaves from plants that have gone to seed.

Larvae fed wilted lupine took significantly more days to pupate than larvae fed all other lupine types (Lane 1999). Grundel et al. (1998a) found that water stressed lupine was one of four types of lupine that produced slow larval growth rates. Lane (1999) also observed a lower percent survival to pupation for larvae fed wilted leaves than for three of the six other lupine types tested.

Faster growth rates are often advantageous to immature stages as they are then vulnerable to parasitism and predation for a shorter period of time. For Karner blue larvae, faster growth rates for second brood larvae may offer the additional benefit of allowing larvae to complete their development before lupine plants senesce (Grundel et al. 1998a).

During field studies, Maxwell (1998) counted a greater number of larvae on non-flowering lupine than on reproductive lupine. In addition, summer brood adult abundance was positively associated with the frequency of non-flowering lupine and negatively with the frequency and density of reproductive lupine.

The quality of lupine as a larval food plant does not appear to be affected by whether the soil is predominately sand or one with an organic O and A horizon (Grundel et al. 1998a). However, because lupine abundance and reproduction on sandy soils can be low (N.B. Pavlovic and R. Grundel unpublished data), selecting sites where soils have greater organic content will be

Lupine also reproduces vegetatively by sending up new stems from rhizomatous buds. Usually, plants a few years old will form a clump of several stems and in areas with dense lupine, it is difficult to distinguish individual lupine plants. Established lupine plants do not grow every year. It is not known how long established plants can remain dormant.

Lupine can be propagated by planting seed or transplanting seedlings. Direct

persist, and under some conditions, occasional disturbances that remove the litter layer are needed for lupine regeneration. Several disturbances have been suggested to be beneficial for renewing lupine habitat, including prescribed fire, mowing, tree removal, and a variety of methods to kill trees and shrubs such as girdling and brush-hogging (Swengel 1995, Swengel and Swengel 1996, Smallidge et al. 1996, Maxwell 1998). Frequency of management treatment to reduce woody cover is an important consideration. Smallidge et al. (1996) found that infrequent removal of woody stems often resulted in an increase in woody plant density and suggested the use of frequent mechanical treatment or a seasonally timed application of an appropriate herbicide (refer to APPENDIX G)

Other factors affecting lupine

Mechanical disturbance of the soil can affect lupine. Research at Fort McCoy has demonstrated that military training activities appear to be beneficial to the Karner blue (refer to PART I, HABITAT/ECOSYSTEM, Renewal of Habitat for the Karner blue, Other contemporary habitats).

Lupine is browsed by deer, woodchucks, and insects. The relationship between grazer density, grazing intensity, and Karner blue populations is largely unknown. If deer populations are too abundant in the spring and browse is scarce, excessive browsing could occur on lupine, with potential detrimental effects on the Karner blue (Schweitzer 1994a). Heavy spring flower browse by deer reduces the number of seedpods for that season's lupine (Straub 1994). Transplanted lupine may be less able to recover from being browsed than field sown plants (Zaremba and Pickering 1994). Herbivory by the painted lady butterfly (

especially butterflies (Chew and Robbins 1989). Although increased longevity and fecundity have not been specifically demonstrated for the Karner blue butterfly, it is generally agreed that nectar is an essential adult resource. Adult Karner blue butterflies spend considerable time nectaring on a wide variety of plant species (refer to APPENDIX C). Adults have been observed during the first brood to feed on flowers of 39 species of herbaceous plants and 9 species of woody plants, and during the second brood, on flowers of 70 species of herbaceous plants and 2 species of woody plants. Indeed, nectar plant availability may be a key factor in determining habitat suitability (Fried 1987). Lawrence and Cook (1989) suggested that the lack of nectar sources may limit populations at the Allegan SGA in Michigan, and Packer (1994) implicated the dearth of nectar sources as one of the causes of the extirpation of populations in Ontario. Bidwell (1994) found a positive correlation between nectar plant abundance, specifically abundance of *Monarda punctata* (horsemint), and the number of Karner blue butterflies. Other researchers, Herms (1996), and Richard King (USFWS, pers. comm. 1996), did not find a correlation between adult butterfly numbers and nectar plant abundance. Herms (1996) suggested that the lack of correlation between Karner blue and nectar sources could also mean that the minimal requirement for nectar was met and that nectar was not limiting during the years of study. It is generally accepted that nectar plant phenology, presence, distribution, and abundance can vary from year to year on any given site. In addition, absence of correlation might also mean that other factors, such as larval density, are more directly determining adult population numbers.

Some plant species appear to be utilized more frequently than others (Fried 1987, Bleser 1993, Leach 1993, Bidwell 1994, Lane 1994a, Lawrence 1994, Herms 1996). The nectar plant used most frequently in the field may be the one that is spatially or temporally available or most abundant, and not the species that is preferred. Observations of nectaring frequency, however, can indicate the relative utility of the species as a nectar resource. For example, Herms (1996) found that *Asclepias tuberosa* was the most frequently used summer nectar sources two years in a row, but was consistently rare on all sites. Common nectar plant species used by first and second brood Karner blues in Minnesota, Michigan and Wisconsin are summarized in Table 1. A more comprehensive list of nectar plants used by the Karner blue can be found in APPENDIX C, Table C1.

Studies by Grundel et al. (2000) at IDNL suggest that the Karner blue is opportunistic in selecting nectar plants, choosing species with the greatest total number of flowers or flowering heads. However, the studies also showed that the Karner blue preferred certain select nectar species (Table 1) and nectar plants with yellow or white flowers.

In addition to nectaring, males and females sip at moist earth (mud-puddling) and human perspiration, and males sip at animal droppings (Swengel and Swengel 1993). Adults may be obtaining sodium or other substances from this behavior.

Subhabitats

Karner blue adults and larvae use a variety of subhabitats created by variation in tree canopy cover, topography, and soil moisture, and the population dynamics of the butterfly is probably influenced by these factors. Adult butterflies use open-canopied areas for nectaring, roosting, mate location, and oviposition (Packer 1987; Lawrence and Cook 1989; Lawrence

1994; Maxwell and Givnish 1994; Lane 1994a, 1994b, 1995, 1999b; Grundel et al. 1998b). The majority of Karner blue nectar plants require medium to high levels of sun to produce

pers. comm. 2002). Lupine quality in shaded subhabitats, direct benefits from shade, and avoiding male harassment are all factors thought to contribute to the observed oviposition patterns (Grundel et al. 1998b, Lane 1999). Lupine quality influences on larval growth and survival are reviewed above in the "Lupine quality and Karner blue" section.

The direct effects of shade have been shown to contribute to higher larval survival rates

beneficial to Karner blue. A highly variable microtopography creates a highly variable thermal environment and a highly variable plant community and canopy structure. Variation in soil moisture will also contribute to variation in plant community and canopy structure. In addition, variation in plant community and canopy could be beneficial to Karner blue in the long-term. In hot dry years Karner blue can be found using shady moist subhabitats, while in cool years, they are more strongly associated with sunny and partially sunny subhabitats.

Although ants appear to be important in the life cycle of the Karner blue, it is uncertain if it is necessary to manage habitat to ensure their presence. The interaction between Karner blue and ants appears to be facultative, and the ants appear to be opportunistic in tending, so that any species that is present might tend the larvae and pupae. In contrast, the apparent variation in protection provided by different ant species could influence Karner blue abundance and population dynamics, and therefore methods to manage the habitat to encourage more beneficial ant interactions may merit consideration.

Within-Habitat Movement and Between-Site Dispersal

Dispersal has not been carefully defined in the Karner blue literature. Dispersal usually refers both to the movement of individuals within and between suitable habitat sites. Because these two types of movements have different ecological implications, they will be separated in this discussion. The movement of individuals away from their natal site of suitable habitat, leaving the site and potentially finding another site will be referred to as dispersal between sites and will include dispersal from sites. Movement that remains in a habitat site (or within the local subpopulation) will be called within-habitat movement. Because suitable habitat sites vary in size, the frequency of these types of movement will vary from site to site. Dispersal from sites may lead to recolonization events, while movement within sites can result in greater use of the site, but will not contribute to recolonization. Karner blue butterfly movements range from relatively short within habitat movements to dispersal movements between sites greater than 1000 meters (1093 yards) apart that are separated by unsuitable habitat. Refer to APPENDIX G (Table G1) for a summary of the within-habitat movement and between-site dispersal studies discussed below.

Within-habitat movement

Nearly all researchers that have examined Karner blue dispersal concluded that Karner blue movements within sites are relatively low and short with nearly all movement less than 100 to 200 meters (110 to 220 yards) (Fried 1987, Givnish et al.1988, Lawrence and Cook 1989, Sferra et al. 1993, Welch 1993, Bidwell 1994, Lawrence 1994, Fuller 1998, King 1998, Knutson et al. 1999) (refer to APPENDIX G, Table G1). Knutson et al. (1999) found that 75 percent of the movements recorded were less than 100 meters (110 yards). The mean distance moved per day ranged from 32 meters ($\pm$3 meters) (Bidwell 1994) to 191 meters ($\pm$52.5 meters) (35 to 209 yards) (Lawrence and Cook 1989). Mean distance moved per day tended to be shorter at the relatively more closed IDNL sites, ranging from 46.4 to 55.0 meters (51 to 60 yards) (Knutson et al. 1999) than in the open landscape of Necedah, where dispersal ranged from 48.2 to 173.2 meters (53 to 189 yards) (King 1998). However, the distances reported by King (1998) are averages of within habitat movements and between site dispersal. Because he recorded many longer dispersal distances, averages are expected to be lower for within habitat movement alone.

Lane (1994a) measured within-habitat flight distances by following individuals and marking all landing points. The average flight distance between points was 4.99 meters (5.5 yards) for males and 1.49 meters (1.6 yards) for females, i.e. most within-habitat flights were short distances, but adults took many small flights in a day (Lane 1994a). The total distance traveled was also calculated from flight data on individuals (time per activity, and distance, angle, and direction of

Table 2. Ant species tending Karner blue butterfly larvae and pupae.

Ant Species Tending Larvae	Locality	Reference
Aphaenogaster rudis	Ont	Packer (1991)
Brachymyrmex debilis Emery	MN, WI	Lane (1999)
Camponotus americanus Mayr	NY	Savignano (1994a)
Camponotus ferrugineus	WI	Bleser (1992)
Camponotus novaeboracensis Fitch	NY	Savignano (1994a)
Camponotus pennsylvanicus	Ont	Packer (1991)
Crematogaster ashmeadi	WI	Bleser (1992)
Crematogaster cerasi Fitch	NY	Savignano (1994 O185.6(Re5.76 610.98 48a8.9(PT03(_ST 5w

flight) (Lane 1999b). Based on the average total square displacement per minute, after five days (the average life span of Karner blues), most of the butterflies would be expected to be within a 2.5 hectares area (1 acre). Individuals engaged in certain sets of behaviors (e.g., oviposition, roosting, testing for oviposition site) may be expected to move farther and be within a 32 hectare (13 acres) circular area after five days. Grundel et al. (1998b) also observed short movement distances, particularly for females. During one minute observation periods, only 8.4 percent of females moved greater than 10 meters (11 yards). The overall picture that emerges is that within-habitat movements of the Karner blues are short and frequent.

Between-Site Dispersal

There is a fair amount of variation in dispersal tendency of Karner blues between habitat sites as demonstrated by various dispersal studies. Distances between populations that are likely to facilitate recolonization in a metapopulation most likely fall in the range of 0.5-2 kilometers (0.31-1.24 miles) and will depend on the nature of the habitat, especially canopy cover between habitat sites. For a detailed discussion of between-site dispersal refer to APPENDIX G, INCREASING THE COLONIZATION RATE OF SUBPOPULATIONS WITHIN A METAPOPULATION, Between-Site Dispersal and Table G1.

Dispersal barriers

Many factors have been suggested to be dispersal barriers for Karner blue butterflies. Anecdotal evidence has indicated that many geographic, vegetational, and human-constructed structures might act as dispersal barriers, including four-lane highways with heavy traffic in urban or semi-urban areas, steep embankments and cliffs, forested areas if no openings such as trails or roads are present, and residential and commercial areas (including paved parking lots and roads). Scientific evidence supporting any of these speculations is absent.

Dispersal corridors

Little data exists regarding dispersal corridors for Karner blues. It is widely believed that open-canopied areas through wooded landscapes provide the Karner blue with a dispersal corridor, but except for anecdotal observations, this hypothesis has remained unproven. Welch (1993) found that dispersing butterflies almost always followed canopy openings along fencerows, woodland trails, or small gaps in the canopy, stopping frequently to bask in the sun. During these between-site movements, open-canopied areas may be needed for thermoregulation (Lane 1994c), orientation (Welch 1993), or both. Based on observations of Karner blue movement patterns at IDNL (a more closed habitat area), Grundel et al. (1998b) suggest that patches of several 25 meter (27 yards) openings, positioned less than 300 meters (328) from a neighboring patch, will allow the butterfly to persist in the patch and disperse. Thus, dispersal corridors may be formed by a network of partially connected canopy gaps and trails (refer also to APPENDIX G**,** INCREASING THE COLONIZATION RATE OF SUBPOPULTAIONS WITHIN A METAPOPULATION, Facilitating Directed Dispersal Using Corridors, Corridors and Living Corridors).

a generally accepted classification system, in this document "oak and pine barrens and savanna"

populated habitats in Wisconsin and sparsely populated sites in Minnesota. In Wisconsin sites, habitat patches are essentially contiguous, whereas in Minnesota habitat is separated into many patches, often separated by more than 100 meters (110 yards) of dense oak woodland (Lane 1999).

Other contemporary habitats

Karner blues also occur in many other habitats managed for various purposes. These

management practice that correlated well with abundance of Karner blue or vegetation patterns (Smallidge et al. 1996, Swengel 1998, King 2000), which suggests that many management factors could be beneficial to the butterfly.

Remnant native habitats

The native barrens and savanna ecosystem and its unique combination of species developed from the interplay of natural disturbance processes, edaphic factors, climate, etc. (Forman 1979, Tester 1989, Faber-Langendoen 1991). Fire is recognized as the key element maintaining savanna vegetational structure and species composition (Tester 1989, Haney and Apfelbaum 1990, Faber-Langendoen 1991, Wovcha et al. 1995). Fire influences ecosystem dynamics by decreasing soil nitrogen and organic matter and raising pH (Tester 1989). It exposes mineral soils and reduces woody plant cover, conditions required by many savanna adapted species (Payne and Bryant 1994), and clears the understory but does not eliminate the adapted tree species. These trees survive by resisting fire with thick barks, by resprouting, or by germinating seeds after disturbance by fire. These setbacks of the woody vegetation maintain a mixture of open- to densely-canopied patches of habitat (Nuzzo 1986, Shuey undated). Fire suppression in recent history has resulted in succession of these barrens and savannas to woodlands.

Mammalian grazing, burrowing, trampling, etc., are considered by some to be a critical element in maintaining the oak savanna ecosystem (Hobbs and Huenneke 1992, Swengel 1994). Elk (*Cervus elapus*) and bison (*Bison bison*) are likely to have once grazed and browsed in Minnesota and Wisconsin (Hamilton and Whitaker 1979, Jackson 1961). During spring, elk feed extensively on grasses, sedges, and weeds. During summer, grasses, shrubs, and trees are eaten,

scientific information for using silvicultural practices to enhance Karner blue butterfly, management planning should take an adaptive management approach.

Because silvicultural practices are implemented to achieve multiple management goals, there will be inevitable tradeoffs between achieving the various goals. For example, at a particular site, a manager may desire maximum immediate financial returns, minimal risk on investment, maximum sustained yields, optimal wildlife game animal production, and increased Karner blue butterfly populations. In most cases, it will not be possible to optimize simultaneously all economic and wildlife goals. Instead, it will be necessary to understand which silvicultural practices are compatible with each of these many possible goals and which practices create trade-offs among them. For some managers, such compatible practices may be those that, for example, enable sufficient financial return while supporting sufficient butterflies. Forest management activities vary considerably, and a better understanding of the complexities of management and their consequences for the Karner blue butterfly in the working landscapes is needed.

Silvicultural practices continually evolve as demand and technology changes. For example, because red pine fiber is now preferred to jack pine fiber in pulp processing, there has been a shift to replacing jack pine plantations with red pine plantations in many commercial forests. The effect of this shift on the Karner blue is not known, but because red pine has a denser canopy at similar stand densities and is grown on a longer rotation than jack pine, this shift may result in declines of the butterfly over the long term.

The monitoring program of the Wisconsin Statewide HCP in Wisconsin is providing insight into the effects of siliviculture on the Karner blue. Information from Plum Creek Timber Company (Lorin Hicks, in litt. 2002) notes that 54 percent of their young red pine plantations had lupine present, and 25 percent of the stands with lupine supported Karner blues. Their data also shows that prior to harvest, 28 percent of mixed oak/jack pine stands had lupine present prior with 25 percent of the stands supporting Karner blues. This information supports the existence of Karner blue on young red pine stands and to a lesser extent in older mixed stands; however, it will be important to learn how Karner blues persist on forest lands dominated by red pine stands as the stands age and whether lupine and nectar plants would regenerate after harvest of mature stands [refer to Recovery Task 5.25 (d)]. Measures should be considered on forest lands that maintain early successional habitat, dispersal corridors, and forest openings; these measures include less dense plantings and creation of wider roads, trails, and landing sites that

over the next century or more is expected to perpetuate Karner blue habitats in Wisconsin, much as it has in the past (Darrell Bazzell, in litt. 2002). The HCP monitoring data is and will continue to be valuable in furthering our understanding of the ability of forest lands to support viable populations of Karner blues [refer to PART II, RECOVERY TASKS, Task 5.25(e)]

Understory legumes, such as lupine, can raise soil nitrogen levels, improve rates of mineral cycling, reduce surface runoff and soil erosion, and may improve soil organic matter content, soil structure, and cation exchange capacity, and inhibit soil-borne pathogens (Turvey and Smethurst 1983, Smethurst et al. 1986). Many of these effects could benefit forestry production. Although a potential cost might be competition between lupine and the establishing of trees, in many situations it may aid production goals to encourage the growth of existing lupine and associated Karner blue butterflies, as long as it is not necessary to plant lupine.

Military training appears beneficial to the Karner blue when managed appropriately. The Fort McCoy Military Reservation contains some of the largest populations of Karner blues in Wisconsin (Leach 1993, Bleser 1994), with over 93 percent of the lupine patches occupied by the butterfly **(**Wilder 1998). It appears that military training activities, particularly inadvertent fires caused by artillery and mechanical disturbance by tracked vehicles, have created a mosaic of successional states similar to those in native habitats. Several studies have examined the effects of tank traffic on Karner blue butterflies and/or their habitat (Bidwell 1994, Maxwell and Givnish 1996, Maxwell 1998, Smith et al. 2002). Comparative studies relating the intensity of training activities to the density of butterflies suggest that these activities have been beneficial to the Karner blue (Bidwell 1994, Smith et al. 2002). Maxwell and Givnish (1996) and Smith et al. (2002) evaluated the effect of tank traffic on plots of established lupine at Fort McCoy, Wisconsin. In both cases greater lupine abundance was associated with areas where track vehicles had traveled as compared with areas where no tracked vehicles had traveled. Maxwell and Givnish (1996) suggested that this kind of traffic causes greater soil disturbance than ORV traffic, and could be comparable to some of the traffic during site preparation and harvest of commercial forest stands. They found that tank traffic crushed emerging lupine plants. Yet, within several weeks, seedling germination was observed on the disturbed soil, and the crushed plants re-grew with a three-week delay in developmental phenology. In the following year, plants on the disturbed areas developed about two weeks faster than the surrounding plants. Smith et al. (2002**)** measured the greatest lupine abundance in the median strip between vehicle ruts, although lupine regrowth was observed in the ruts and on eroded margins of the tracked vehicle trails. Maxwell and Givnish (1996) concluded that mechanical disturbance could create greater heterogeneity in lupine development. However**,** Smith et al. (2002) cautioned that repeated disturbance by tracked vehicles might have a negative effect on lupine because of repeated disturbance/damage to lupine roots and/or repeated duff removal.

Areas disturbed by tracked vehicles also had higher nectar plant abundance and lower shrub cover as compared with areas unaffected by tracked vehicles (Smith et al. 2002). However, because of experimental design constraints, it was not possible to determine if tracked vehicle traffic contributed to the reduction of shrub cover or if areas with low shrub cover were preferentially selected as easy routes.

Historical disturbances were also responsible for the pattern and abundance of Karner blue habitat at Fort McCoy (Bidwell 1995, Maxwell 1998). Maxwell (1998) found lupine frequency to be significantly higher in areas of military disturbance. Military caused fire may be one of the primary factors influencing Karner blue habitat and abundance at Fort McCoy (Smith et al. 2002). Some of the largest lupine patches occur in the ordnance impact area, a portion of which is burned each year by military activities.

Although Maxwell's (1998) study plots were monitored to assess the effects of prescribed burns, they were often subjected to light military traffic with untracked vehicles which resulted in an immediate flush of new seedlings in closed canopied plots. Her research indicates that the efforts to regenerate lupine in late successional sites may benefit from disturbance to soils to reactivate the seed bank.

Maintenance of suitable Karner blue butterfly habitat on rights-of-way and near airport runways in New York has been studied by Smallidge et al. (1996). The effects of eight management methods and two management modes (broadcast or selective mechanical and/or herbicide treatments) on Karner blue abundance and several habitat characteristics were examined. No clear pattern was detected between management scheme and vegetation patterns. However, both Karner blue and lupine abundance were greater at sites that had been more recently managed. Broad-scale applications of broad-spectrum herbicides can be detrimental to existing lupine in these habitats, but could be beneficial if they suppress lupine competitors and enable lupine to establish. Smallidge et al. (1996) suggest that frequent mechanical treatments or applications of herbicides (using the appropriate type, methods and timing) will be effective in maintaining suitable Karner blue habitat**.** Disturbance activities related to building, mowing, and grading activities in rights-of-way possibly can have beneficial effects on lupine and butterflies, but the magnitude and direction of the effects may depend on the scale and timing of the activity. Refer to APPENDIX G, REDUCING LOCAL EXTIRPATION RATES, Improving and Maintaining Karner Blue Habitat). Much work has been done by utility companies and highway departments (partners to the HCP) in Wisconsin to alter the timing of mowing in order to minimize the take of the butterfly, while still promoting habitat conditions that favor the butterfly (Darrell Bazzell, in litt. 2002)

Prescribed fire

Fire has been widely regarded as an effective means of maintaining an early successional habitat suitable for growth of lupine in native barrens/savanna ecosystems (Payne and Bryant 1994). Fire influences savanna/barrens structure and composition in many ways including reducing woody plant cover, increasing the abundance of some species while decreasing the abundance of others, and exposing mineral soil. Fire also volatilizes nitrogen (returning it to the atmosphere) while leaving much phosphorus behind in ash; together with opening the canopy, these two processes should strongly favor plants associated with nitrogen fixing bacteria, such as lupine.

When using fire as a management tool, it is important to recognize the balance between Karner blue (and other insect) mortality in the short term, and improvement in the quality of their savanna/barren habitats in the long term (Givnish et al. 1988, Andow et al. 1994, Maxwell and Givnish 1996, Swengel and Swengel 1997, Schultz and Crone 1998). In addition, the use of

prescribed burn for habitat restoration will require different considerations than when fire is used for habitat maintenance. Some of the key factors to consider in developing habitat restoration and maintenance plans that include prescribed fire as a tool are: 1) site history and current condition, 2) amount of direct Karner blue mortality likely to occur during the fire, 3) potential for Karner blues to reoccupy the site, 4) characteristics of prescribed fire, 5) response of lupine and nectar plants to fire, and 6) other habitat responses. Because each recovery unit presents a unique combination of many of these key factors, it is important to develop site specific fire management plans for each Karner blue population. Refer to Appendix G for a review of each of

significant role in the conservation of the butterfly. Overall, the partners have committed to implementation of the HCP's conservation program on about 252,299 acres of land in Wisconsin (WDNR 2000, WDNR 2002a).

Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

As noted above, the most significant threat to the Karner blue range wide is habitat loss, alteration, and destruction. Habitat loss has resulted in a reduction in the number of Karner blue subpopulations, habitat fragmentation, and smaller-sized occupied sites. Habitat alteration has reduced the abundance and quality of the Karner blue's food resources (lupine and nectar plants) and subhabitat diversity. Non-management of habitat has resulted in habitat loss over time due to ecological succession. Loss to commercial, industrial, and residential development is more a threat in areas where Karner blue populations are in close proximity to cities or desirable recreational lands (e.g. West Gary, Indiana, the Glacial Lake Albany Recovery Unit in NY, and Concord, New Hampshire, and the Morainal Sands Recovery Unit in Wisconsin).

Loss and alteration of native habitat

The major threat to native habitats is conversion to alternate uses, such as agriculture, forestry, industrial, residential and commercial development, and road construction. Originally, barrens and savanna were widespread in the central United States but rare in the eastern United States. In both regions, there has been a precipitous decline in these habitats. Remaining barrens

Global warming is expected to reduce agriculture on these more arid soils over the next century (Darrell Bazzell, in litt. 2002).

Some silvicultural habitats that are suitable for Karner blues are being converted to residential and commercial uses, and others to intensive forestry practices that may affect the ability of these lands to support Karner blues. Conversion of former jack pine plantations to red pine could result in a loss of Karner blue habitat because red pine canopy is thicker and closes more rapidly. In addition, it is questionable whether lupine will regenerate after harvest of mature stands, but this requires confirmation (refer to PART I, HABITAT/ECOSYSTEM, Renewal of Habitat for Karner Blue, Other contemporary habitats).

Silvicultural habitats that are suitable Karner blue habitats degrade as the trees mature and the canopy closes. This is a natural part of the production cycle, and as long as other silvicultural habitat is opened up within dispersal distances of extant Karner blue butterfly subpopulations, such as by harvesting (creating a shifting mosaic of habitat), a metapopulation

trade-off with its detrimental effect on the butterflies to be acceptable. Incompatible management practices can occur as described below:

1. Pesticide Use

Poorly timed or poorly located use of herbicides can have a negative effect on Karner blue butterflies, by killing or suppressing lupine or important nectar plants. Application of herbicides in Karner blue butterfly occupied areas is best done after lupine and nectar plants senesce.

3. Prescribed fire

Fire is being used as a management and restoration tool (sometimes in conjunction with mechanical management) on several Karner blue sites e.g., the Albany Pine Bush Preserve (Albany, New York), Necedah NWR (Wisconsin), and at several Wisconsin DNR properties with positive effects for the Karner blue. Fifty years of fire and mechanical management on

stages is very high (Savignano 1990, Lane 1994b). Part of this mortality is caused by predators, parasitoids, or pathogens (Savignano 1990). Larval predators include pentatomid stink bugs (*Podisus maculiventris*), wasps (*Polistes fuscatus* and *P. metricus*), ants (*Formica schaufussi* and *F. incerta*) (Savignano 1990, 1994a), spiders (Packer 1987), and ladybird beetles (*Coccinella septempunctata*) (Schellhorn et al. unpublished data). Four larval parasitoids have been reared from field collected larvae: a tachinid fly (*Aplomya theclarum*), a braconid wasp (*Apanteles* sp.), and two ichneumonid wasps (*Neotypus nobilitator nobilitator* and *Paranoia geniculate*) (Savignano 1990). Several insect predators have been observed attacking adults, including spiders, robber flies, ambush bugs, assassin bugs, and dragonflies (Packer 1987, Bleser 1993). Disease pathogens of the Karner blue butterfly have not been identified, but probably exist.

It is unknown whether birds or mammals cause significant mortality at any life stage of the Karner blue. Bird beak-marks are occasionally observed on adult wings. Direct mortality to Karner blue larvae by deer browse can have a detrimental effect on the butterfly (Schweitzer 1994a).

Plant diseases of lupine could reduce its food quality or render it unsuitable, resulting in larvae mortality or reduced adult fecundity. Lupine leaves are attacked by both powdery mildew (*Erysiphe polygoni*) and a leaf rust (*Puccinia andropogonis*). Research on the effect of powdery mildew on Karner blue butterfly host plant quality is inconclusive. Maxwell (1998) found lower densities of larvae in areas where the proportion of lupine with mildew was the greatest. However, Grundel et al. (1998a) fed mildew infected leaves to larvae in laboratory feeding studies and measured more rapid larval development on post-flowering mildewed leaves than on comparable uninfected lupine.

Of particular interest is how fragmentation and degradation of habitat influences the population dynamics of natural enemies and competitors of the Karner blue butterfly and lupine,

Other Natural or Man-made Factors Affecting Its Continued Existence

Stochastic events, such as unusual weather, can detrimentally affect Karner blue populations. Spring and summer drought can stress lupine and may reduce larval populations, and reduce flowering of nectar plants (Cynthia Lane, pers. comm. 1996) which may result in greater adult mortality. Cool springs can delay lupine emergence until after egg hatch (Lane, unpublished data). Cold, wet weather during the flight periods reduces the time available for oviposition and could increase adult mortality. A combination of summer drought and cool, wet springs is one of the suspected causes of population extirpation in Ontario (Packer 1994, Schweitzer 1994b) although habitat damage also contributed to extirpation. In particular home building in some key lupine areas at the Port Franks Estate site and logging at the Port Franks Bowl site were detrimental. The greatest impact of the logging was thought to be the removal of one large shade tree in the center of the most suitable habitat area at the Port Franks Bowl site. The reduction in shade increased light levels which may have made the site more susceptible to drought (Packer 1994).

Heavy browse by mammals (e.g., deer, rabbit, woodchuck), or insect herbivores on lupine in Karner blue areas can also have a detrimental effect. Larvae may starve if lupine is severely defoliated. Browse or herbivory on the flowers or fruits can reduce lupine seed and possibly affect the long-term survival of the lupine population (Straub 1994). Insect herbivores, such as painted lady larvae *(Vanessa cardui)* and blister beetles, can defoliate high percentages of the lupine in an area, which may result in larval starvation.

Large-scale wildfire could destroy a large metapopulation. These events are infrequent, but potentially devastating. Although these rare events would have large detrimental effects that last for several years, it is possible that the metapopulation could recover if enough healthy unburned populations existed nearby or if the fire left patches of unburned refuge areas.

Aggressive exotic (non-native) plant species may pose a threat by out-competing other plant species required by the Karner blue butterfly. Orange hawkweed (*Hieracium*

CONSERVATION MEASURES

Many conservation efforts have been initiated to conserve and recover the Karner blue butterfly and its habitat. These activities are briefly summarized here; some are discussed in more detail in PART II, RECOVERY TASKS, and/or in APPENDICES A and B.

Federal Regulatory Protection

"Take"

Section 9 of the Endangered Species Act as amended in 1973 (Act) prohibits any person subject to the jurisdiction of the United States from "taking" federally listed threatened and endangered species. "Take" is defined as harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting these species. It is also unlawful to attempt such acts, solicit another to commit such acts, or cause such acts to be committed. Regulations implementing the Act (50 CFR 17.3) further define harm to include significant habitat modification or degradation that results in the killing or injury of wildlife by significantly impairing essential behavioral patterns such as breeding, feeding, or sheltering. "Harass" means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to breeding, feeding, or sheltering.

Federal permits

Section 10 of the Act provides for the issuance of two types of permits that may be granted to authorize activities prohibited under Section 9:

- Section 10(a)(1)(A): permits for scientific purposes or to enhance the propagation or survival of a listed species (also called recovery permits);

- Section 10(a)(1)(B): permits for "take" that is "incidental to, and not the purpose of, carrying out an otherwise lawful activity."

Several section 10(a)(1)(A) permits have been issued for Karner blue butterfly research and management activities, including research on the butterfly's habitat preferences, its response to various barrens management activities such as mowing and burning, and its response to various forestry practices. Other studies have focused on the effect of herbicides on lupine, nectar plants, and Karner blue butterfly eggs; the effect of *Bacillus thuringiensis kurstaki* (*Btk*, an insecticide used in gypsy moth suppression) on Karner blue larvae, and on butterfly dispersal in forested and open landscapes. Permits have also been issued to study the genetic composition of Karner blue butterfly populations across its range, and for reintroduction efforts in Ohio, Indiana and New Hampshire.

Results of many research efforts have contributed to the conservation and recovery of the Karner blue. Results from the research work demonstrating that *Btk* results in Karner blue larvae mortality has, and continues to be used, in the Service's consultation work with the U.S. Forest

Service's gypsy moth spraying programs in Michigan and Wisconsin. As a result of this research, spray programs have been designed to minimize harm to the Karner blue butterfly. Habitat related work by several researchers has demonstrated the importance of maintaining heterogeneity of habitats (open and closed) to further the recovery of the species; of special note has been the increased understanding of the value of shady forested areas as oviposition sites for the Karner blue, leading to the Service's recommendations in this plan (refer to APPENDIX G), as well as other recovery and conservation related plans, for the establishment of habitat heterogeneity in restoration and enhancement projects. Dispersal research at Necedah National Wildlife Refuge (NWR) has been instrumental in the design of their fire management program. Overall research related to the dispersal abilities of the Karner blue has increased our understanding of this aspect of the butterfly's behavior and is reflected in the recovery goals and management recommendations in this plan.

A Safe Harbor Policy has been established by the Service and the National Marine Fisheries Service (NMFS) (USFWS and NMFS 1999). This policy encourages private landowners to voluntarily conserve threatened and endangered species. Under a Safe Harbor Agreement, a private landowner would agree to create, restore or maintain habitats, and/or manage their lands so that listed species will benefit. In return, the Service provides assurances that future landowner activities will not be subject to restriction from the Act above those applicable to the property at the time of enrollment in the agreement. The Service issues section

Section 7 consultation

Section 7(a)(2) of the Act requires Federal agencies, in consultations with the Service to insure that any actions authorized, funded, or carried out by such agencies, are not likely to jeopardize the continued existence of endangered or threatened species. Section 7(a)(1) also requires that these agencies use their authorities to further the conservation of federally-listed species. Section 7 obligations relative to the Karner blue have resulted in several informal and formal consultations for projects such as road construction (Federal Highway Administration), recreational development (U.S. Army Corps of Engineers), solid waste landfill approvals (U.S. Environmental Protection Agency), management activities (National Park Service, U.S. Fish and Wildlife Service), military activities (Fort McCoy and Hardwood Range), and gypsy moth suppression programs (U.S. Forest Service).

Some Federal land managers such as the Department of Defense (Fort McCoy), U.S. Forest Service (Huron-Manistee National Forest [NF]), and Necedah National Wildlife Refuge (NWR) are conducting research activities and participating in conservation efforts that go beyond those required to avoid take. The National Biological Service (now the U.S. Geological Survey) has provided funding to assist with several of the research and management efforts underway for development of the Wisconsin Statewide HCP for Karner blue; these efforts will likely also contribute to the recovery of Karner blue.

Memorandum of Understanding

In September 1994, fourteen Federal agencies, including the Service, National Park Service, US Army Corps of Engineers, Federal Highway Administration, and Department of Defense signed a Memorandum of Understanding (MOU) affirming their commitments to carry out programs for the conservation of federally listed species and the ecosystems on which they depend, including cooperation in the implementation of recovery plans.

State Protection

The Karner blue butterfly is state listed as endangered in Minnesota, New York, New Hampshire, Indiana, and Ohio. In Michigan, it is listed as threatened, and in Wisconsin as a species of special concern. In Indiana, the Karner blue butterfly is listed as endangered, and is protected on state-designated nature preserves. On March 2, 1999, the State of Indiana passed a resolution urging the Indiana DNR to monitor the status of the Karner blue and to do everything it could to keep the species alive and thriving within the state. Except for Indiana, all of the states' endangered species laws and regulations prohibit take of state-listed species for various purposes. It is not listed in Illinois because it has been extirpated from the state. Although the Karner blue is not state-listed in Wisconsin, the Wisconsin DNR has a cooperative agreement with the Service committing the state to furthering the conservation and recovery of federally listed species including the Karner blue butterfly.

Other state and local regulations have also protected Karner blue butterfly and its habitat. At the Crossgates Mall in Albany, New York, protection of Karner blue habitat resulted from the need for two permits: a wetland permit required by Articles 24 and 25 of the state's Environmental Conservation Law, and a water discharge permit regulated by the state's Pollution

Discharge Elimination System program. In another case, mitigation for not meeting the City of Albany's green space requirements resulted in barrens restoration adjacent to an existing Karner blue site. In Minnesota, access and hunting activities in at least one Karner blue area at the Whitewater WMA have been limited by the regulations pertaining to use of state wildlife management areas.

Other Related Recovery Plans

Midwest Oak Ecosystem Recovery Plan

This plan by Leach and Ross (1995) supports the restoration of oak savanna habitats (for Karner blue as well as many associated species). This plan promotes current and future efforts to restore oak savannas in the Midwest and suggests certain goals, strategies, and possible actions that will move recovery efforts forward. The plan notes that only about 0.02 percent of the presettlement high quality savannas remain. Some of the recovery work associated with Karner blue will involve restoration of these rare habitats.

Ontario, Canada Recovery Plan and recovery efforts

Extirpation of the Karner blue in Ontario has been attributed to a number of interacting factors including canopy closure and alteration of habitat by pine plantations, disruption of natural fire regimes, habitat loss and fragmentation due to human incursion and three consecutive years of drought (1987-89). Oak savanna habitat is the most endangered habitat type in Canada and current recovery efforts are aimed both at habitat restoration and at reintroduction of Karner blue.

Only two of the several historic sites in southern Ontario have been occupied by the Karner blue in recent years. The first site is in Lambton County (Lambton Site) on the southeastern shore of Lake Huron and is composed of two areas: 1) Pinery Provincial Park (Park) near Goderich, and 2) a nearby Karner blue sanctuary (Sanctuary) operated by Lambton Wildlife Inc. The second site is the Manestar Tract of the St. Williams Crown Forest about mid-way along the north shore of Lake Erie, near Long Point. The last adults were seen at the Sanctuary in 1990 and at the Manestar Tract in 1991.

Biological inventories of the Lambton sites and Manestar Tract are ongoing. Recovery efforts include monitoring populations of other insects to identify species at risk, active habitat restoration including small-scale burns, brushing, manual cutting and clearing, seeding, habitat protection via fencing, signage, public education, and creation of corridors between prospective subpopulation sites. One problem at the Park has been the removal of the herb layer by the overly large deer population thus depleting the seed bank. Deer culls have occurred in several recent years, and an annual deer count has been implemented. The reduced deer impact has been obvious with the shrub layer responding and forbs flowering and seeding again.

A recovery plan for the Karner blue butterfly in the province of Ontario has been developed (Schweitzer 1993), an Ontario Karner Blue Recovery Team has been formed, and a Recovery Document is being rewritten to adhere to the Recovery of Nationally Endangered Wildlife (RENEW) guidelines (a Federal program to recover species at risk). A strategy for the

recovery of the Karner blue butterfly in Ontario has been developed (Previtt 1994). That strategy entails habitat restoration work at both of the sites noted above and the captive rearing of Karner blues for reintroduction in the future. The Metro Toronto Zoo has been working on captive rearing protocols and will oversee the rearing and release of butterflies. Metro Zoo and York University have been doing micro-habitat analysis, which will help identify suitable release sites and donor sites. It is likely that the first release of Karner blues will be at the Lambton site followed by the St. Williams site. A Service export permit and Canadian import permit will be necessary to allow transfer of the Karner blues from the U.S. to Ontario.

U.S. efforts to recover the Karner blue are being shared with members of the Ontario Recovery Team to help promote recovery of the butterfly in Ontario consistent with the framework for cooperation established between the U.S. Department of Interior and Environment Canada as described in "Conserving Borderline Species" (Ministry of Public Works and Government Services Canada and U.S. Department of the Interior, Fish and Wildlife Service 2001).

Reintroduction/Translocation

Four translocation efforts are ongoing. Three of them are reintroductions, one each in Ohio, New Hampshire, and Indiana, and one is an accelerated colonization project in Minnesota. Along with reintroducing Karner blues, each project also includes habitat restoration and management activities.

The Ohio reintroduction effort is in its fifth year with the goal of restoring a viable population of Karner blues to the oak openings of northwest Ohio. The first butterflies from this program were released at TNC's Kitty Todd Nature Preserve in the summer of 1998. The butterflies were raised at the Toledo Zoo in Toledo, Ohio, with the donor population coming from Michigan. The reintroduction is part of an overall conservation plan for the butterfly developed by the Ohio Karner Blue Butterfly Recovery Team (Ohio DNR 1998). The five-year effort has resulted in the restoration of the Karner blue to Ohio and the development of successful captive propagation techniques (Toledo Zoo, 2002) (refer to APPENDIX I, CAPTIVE REARING AND CAPTIVE PROPAGATION). During 2002, the Karner blue butterfly was present at three sites within the Kitty Todd Nature Preserve with 212 butterflies recorded at one site (Peter Tolson, Toledo Zoo, pers. comm. 2002). Monitoring the Karner blue population at the Kitty Todd Nature Preserve remains important in tracking the success of the reintroduction effort and determining whether additional work will be needed to establish a viable butterfly population.

The reintroduction program in Concord, New Hampshire began in 2000, the year the native population went extinct (Amaral 2000). The goal of the program is to restore a viable population of Karner blues to the Concord pine barrens. Initial efforts by the New Hampshire Fish and Game Department (F&G Department) to captive rear Karner blues from the few remaining eggs from New Hampshire butterflies failed as none of the eggs hatched. Because the taxonomic work (microsatellite and mtDNA data) from Nice et. al. (2000) indicated that the Concord, New Hampshire, Karner blue population was closely related to the Saratoga, New York, population, butterflies from the Saratoga Airport are being use in the reintroduction project. Donor Karner blue eggs from the Saratoga Airport were captive reared in 2001 and

2002, with 23 and 70 Karner blues (respectively) released at the Concord Municipal Airport (Steve Fuller, pers. comm. 2002). The Federal Aviation Administration (FAA) is assisting with the project, as a result of their section 7 consultation with the Service on the construction of military facilities at the Concord Airport.

A reintroduction program began in West Gary, Indiana, in 2000 as well, shortly after the last Karner blues were recorded from that area. TNC is using donor Karner blue females obtained from the IDNL to captively rear butterflies. In 2001 and 2002, 250 and 850 Karner blue pupae (respectively) were transferred to one TNC property in West Gary. The pupae were placed in protective nets from which the adults emerged. The goal of the project is to restore a viable Karner blue population to the dune and swale system of West Gary. Karner blues were found at a second site in West Gary in 2002 which likely resulted from a single adult reared in 2001 dispersing about 0.7 miles to that site (Paul Labus, TNC, pers. comm. 2002; TNC 2002). The reintroduction effort appears successful thus far and will be monitored to determine whether future captive rearing efforts are needed. For further information on this reintroduction project refer to the following web site: http://nature.org/wherewework/northamerica/states/indiana/.

A translocation project to accelerate Karner blue colonization of restored habitat was started at Whitewater WMA in southeastern Minnesota in 1999 (Lane 1999a). Female Karner blues from the WMA were used to captive rear butterflies that were released in 1999, 2001, and 2002 to Lupine Valley. During 2001, Karner blues were seen during first flight in Lupine Valley, indicating some success of the translocation effort.

Future reintroductions or translocation projects are being planned or considered at TNC's Quincy Bluff and Wetland Preserve (Glacial Lake Wisconsin RU), Illinois State Beach Park (Kenosha Potential RU), in western New York (Tonawanda Potential RU); in the east management unit of IDNL (Indiana Dunes RU), and in Ontario, Canada.

Recovery tasks include the need to continue to refine protocols and guidelines for reintroductions/translocations; to continue the reintroduction efforts at Concord, New Hampshire, West Gary, Indiana, and Toledo, Ohio; and the accelerated colonization work in Minnesota (refer to PART II, RECOVERY TASKS). APPENDIX I contains translocation guidelines for the Karner blue butterfly; these guidelines can be used to assist managers in deciding when and how translocation could be used to enhance management and recovery efforts. Schweitzer (1994a) also provides guidelines relative to translocation and reintroduction of the Karner blue.

Captive rearing

Research and management of Karner blues has entailed captive rearing in some situations. Captive rearing protocols developed by Lane and Welch (1994) and by VanLuven (1994a) have been used successfully to raise hundreds of larvae for research purposes and/or for population supplementation. TNC in New Hampshire uses VanLuven's protocol to overwinter second brood eggs from the Concord, New Hampshire site. An overwintering protocol for Karner blue eggs has also been developed by Curt Meehl and Cynthia Lane (Lane, unpublished data) in Wisconsin. Herms (1996) utilized captive rearing in her studies of the effect of the insecticide *Btk* on Karner blue. Captive rearing can be used as a tool in reintroduction strategies,

and many of the components for a successful captive propagation effort have been developed (Toledo Zoo, 2000). The Metro Toronto Zoo (Zoo) has captive-reared eastern tailed blues (*Everes comyntas*), as a model for captive propagation of the Karner blue for reintroduction purposes in Ontario. While they have successfully reared larvae, they have yet to determine how to overwinter and to mass produce butterflies.

Role of Federal Lands and Programs in Recovery Efforts

Protection of the Karner blue butterfly on Federal lands is important because of the direct benefits gained for the butterfly and other rare species associated with barrens habitat and because these recovery programs serve as examples to non-Federal partners. Federal agencies are also conducting several research projects that will contribute to understanding the impact of management activities on the Karner blue. The following Federal agencies are involved (or are anticipated to be involved) in the recovery of the Karner blue butterfly at six locations, contributing to the recovery of 12 of the metapopulations needed for delisting:

- Department of Defense: Fort McCoy and Hardwood Range, WI,
- Federal Aviation Administration: Concord, NH
- National Park Service: Indiana Dunes National Lakeshore, IN,
- U.S. Fish and Wildlife Service:
  Great Bay NWR, NH *Necedah NWR, WI*
  Meadow Valley State WA (which is part of Necedah Wildlife Management Area), and the
- U.S. Forest Service: Huron-Manistee National Forest, MI.

Table B1 (APPENDIX B) identifies Federal lands as well as other lands where recovery of Karner blue butterfly metapopulations is possible.

Private Land Initiatives

The efforts of private landowners in helping to conserve and protect the Karner blue butterfly will be important to achieving recovery goals throughout the range of the Karner blue, and especially in the more fragmented portions of the range (New York, New Hampshire, and Indiana). A brief review of some private landowner efforts in the various states are noted below.

In Wisconsin, as of July 1998, 22 private landowners have signed voluntary conservation agreements with the Wisconsin Department of Natural Resources for the conservation of Karner blues on their lands (Darcy Kind, WDNR, pers. comm. 2002). These landowners are agreeing not to adversely impact the butterfly or its habitat on their property. Some of these landowners are taking very proactive measures to assist restoration of populations including the planting of lupine and nectar plants, and the expansion of savanna/barrens habitat. In addition, the Wisconsin Department of Agriculture, Trade and Protection (DATCP) is working with private property owners on protection of Karner blue butterfly habitat from pesticide uses.

TNC's registry site program in Indiana maintains a record of those landowners who own significant parcels of land (including known and high potential Karner blue sites) and informs the landowners of their ecological significance. Registry landowners are encouraged to manage

RECOVERY STRATEGY

The goal of this recovery plan is to perpetuate viable metapopulations of the Karner blue butterfly in the major ecological regions throughout its geographic range. This will be

A viable metapopulation of Karner blue butterflies must be large enough, and be managed and monitored to persist indefinitely over time. The management and monitoring system must buffer the metapopulation against adverse disturbances and threats to survival, maintain suitable habitat over time in an appropriate spatial structure, and identify appropriate responses to potential declines in the metapopulation. Adaptive management for improving or maintaining Karner blue metapopulations is essential. Several adaptive strategies can be pursued, including adapting management to change the structure of the metapopulation, changing the geographic base of the metapopulation over time, and reducing monitoring as the duration of successful management increases. In addition, this definition should discourage a minimalist perspective; if the metapopulation can be made larger and more secure, management and monitoring costs can be reduced.

The recovery strategy relies in part on Federal lands (refer to PART I**,** CONSERVATION MEASURES, Role of Federal Lands and Programs in Recovery Efforts). Federal efforts are focused on ecosystem recovery, restoration of native habitats, and incorporation of butterfly conservation measures into existing activities such as forestry and military activities. State efforts on state owned or managed lands are also anticipated to contribute to recovery. Contact needs to be made with other private entities (e.g., counties, municipalities, private landowners, etc.) to explore collaborative efforts for the conservation and recovery of the butterfly (refer to Table B1, APPENDIX B). Native habitat restoration is encouraged on all lands where recovery of the Karner blue will occur, but it is recognized that public landowners may have competing goals. Working with private landowners is anticipated to be needed to achieve, or enhance recovery in nearly all RUs. Because some private landowners may not wish to participate in recovery efforts, or will have competing management goals, it will be necessary to explore collaborative efforts that factor in private landowner concerns. Recovery must maintain flexibility with respect to these concerns. Approaches that start with a recovery plan and proceed to recruit willing partners may not always be effective. An alternative is to start recovery by assessing interest and willingness, creating incentives to increase participation, and developing a specific recovery plan for a viable population around these willing participants.

Priority 1 recovery activities are those necessary to prevent the extinction or irreversible decline of Karner blue butterflies in a RU. Priority 1 activities have been identified in the Merrimack/Nashua River System (New Hampshire), Glacial Lake Albany (New York), Ionia, Newago, and Paleozoic Plateau (Michigan), the Indiana Dunes (Indiana), and Paleozoic Plateau (Minnesota) RUs. In the Merrimack/Nashua River System RU in Concord, New Hampshire, it is essential to improve habitat and continue the reintroduction effort on lands with cooperative management agreements. Tree canopy cover should be decreased and lupine established at all sites, and nectar plants must be increased at the Main Site. Monitoring of the population is important to analyze the success of the recovery effort. In the Glacial Lake Albany RU in New York, populations have declined precipitously because habitat has been converted to incompatible uses and degraded by canopy closure from unchecked growth of brush. At all sites, it is necessary to protect the existing suitable and restorable habitat so that it is possible for the butterfly to recover. In addition, it is necessary to stop and reverse succession on these lands and develop and implement plans and activities that will lead to the establishment of viable populations. In the Ionia RU in Michigan, the only populations are associated with the Flat

contact appropriate parties and seek their participation in cooperative efforts to prevent the potential extirpation of the butterfly. In the Newago RU in Michigan, only a portion of the area of potential habitat has been surveyed, and the emphasis is on surveys to enable effective recovery planning. This RU has a complex mixture of land ownership and until the area has been adequately surveyed it will be difficult to prevent an irreversible decline caused by conversion of habitat to incompatible uses. In the Paleozoic Plateau RU in Minnesota, much of the habitat near the small population has degraded from canopy closure, and there is considerable unoccupied, apparently suitable habitat in adjacent valleys. To prevent extirpation, it is essential to expand suitable habitat near occupied sites, to continue implementing the management plan, and to move adults by accelerated translocation to adjacent valleys to expand the population. In the Indiana Dunes RU, the reintroduction program in West Gary should continue until a sufficient number of Karner blues are restored to the site to meet recovery goals. Priority 1 research needs are expected to complement and facilitate these priority 1 recovery tasks. Finally, there is a need to develop cost-effective monitoring methods so that the effects of management can be quantified and the status of the populations can be tracked. Because Wisconsin has almost one-half of the recovery goals for the Karner blue range wide, many of them involving the recovery of large viable populations, and because the Wisconsin DNR is very concerned about it's ability to demonstrate recovery of this proportion, a priority 1 recovery task has been included in this plan to further identify streamlined monitoring methods that are more habitat based for documenting the presence of 6,000 butterflies (refer to PART II, RECOVERY TASKS, Task 3.4)

Priority 2 recovery activities are those necessary to prevent a significant decline in the butterfly population or the quality of its habitat in a RU. There are many priority 2 tasks range wide. The following provides a simplified summary of them. Many of the priority 2 tasks focus on ways to maintain and encourage management practices to create and maintain suitable habitat. These include educational efforts to reduce or modify pesticide use on habitats with Karner blue and lupine, programs to contact private landowners, developing incentives for participation in recovery programs encouraging certain forest management practices to keep the canopy partially open, and implementing mechanisms to guarantee a land base on which viable metapopulations can persist. In addition, there is a need to put the management practices on firmer scientific footing so that they can be reliably used. Recovery tasks include incorporating Karner blue management planning into the on-going management planning processes at each site. Finally there is a need to develop cost-effective monitoring methods so that the effects of management can be quantified and status of the populations can be tracked.

In this recovery plan, priority 3 tasks are also necessary for recovery and include, as appropriate, recovery of Karner blue metapopulations in potential RUs. Most of the priority 3 tasks provide the essential support to guarantee the persistence of viable populations of Karner blue indefinitely into the future. Delisting and possibly reclassification will be difficult without accomplishing many of these tasks.

PART II. RECOVERY

RECOVERY OBJECTIVE

Table 4. Metapopulation goals by recovery unit for the Karner blue butterfly.

Recovery Unit (RU) (refer to APPENDIX B)	State	* Recovery Goals[1]	
		Reclassification	Delisting
Merrimack/Nashua River System	NH	1VP[2]	1VP[2]
Glacial Lake Albany	NY	3VP	3VP
Ionia	MI	2VP or 1LP	2VP or 1LP
Allegan	MI	2VP	1VP + 1LP
Newaygo	MI	2VP	1VP + 1LP
Muskegon	MI	2VP	2LP
Indiana Dunes	IN	3VP	3VP
Morainal Sands	WI	1LP	

cases the 1 kilometer dispersal distance may be too far (refer to APPENDIX G, INCREASING THE COLONIZATION RATE OF SUBPOPULATIONS WITHIN A METAPOPULATION)

The management and monitoring systems and the buffering capacity and structure of the metapopulation are all linked (refer to APPENDICES G and H).

Each LP shall have in addition to Criterion 2.1

4. a larger areal extent and more suitable habitat than required for a minimum VP, specifically:

   a. an areal extent of at least 10 contiguous square miles (10 mi^2), in which approximately 10 percent or more of the area has suitable habitat (i.e., an equivalent of about 640 acres of suitable habitat in a 10 square mile area);

   b. the suitable habitat is distributed over two-thirds of the 10 square mile area.

5. a more robust metapopulation structure with larger numbers of individuals than a VP, specifically:

   2

Criterion 2

Same as Criterion 2 above for reclassification with the addition that each VP shall be demonstrably self-reproducing, shall be maintained at or above minimum allowable population sizes, and shall be managed and monitored under the specified management and monitoring plans for at least 10 consecutive years**.** Each LP, after the initial 5 years of monitoring for reclassification purposes, shall be monitored sufficiently to demonstrate that the LP is being maintained (this should not require as intensive monitoring as for reclassification purposes, refer to APPENDIX H).

Refer to APPENDIX B, Table B1 for potential locations of metapopulations across the species range.

Note: The above noted reclassification and delisting criteria are preliminary, and may be revised on the basis of new information**.** Refer also to RECOVERY TASKS, Task 6.3, pertaining to the re-evaluation of recovery goals for Wisconsin.

RATIONALE

Management of a Viable Metapopulation (Refer also to APPENDIX G)

Purpose

Management is essential to maintain the metapopulation, to respond in the event that the metapopulation begins to decline, and to buffer the metapopulation from the influences of various sources of environmental variation that could adversely affect the metapopulation. Thus, a management plan must specify how each of these three functions will be met.

Specificity

A management plan shall be developed for each metapopulation that is required in Criterion 1 for reclassification, delisting or both.

Management risks

If a metapopulation is a minimum VP, there is little room for management error, and the management system must use methods that have been proven to have a beneficial effect on Karner blue metapopulations and do not put any part of the metapopulation at risk of long term reduction. If the metapopulation is larger than the minimum, then more experimental management can be encouraged to provide the evidence to justify reducing the costs of maintaining the viable population. A metapopulation is large enough to allow experimental

Management strategy

Management shall maintain the minimum VP by maintaining an appropriately disturbed habitat mosaic and facilitating the use of suitable habitat by the Karner blue. The mosaic shall be managed so that suitable habitat does not decline in total area or in the number of suitable habitat sites, and so that the degree of connectivity among occupied and occupiable sites is maintained. A shifting mosaic of suitable habitat may be appropriate in many cases, allowing annual variation in the area of suitable habitat. Management practices shall be designed and implemented to renew suitable habitat at appropriate rates. If the renewal rate is too low, habitat will deteriorate (for example, by succession), eliminating Karner blues from sites; and if it is too high, then local Karner blue subpopulations may have insufficient time to recover from the disturbance. Refer to APPENDIX G for more specific management guidelines.

Monitoring of a Viable Metapopulation (Refer to APPENDIX H)

Purpose

The monitoring system of a viable metapopulation shall provide (1) timely information on any decline in the metapopulation or the habitat mosaic, and (2) information on the status of the metapopulation, its associated habitat and the potential adverse disturbances and threats to survival. Monitoring shall be frequent and precise enough so that declines or reductions can be detected in enough time that improvements to management can be implemented.

Specificity

A monitoring system shall be developed for each metapopulation that is required in Criterion 1 for reclassification, delisting, or both.

Use of information

A decision framework for how the information from the monitoring activities will be used in making management decisions shall be specified. Action triggers, such as a decline in the metapopulation or an adverse change in the habitat mosaic, shall be identified, and the changes in management action that must be implemented consequent to the action trigger shall be specified. Communication and implementation routes must be clarified so that management practices can be modified and modifications can be implemented in a timely manner if the action triggers are reached.

Monitoring strategy

Monitoring shall occur frequently during the initial period of maintaining a viable

Redundancy

All metapopulations should have more than one subpopulation. Because the best management plan may have design flaws, and errors in implementation can occur, and because of the threat of large-scale catastrophic disturbance, it is necessary and desirable to maintain a larger metapopulation than would be necessary in a risk-free, constant environment. More research is necessary to show that a VP could be maintained on a single site.

STEPDOWN RECOVERY OUTLINE

1. Protect and manage the Karner blue and its habitat to perpetuate viable metapopulations of Karner blue butterflies.

    1.1. Monitor population trends, habitat and distribution in RUs and search for new populations/occupied habitats in unsurveyed areas.

        1.11. New Hampshire
        1.12. Minnesota
        1.13. Michigan
        1.14. New York
        1.15. Indiana
        1.16. Wisconsin

    1.2. Continue/start management activities for all metapopulations in RUs.

        1.21. New Hampshire
        1.22. Minnesota
        1.23. New York
        1.24. Michigan
        1.25. Indiana
        1.26. Wisconsin

    1.3. Develop and implement protection and management plans for metapopulations within RUs and integrate into management operations

        1.31. Develop a management and monitoring plan for each metapopulation that addresses all recovery metapopulation criteria detailed in PART II, RECOVERY OBJECTIVE.

            1.311. Minnesota
            1.312. New York
            1.313. Indiana
            1.314. Michigan
            1.315. Wisconsin
            1.316. New Hampshire

        1.32. Implement the management and monitoring program for each metapopulation in the RU.

            1.321. Implement the management plan.

                1.321.1. New Hampshire
                1.321.2. Minnesota

1.321.3. New York
1.321.4. Wisconsin
1.321.5. Indiana
1.321.6. Michigan

1.322. Implement strategies to guarantee the long-term availability of the geographic land base for the viable metapopulations.

1.322.1. New Hampshire
1.322.2. New York
1.322.3. Indiana
1.322.4. Michigan
1.322.5. Wisconsin
1.322.6. Minnesota

1.323. Implement the monitoring plans.

1.323.1. New Hampshire
1.323.2. Minnesota
1.323.3. New York
1.323.4. Indiana
1.323.5. Michigan
1.323.6. Wisconsin

1.4. Protect existing Karner blue butterfly populations.

1.41. Review Federal, state and private activities.

1.411. Section 7 Federal responsibilities
1.412. Section 10(a)(1)(A) scientific permits
1.413. Section 10(a)(1)(B) incidental take permits

1.42. Develop standardized conditions for scientific permits
1.43. Identify mechanisms to streamline the Federal permit process for private landowners

1.5. Develop recovery implementation strategies to promote recovery.

2. Evaluate and implement translocation where appropriate.

2.1. Continue to develop and refine protocols and guidelines for translocation.

2.11. Continue to develop protocols, guidelines and selection criteria for translocation.
2.12. Incorporate research findings on captive propagation into protocols.

2.2. Implement translocations in RUs.

2.21. Initiate/continue augmentation and reintroductions and accelerated colonization.

2.211. New Hampshire
2.212. Minnesota
2.213. New York
2.214. Indiana
2.215. Other sites as need develops

2.3 Consider additional reintroductions if necessary in PRUs.

2.31. Ohio
2.32. Other sites as need develops

3. Develop rangewide and regional management guidelines.

3.1. Continue development of Karner blue butterfly Forest Management Guidelines.
3.2. Develop guidelines for protection of Karner blues from biocides.
3.3. Continue development of Karner blue management guidelines.
3.4. Continue development of standardized monitoring protocols for the Karner blue

4. Develop and implement information and education program.

4.1. Continue to develop outreach material on Karner blue life history and conservation.
4.2. Inform local and county governments of Karner blue RUs.
4.3. Encourage private landowners to conserve the Karner blue butterfly.
4.4. Assess the needs, goals, and outcomes for public outreach.

5. Collect important ecological data on the Karner blue and associated habitats.

5.1. Priority 1 research

5.11. Habitat management relative to the Karner blue
5.12. Lupine propagation
5.13. Karner blue translocation methods
5.14. Alternative habitat restoration methods
5.15. Remote sensing
5.16. Glacial Lake Albany RU metapopulation decline

5.2. Priority 2 research

5.21. Karner blue dispersal
5.22. Dispersal corridors and barriers
5.23. Ecosystem management
5.24. Karner blue monitoring
5.25. Forest management research

5.26. Highly dispersed metapopulations

5.3. Priority 3 research

5.31. Ecology of local populations
5.32. Effects of human activities
5.33. Browse threshold
5.34. Re-establishment of lupine
5.35. Population structure
5.36. Taxonomic research
5.37. Monitoring protocols using non-adult life stages
5.38. Effects of atmospheric nitrogen on lupine

6. Review and track recovery progress.

6.1. Develop a clearinghouse for Karner blue data, progress reports, metapopulation plans, HCPs, guidance documents, and other relevant information.
6.2. Conduct Recovery Team meetings every 2-3 years to evaluate progress.
6.3. Revise plan as appropriate
6.4. Hold periodic meetings to promote recovery and information sharing.

Note: Refer to APPENDIX B, Table B-1 for potential locations of metapopulation centers across the species range.

RECOVERY TASKS

1. Protect and manage the Karner blue butterfly and its habitat to perpetuate viable metapopulations of Karner blue butterflies.

Many Karner blue butterfly metapopulations are currently vulnerable to short-term decline, and interim protection, management and monitoring measures are required to maintain and/or stabilize them until more comprehensive site-specific metapopulation management plans can be developed and implemented.

1.1 Monitor population trends, habitat and distribution in RUs with imperiled

private lands will be required before an adequate strategy for protecting Karner blue in this RU can be developed.

Ongoing inventory and monitoring work is essential within the Muskegon RU to determine near-term trends in Karner blue populations and to determine the extent of Karner blue distribution within the landscape.

1.14 New York

The downward trend in numbers and occupancy of habitat of most populations in the Glacial Lake Albany RU must be carefully monitored. Many existing sites are under intense pressure to be converted to incompatible uses, and protection of suitable sites, whose occupancy status is unknown, is frequently challenged. Declining habitat quality must be documented to motivate the need for active management. Unknown populations must be located and protected.

1.15 Indiana

The last Karner blues were seen in West Gary in 2000 and a reintroduction program is ongoing to restore the butterfly to that area. Ongoing monitoring of the West Gary metapopulation is essential to the success of the reintroduction effort. The two metapopulations in the IDNL are not as precarious, but annual monitoring is still required.

1.16 Wisconsin

Monitoring of the Yellow River Focus Area adjacent to the east boundary of Necedah NWR located in the Glacial Lake Wisconsin RU is needed to determine if Karner blue populations exist and to assess whether they can contribute to achieving the recovery goals of this RU.

1.2 Continue/start management activities for all metapopulations in RUs.

Karner blue metapopulation persistence is under immediate threat in some RUs, mainly due to poor habitat quality. Immediate implementation of efforts to counter these threats is necessary. These preliminary management efforts will be a positive first step towards stabilizing the metapopulations and implementing longer-term management to maintain viable metapopulations.

1.21 New Hampshire

Because of the precarious state of the Concord Karner blue population, intensive habitat improvement and expansion is necessary including lupine and nectar source enhancement through artificial planting and seeding. Although lupine is relatively abundant at the Main Site and the Concord Airport site, it is sparse at the Service's Great Bay NWR conservation easement (Easement). Newly established lupine plants must be protected

from herbivores. Nectar availability is a limiting factor for Karner blues at the Main and the Airport sites, especially during dry summers.

Habitat management to control woody encroachment at the Main Site is also needed in the short-term by working closely with the Public Service of New Hampshire and private landowners to (mechanically) manage vegetation. Other management needs include mechanical vegetation management and controlled burns to improve habitat at the Service easement, and at the Concord Airport, monitoring of the mowing regime of the safeways at the airport, and working with the City to adjust the timing and height of mowing as appropriate.

1.22 Minnesota

Continued small and large scale experimental habitat restoration is

at all other subpopulation sites to prevent their loss, to expand the sites, and to develop needed dispersal corridors.

The Saratoga Sandplains metapopulation has been severely reduced because of the loss of sites or conversion to land uses incompatible with Karner blue butterflies. Management efforts by the Wilton Wildlife Preserve and Park, The Nature Conservancy (TNC), and private landowners is crucial in preserving, managing and enlarging the remaining clusters of Karner blue subpopulations in the heart of the area. Until recently, actual management has been limited. Large-scale management has recently begun at a former Boy Scout Camp now owned by TNC. Nectar and lupine were planted at the NSComp and Edee Road Sandpit sites now owned by the state. Attempts to re-establish nectar species at

program. Ongoing habitat restoration at Ivanhoe dune and swale will provide additional buffering from catastrophic events and allow for development of a larger Karner blue metapopulation. Habitat management work required in the Service's Biological Opinion for the Karner blue at IDNL should continue.

1.26 Wisconsin

Habitat restoration, enhancement and/or management activities are needed on all properties where recovery efforts are focused. Ongoing barrens management activities on state [e.g., Sandhill WA, Glacial Lake Grantsburg Work Unit (Crex Meadows and Fish Lake State WAs), Black River State Forest, Emmons Creek State Fisheries Area], Federal (Necedah NWR, Fort McCoy), and private properties (Mr. Bob Welch,

dispersal, etc.). The objectives of all management programs should be integrated into the management and monitoring plan for the butterfly. No one management unit is likely to satisfy all management objectives, but every site should attempt to satisfy as many as possible within real world ecological, sociological and financial constraints. Refer to the recovery criteria and APPENDICES G and H for guidance on development of management and monitoring plans.

1.311 Minnesota

Paleozoic Plateau RU

Modify existing Karner blue butterfly management and monitoring plan for the Whitewater WMA (Lane 1994c) to incorporate recovery criteria necessary to meet the recovery objectives for this RU and to preclude loss of subpopulations that are at risk due to low numbers.

1.312 New York

Glacial Lake Albany RU

Incorporate Federal and state recovery guidance for the Karner blue butterfly and its support habitats into the existing preserve design for the Albany Pine Bush Preserve (Albany Pine Bush Preserve Commission 1993). Incorporate Federal and state recovery criteria into the existing Site Conservation Plan for the Saratoga Sandplains Macrosite (Pickering 1994), and develop into a metapopulation management plan. Contact local governments (Town of Wilton and Saratoga County) and non-governmental organizations to explore cooperative efforts to formulate plans. Develop a preserve design for the Saratoga West metapopulation through involvement of the state recovery team and cooperative efforts with local governments (Towns of Milton and Saratoga Springs, City of Saratoga Springs, and Saratoga County) and non-governmental organizations. Through involvement in the state recovery planning process, encourage incorporation of protection designs and management strategies into local municipality planning projects.

1.313 Indiana

Indiana Dunes RU

Modify existing management plans for West Gary (Shuey, undated) and the IDNL to incorporate recovery criteria necessary to meet recovery goals. The recovery implementation plan for

West Gary should include Lake County Parks Natural Areas, TNC holdings and adjacent private landowner stewardship plans.

1.314 Michigan

Modify existing management and/or master plans to incorporate recovery criteria necessary to meet recovery goals. Evaluate permit options and develop procedures to cover multiple take activities on multiple sites resulting from management activities of the Karner blue butterfly.

Allegan RU

Modify existing management plans for Allegan SGA.

Ionia RU

Modify existing management plans for Flat River SGA and adjacent private lands.

Muskegon RU

Modify existing management plans for Huron-Manistee NF and adjacent private landowner stewardship plans.

Newago RU

Modify existing management plans for Huron-Manistee NF and adjacent private landowner stewardship plans.

1.315 Wisconsin

State property planning will be done via DNR-HCP implementation and state master planning.

Morainal Sands RU

Modify existing management and/or master plans to incorporate recovery criteria necessary to meet recovery goals for properties within the Hartman/Emmons/Welch complex which include Hartman Creek State Park, Emmons Creek State Fishery Area, National Park Services' Ice Age Trail segment, and privately owned "Welch" forest crop law stand. In addition, seek to develop protection agreement with Mr. Welch for Sawyer Prairie, and with other willing private landowners in this complex as needed and available. Incorporate recovery guidance into management and/or

master plans for Greenwood and White River Marsh State WAs. Pursue State Natural Area designation of state lands.

Glacial Lake Wisconsin RU

Modify existing management and/or master plans to incorporate recovery criteria necessary to meet recovery goals for (1) Meadow Valley State WA (via the ITP for the Wisconsin Statewide HCP, section 7 consultation for this federally owned property, and DNR Master Planning), (2) Necedah NWR (via section 7 consultation process), (3) Sandhill State WA (via the ITP for the HCP), and (4) Quincy Bluff Natural Area.

Incorporate recovery guidance for the Karner blue into conservation measures for the Air National Guard Hardwood Range (Hardwood Range) via section 7 consultation. Because the Hardwood Range site is not large enough to support a Karner blue metapopulation, contact Wood and Juneau County's Forest and Parks Departments to explore collaborative efforts for the recovery of the metapopulation in this portion of the RU. Also determine whether Necedah NWR can be of assistance (relative to the Yellow River Focus Area) with this effort.

West Central Driftless RU

Modify existing management and/or master plans as needed to incorporate recovery criteria necessary to meet recovery goals for (1) Black River State Forest (via the ITP for the Statewide HCP and DNR master planning) and Fort McCoy Military Reservation (via section 7 consultation process). Contact the Jackson County Forest and Parks Department to explore ways to develop collaborative efforts for the recovery of a LP in this portion of the butterfly's range**.**

Wisconsin Escarpment and Sandstone Plateau RU

Because some of the larger habitats for the Karner blue occur on county forest lands in this RU, contact the Forest and Parks Departments of Eau Claire and Clark Counties to explore collaborative efforts for the recovery of an LP in this portion of the butterfly's range. Also contact some of the HCP utility partners, and the Eau Claire and Clark County's Highway Commissions to explore their willingness to participate in recovery efforts**.**

Superior Outwash RU

Modify existing management and/or master plans to incorporate recovery criteria necessary to meet recovery goals for (1) Glacial Lake Grantsburg Work Unit (Crex Meadows and Fish Lake State WAs), combined with Governor Knowles State Forest (via the ITP for the HCP). Also contact the Burnett County Forest Department to explore collaborative partnership efforts to help recover a LP in this portion of the range.

1.316 New Hampshire: Merrimack/Nashua River Systems RU

Modify existing Karner blue butterfly management and monitoring plans to incorporate recovery criteria and guidance necessary to meet recovery goals for this RU. This will entail reviewing and amending as necessary, the Concord Pine Barrens Preserve Design, the Concord Airport and Service Easement Plans, and the management plan for the Main Sites.

1.32 Implement the management and monitoring plan for each metapopulation in the RU.

1.321 Implement the management plan.

Metapopulation-specific management plans must be implemented in ways to ensure that management will persist into the indefinite future if populations are to qualify as VPs and LPs.

1.321.1 New Hampshire

Merrimack/Nashua River Systems RU

It is crucial to maintain existing habitat and restore degraded habitats for the Karner blue at Concord due to the declining and precarious nature of the population.

1.321.2 Minnesota

Paleozoic Plateau RU

Restore habitat and create fire breaks to expand and protect populations that are at risk of decline due to low numbers at the Whitewater WMA.

Glacial Lake Wisconsin RU

(1) Meadow Valley State WA: Establish barrens restoration and management project, working as necessary with Necedah NWR to complement its efforts on adjoining lands. Incorporate results of barrens management into management activities at this site and Sandhill State WA using adaptive management principles.

(2) Necedah NWR: Continue barrens restoration and management efforts across property, and maintain appropriate disturbance regime. Evaluate effects of various disturbance techniques in progress and incorporate results using adaptive management principles.

(3) Air National Guard Hardwood Range: Develop and maintain appropriate disturbance regime, establish firebreaks where needed and enhance habitat as needed.

(4) Sandhill State WA: Continue habitat restoration and maintenance efforts. Delay mowing of County Highway X until after September.

(5) Quincy Bluff Wetland Preserve: Continue barrens restoration efforts, augmented with lupine propagation and/or Karner blue translocation/reintroduction if necessary.

West Central Driftless RU

(1) Black River State Forest/Jackson County Forest: Maintain positive disturbance regime via wildlife management and silvicultural practices throughout Indian Grave Creek Barrens Complex and Dike 17 complex, using permanent core populations at designated areas and trails and roads as corridors to extent possible. Develop connectivity between those populations around Dike 17 refuge and those north of Highway 54 in Staffon and Cemetery Road areas. Delay mowing along occupied and connecting roadsides until after September.

(2) Fort McCoy: Maintain positive disturbance regimes through military, silvicultural, and wildlife practices

to establish and maintain two LPs (one each on the North and South Post), and to conserve Karner blues south of State Highway 16. Establish connectivity between the North Post LP and Habelman Road area of Black River State Forest south of I-94 compatible with military operations.

(3) Monroe County Forest

managers to enhance Karner blue metapopulation function/health.

1.321.6 Michigan
function/health.

1.321.6 Michigan

Newago RU

Maintain existing habitat and restore suitable habitats for the Karner blue on public and private lands in the RU. Maintain sufficient Karner blues to meet the metapopulation objectives. Protection from ORV and development is needed. Prairie and barrens restoration projects should continue through cutting, nectar and lupine propagation and burning.

1.322 Implement strategies to guarantee the long-term availability of the geographic land base for the viable metapopulations.

In all RU except the Paleozoic Plateau RU in Minnesota, it will be necessary to guarantee the long-term availability of the geographic land base of each viable metapopulation. Most plans will identify important Karner blue habitat areas which need to be available long-term. This might be accomplished by land acquisition from willing land owners, conservation easements, management agreements, HCPs, or other means. These efforts should be taken in a timely fashion. As the Service and its partners seek to work with willing landowners on the recovery of endangered species, and some of the key butterfly sites are on private lands, it is important to explore collaborative recovery efforts with these landowners. Brief reviews of land protection needs are described in Task 1.322.1 through Task 1.322.6.

1.322.1 New Hampshire

Merrimack/Nashua River Systems RU

An informal management agreement currently exists with the electrical utility company that manages vegetation at the Main Site; obtain a formal management agreement or conservation easement for the Main Site. Monitor City of Concord and Federal Aviation Administration implementation of Concord Airport Master Plan Update (City of Concord 1996), review proposals for new construction and facility improvements, recommend locations and project designs that minimize loss of Karner blue habitat. Manage/restrict ORV use at the Main Site and Service Easement. Work with City of Concord to implement the management agreement for the Airport.

1.322.2 New York

Land acquisition is needed in the Albany Pine Bush, Saratoga Sandplains and Saratoga West metapopulation areas. Conservation easements and other protection will be needed at all three areas. Private landowner cooperation regarding ORV use and prescribed burning will be especially important. Establish a cooperative protection and management entity for the Saratoga West area (the management entity for Saratoga Sandplains is the Wilton Wildlife Preserve and Park). Work with the state, city, town, and private landowners in and near the Albany Pine Bush, Saratoga Sandplains, and Saratoga West metapopulation sites to include Karner blue preserve design concepts into local planning to facilitate restoration of one metapopulation in each area.

1.322.3 Indiana

Indiana Dunes RU

Land acquisition is needed in the West Gary population. Habitat protection is expected at the West Gary population site and both metapopulations associated with the IDNL.

1.322.4 Michigan

Allegan RU

Promote long-term, cost efficient management strategies and work with private landowners to develop cooperative management agreements that minimize loss of Karner blue habitat. Maintain regular contact with utilities that manage rights-of-way on the Allegan SGA to update management agreements.

Ionia RU

Develop strategies to manage/restrict ORV use on Flat River SGA. Maintain regular contact with utilities that manage rights-of-way on the Flat River SGA to update management agreements.

Muskegon RU

Manistee NF boundary. Land acquisition may be considered if the lands are necessary for recovery and other agreements are inadequate to ensure recovery.

Newago RU

Habitat protection within the metapopulation, especially in areas threatened by development, is expected in the Huron-Manistee NF boundary. Land acquisition may be considered if the lands are necessary for recovery, and other agreements are inadequate to ensure recovery.

1.322.5 Wisconsin

Morainal Sands RU

Consider designation of Emmons Creek/Hartman Creek State Park and Ice Age Trail complex as State Natural Areas; pursue conservation easement or other permanent protection with private owners in the complex.

Glacial Lake Wisconsin RU

If Karner blue sites in the Yellow River Focus Area are necessary to establish a viable metapopulation in this RU, agreements with willing landowners should be explored to ensure long-term maintenance of these sites. Land acquisition may be considered from willing landowners if the sites in the Yellow River Focus Areas are necessary for recovery and other agreements are inadequate to ensure recovery.

West Central Driftless RU

Consider designation of Indian Grave Creek Barrens as a State Natural Area.

1.322.6 Minnesota

Paleozoic Plateau RU

Coordinate and implement recovery activities at the Whitewater WMA.

1.323 Implement the monitoring plans

Because monitoring is included as a key component of Karner blue metapopulation viability, implementation of an appropriate monitoring plan is essential. As explained in PART II, RATIONALE, Monitoring of a Viable Metapopulation, monitoring programs should be designed to provide essential feed back to managers so that the effectiveness of management can be evaluated and management can be adapted. Consequently, the monitoring protocol will likely be slightly different for each metapopulation.

1.323.1 New Hampshire

Merrimack/Nashua River System RU

Implement the monitoring plan. Track the phenology, numerical abundance and extent of habitat utilized by first and second brood Karner blue butterflies at the three subunits (Main Site, Easement and Airport) in this RU.

1.323.2 Minnesota

Paleozoic Plateau RU

Implement the monitoring plan. Monitor Karner blue populations, habitat and habitat occupancy as recovery and habitat restoration activities are implemented.

1.323.3 New York

Glacial Lake Albany RU

Implement the monitoring plan. Monitor Karner blue populations, habitat and habitat occupancy as recovery and habitat restoration activities are implemented. Coordinate monitoring on public and private lands.

1.323.4 Indiana

Indiana Dunes RU

Implement the monitoring plan. Monitor Karner blue populations, habitat and habitat occupancy as recovery and habitat restoration activities are implemented. Coordinate monitoring on public and private lands.

1.323.5 Michigan

Allegan RU

Implement the monitoring plan. Monitor Karner blue populations, habitat and habitat occupancy as recovery and habitat activities are implemented. Coordinate monitoring on public and private lands. Ensure monitoring protocol is reliable and efficient across extensive acreage.

Ionia RU

Implement the monitoring plan. Monitor Karner blue populations, habitat and habitat occupancy while recovery and habitat restoration activities are implemented.

Muskegon RU

Implement the monitoring plan. Coordinate monitoring efforts to meet criteria for viable population objectives. Ensure monitoring protocol is efficient, accomplishable, reliable, and portrays population trends for metapopulations.

Newago RU

Implement the monitoring plan. Coordinate monitoring efforts to meet criteria for viable population objectives. Ensure monitoring protocol is efficient, accomplishable, reliable, and portrays population trends for metapopulations.

1.323.6 Wisconsin

In all RUs, implement the respective monitoring plans for each metapopulation. Coordinate recovery monitoring efforts with those developed for the statewide HCP to avoid duplication of effort. Ensure monitoring protocol is efficient and doable across extensive acreage involved. This may require a modified monitoring protocol involving subsampling of habitats (refer to Recovery Task 3.4)

1.4 Protect existing Karner blue populations

1.41 Review Federal, state and private activities

Federal, state and private activities that may affect the habitat or result in the taking of Karner blue butterflies should be reviewed to the extent possible under Federal and state law. Appropriate measures should be taken to protect the butterfly and its habitat due to proposed activities. The States of New Hampshire, New York, Michigan, Minnesota, and Ohio have regulations regarding the potential of Karner blues. Although the Karner blue is not listed in Wisconsin, it is a species of Special Concern and the WDNR, through a cooperative agreement with the Service is committed to furthering the conservation and recovery of the species (refer to PART I, CONSERVATION MEASURES, State Protection). Three Federal regulatory review processes are discussed below.

1.411 Section 7 Federal responsibilities

Under section 7(a)(1) of the Act, Federal agencies are directed to utilize their programs to conserve threatened and endangered species. Section 7(a)(2) requires Federal agencies to consult with the Service to insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of listed species, nor destroy or adversely modify critical habitat (no critical habitat has been designated for the Karner blue butterfly). Federal programs and consultations with the Service should strive to implement recovery goals for the Karner blue butterfly to the maximum extent possible.

Formal section 7 consultations for the Karner blue butterfly have been completed for Federal actions in Wisconsin, Michigan, Indiana, New York, and New Hampshire. The guidance and information in this plan should be used when reviewing Federal projects and programs and when developing biological opinions.

Consultations are expected to continue in all states with occupied Karner blue habitat, with the greatest number of them taking place in Wisconsin and Michigan which support the majority of butterfly sites. Refer to PART I, CONSERVATION MEASURES, Federal Regulatory Protection, Section 7 consultation for overview of consultation activities.

1.412 Section 10(a)(1)(A) scientific permits

Scientific permits (also called recovery permits) under section 10(a)(1)(A) of the Act are issued by the Service to researchers for

scientific purposes or to enhance the propagation or survival of the listed species. They also can be used to authorize take of the butterfly for management activities that contribute to the survival of the species. Due to the intense interest in research pertaining to the Karner blue butterfly, the Service has issued several scientific permits in the past, and anticipates issuing more in the future to address still unanswered research needs, management and recovery questions. Research permit applications should be well thought out, designed to minimize harm to the species, and reviewed by appropriate experts to ensure meaningful results. Scientific permits may also be used to encourage Safe Harbor approaches to conservation of the Karner blue butterfly. Refer to PART I, CONSERVATION MEASURES, Federal Regulatory Protection, Federal permits for further information on research permits, and the Safe Harbor approach to conservation.

1.413 Section 10(a)(1)(B) incidental take permits

Section 10(a)(1)(B) of the Act provides for the issuance of "incidental take" permits for the take of federally-listed animals such as the Karner blue butterfly for actions not authorized, funded or carried out by Federal agencies (see 1.411 above); namely, most state, county, municipal and privately owned lands. Applicants for an incidental take permit must develop a habitat conservation plan (HCP), and except for low-effect HCPs, must also develop an accompanying NEPA document. The Service has currently issued two “incidental take” permits involving the Karner blue. The first to the Town of Rome (Adams County), Wisconsin, and the second to the Wisconsin DNR for the Wisconsin Statewide HCP for the Karner Blue Butterfly (refer to PART I, DISTRIBUTION, State Distribution of Karner blues, Wisconsin, and CONSERVATION MEASURES, Federal Regulatory Protection, Federal permits). The Michigan DNR is currently taking the lead on development of a statewide HCP for the Karner blue in Michigan.

1.42 Develop standardized conditions for scientific permits

To expedite the processing of section 10(a)(1)(A) scientific permits (refer to 1.412 above), and to ensure uniformity of data rangewide, standardized permit conditions should be developed and provided to Service and state offices that may be involved in Karner blue butterfly scientific permit activities.

1.43 Identify mechanisms to streamline the Federal permit process for private landowners

Presence of an endangered species on private lands can result in additional costs and concerns for the landowner, especially in relation to the future value and use of the property. Because all "take" of a listed species must be authorized via a Service permit, streamlining the permit process could address some of these private landowners concerns. In addition, streamlining these procedures might encourage private landowners to participate in recovery (private landowners cannot be mandated to recover federally listed species).

Streamlined regulatory approaches to authorize "take" of the Karner blue butterfly include use of low-effect incidental take permits on an individual landowner basis, and programmatic, regional, or statewide incidental take permits (USFWS and NMFS 1996) that include a strategy to cover private landowners. The Wisconsin Statewide HCP for the Karner blue butterfly includes a participation strategy that covers "incidental take" for a select group of private landowners and provides a mechanism to extend permit coverage to new partners in the conservation program, thereby not only streamlining the permit process but eliminating it for some private landowners.

Another tool offered by the Service to encourage private landowner participation in conservation and recovery of listed species that can be considered is the Safe Harbor Agreement (refer to PART I, CONSERVATION MEASURES, Federal Regulatory Protection, Federal permits). A Safe Harbor approach to Karner blue butterfly conservation is currently being developed by TNC in northwest Indiana in concert with the Karner blue reintroduction effort to West Gary.

1.5 Develop recovery implementation strategies to promote recovery

It is important to encourage public participation in implementation of recovery actions. Private landowners are key to recovery in several areas of the Karner blue's range because their lands support existing butterfly populations. The Service and its partners seek to work with willing landowners on the recovery of threatened and endangered species; collaborative efforts with key landowners to promote recovery should be explored.

Participation strategies/plans should be developed as appropriate that provide a framework for recovery. Members to this process should include representatives of all interested parties that could be affected by implementation of the recovery actions and/or could assist with recovery, including Federal and state agencies, and private landowners (e.g., companies, private citizens and conservation groups). Education and outreach activities (refer to Task 4. Develop and implement information and education program below) may provide a vital link for involving important stakeholders in development of recovery strategies,

especially in recovery areas that include or affect private lands. Karner blue butterfly state working groups should consider serving as leads for these efforts.

The New York State Working Group is developing a state recovery plan which provides a general recovery framework. Site specific management plans for the metapopulation sites will be appended as part of the plan. The planning process will involve local governments, non-profits, and interested and affected parties.

2. Evaluate and implement translocation where appropriate

Translocation efforts include population augmentation, accelerated dispersal and reintroductions (refer to APPENDIX I). The reintroduction of the Karner blue to historic habitats and translocations of the butterfly to unoccupied habitat (augmentation) or areas with low population densities (accelerated dispersal) within developing metapopulations (with an extant Karner blue population) are anticipated to enhance or accelerate the rangewide recovery effort. Protocols and guidelines should be developed and refined to ensure that translocation procedures are both appropriate and likely to be successful.

2.1 Continue to develop and refine protocols and guidelines for translocation

efforts in Minnesota, and the on-going reintroduction efforts in New Hampshire and Indiana should be examined to help further develop and document successful translocation protocols.

2.12 Incorporate research findings on captive propagation into protocols

As new ecological data are generated, and as experience with rearing protocols accumulates, timely refinements should be incorporated into the standardized captive propagation protocols. The Toledo Zoo's Captive Propagation Handbook for the Karner Blue (Toledo Zoo 2002) currently provides good guidance on captive propagation techniques. Additional

2.212 Minnesota

Karner blue numbers in Minnesota are precariously low. Captive rearing of adults and larvae (begun in 1999) to accelerate colonization to Lupine Valley should continue.

2.213 New York

Karner blue numbers in nearly all of the Glacial Lake Albany RU are precariously low. Captive rearing of adults to accelerate colonization to an unoccupied but apparently high-quality site may greatly increase metapopulation buffering and may increase the probability of Karner blue persistence in the state.

2.214 Indiana

The on-going reintroduction in West Gary, Indiana should continue until population densities/levels increase to viable population levels.

2.215 Other sites as need develops

If translocation efforts are determined to be an appropriate tool for use at other RUs, plans should be developed and implemented on an as needed basis to restore or recover viable metapopulations. Reintroduction may be necessary at TNC's Quincy Bluff and Wetland Preserve property in the Glacial Lake Wisconsin RU once sufficient habitat has been restored.

2.3 Consider additional reintroductions if necessary in PRUs

Because recovery of Karner blues in PRUs could contribute to the plan's goal of restoring viable populations throughout the range of the butterfly reintroductions to these areas may be appropriate and could serve to offset recovery goals in other portions of the range (refer to APPENDIX B, POTENTIAL RECOVERY UNITS).

2.31 Ohio

Continue the reintroduction program as appropriate to restore a viable population of Karner blues to the oak openings of northwest Ohio.

2.32 Other sites as need develops

Reintroduce Karner blues to other PRUs should such action be determined beneficial and appropriate to the recovery of the species.

3. Develop rangewide and regional management guidelines

While each metapopulation will have its own management and monitoring plan, some of the protocols and management practices can be standardized throughout the species range. The development of generic Karner blue guidelines will simplify RU-specific plan development.

3.1 Continue development of Karner blue butterfly Forest Management Guidelines

Several Karner blue populations occupy commercial and public forest lands such as Huron-Manistee NF in Michigan, and state and county forest lands in Wisconsin. Because much of the Karner blue butterfly landscape in the Midwest is forest land, it is important to understand the effects of forest management practices on the butterfly and its habitat and to be able to assess how practices can be modified to conserve the butterfly. Forest Management Guidelines (Guidelines) for the Karner blue butterfly have been developed by Lane (1997). They are available from the Service's Green Bay Field Office (2661 Scott Tower Drive, New Franken, Wisconsin 54229) and should be updated as new information becomes available.

The Guidelines review various forest management operations (e.g., planting, harvesting, site preparation, and thinning) and identify what is known about the effects of these practices on the Karner blue butterfly and its habitat. In addition, the Guidelines identify how the practices could be compatible with, or enhance conservation of the butterfly (e.g., through the use of woods roads as dispersal corridors, or stand thinning to promote lupine persistence). They also identify research questions that need addressing to further assess the impact of forest management practices on the butterfly and its habitat. It is anticipated that the Guidelines would be used by landowners involved in managing forests and by wildlife managers; the guidelines may also assist private landowners in the development of habitat conservation plans.

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Herbicides are used to control vegetation along roadways and utility corridors and in forestry management. Guidelines pertaining to pesticide use have been incorporated into APPENDIX G and should be revised as new information becomes available.

Formulations of *Btk* (*Bacillus thuringiensis kurstaki*) are currently used in the Midwest for control of gypsy moth. The following guideline is currently recommended by the Service for *Btk*: No aircraft broadcasting of *Btk* should occur within one-half mile of any Karner blue butterfly sites. Distances of less than one-half mile may be acceptable on a case by case basis by building in precautions to minimize drift (refer also to APPENDIX G).

New York State DEC requires that aerial spraying of the mosquito adulticide Scourge remain outside of a 100 foot buffer area around occupied Karner blue butterfly sites in the Towns of Wilton and Northumberland in the Saratoga Sandplains and cannot take place when wind drift would make conforming to the requirement doubtful.

The Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) has a landowner contact program designed to assist landowners, especially agricultural landowners, to avoid "take" of the Karner blue from pesticide applications, and is developing comprehensive pesticide use guidelines for the Karner blue. These guidelines should be finalized and updated as new information becomes available.

3.3 Continue development of Karner blue management guidelines

Several Karner blue RUs are centered on multi-use public and private lands, several of which are managed in part for wildlife production and hunting. Because many of these areas are important for the recovery of the Karner blue, it is important that land managers understand the impact of wildlife management practices on Karner blue populations and adjust accordingly given pre-existing constraints. Generic Karner blue management guidelines should provide overviews of current practices and suggest alternative practices when appropriate to minimize potential negative impacts from wildlife management. The WDNR has produced a set of wildlife management guidelines for the Karner blue (WDNR 1998, WDNR 2000) for use by its land manager and other interested parties. APPENDIX G provides management guidelines that should be revised as new information becomes available.

3.4 Continue development of standardized monitoring protocols for the Karner blue

Standardized monitoring protocols can be developed that could be applicable throughout the range of the species. Because monitoring needs will be different in each metapopulation, there is no need to use the same monitoring method throughout the range. Instead, a set of suitable, standard monitoring methods can be developed. Although this will not enable direct comparisons across the range,

the monitoring systems will be refined to provide the best information to the local manager. Ongoing monitoring efforts in all RUs should serve as the starting point in development of these protocols (refer to APPENDIX H).

Two priority monitoring tasks are needed. The first is to evaluate existing methods for extrapolating Karner blue adult population sizes from transect counts (e.g., straight line, Pollard-Yates, and meandering transects) and to clarify these methods or conduct further research if needed to clarify protocols. The second is to determine if habitat-based monitoring can be used to reduce monitoring requirements for large viable populations with the goal of producing a more cost effective yet reliable protocol**.**

4. **Develop and implement information and education program**

The assistance of private landowners will be crucial for successful recovery in many RUs, including Merrimack/Nashua River System, Glacial Lake Albany, Newago, Muskegon, Indiana Dunes, Morainal Sands, and Glacial Lake Wisconsin, and possibly West Central Driftless, Wisconsin Escarpment/Sandstone Plateau, and Superior Outwash RUs. Private landowner participation in recovery is especially important in the Glacial Lake Albany RU where few sites are in public ownership, and even those sites may not have wildlife management as their primary goal (e.g., Saratoga County Airport).

In general, private landowners are likely to fall into the following three types: (1) those whose primary goal is to be involved in recovery, (2) those who want to use their land for multiple purposes, and are willing to trade-off among these purposes, and (3) those who want to use their land for one dominant use that is not related to Karner blue conservation and would include uses that are detrimental to the butterfly. The information and education programs may have several goals. For example, they can be used to assist the type (1) landowners, to encourage participation by type (2) and (3) landowners, and to diffuse potentially adverse public relations that might originate with some of the landowners. Information and education programs can be designed to recruit willing participants to meet identified recovery goals, or to identify willing participants who can assist in goal identification and planning on how to meet those goals. Private landowners will need to make their own decisions and determine the degree of participation in recovery they are willing to make. Information and education programs can be useful for facilitating this process.

4.1 <u>Continue to develop outreach materials on Karner blue life history and conservation</u>

In some portions of the Karner blue's range where the general public is aware and interested in the butterfly, there is little in the way of standardized information available to them. Information detailing the life history, habitat requirements, and habitat enhancement activities need to be developed and made available to public and private landowners. Educational materials on prescribed burning and the values of non-forest habitats (barrens and savannas) will be especially important

for the Glacial Lake Albany and Glacial Lake Wisconsin RUs. Outreach materials and efforts should include reaching schools, scouting clubs, Americorps programs, and gardening clubs (especially in the Glacial Lake Albany RU) whose interest in butterfly gardening may be helpful in efforts to improve habitat. A part of the planned Wilton Wildlife Preserve and Park in Saratoga Sandplains includes a visitor's center within the area of the metapopulation, which would inform visitors about the Karner blue and other species present in the local environment. The visitor's center will include a butterfly garden featuring some of the native species on which the Karner blue depends. Refer to PART I, CONSERVATION MEASURES, Education and Outreach Activities, and APPENDIX J for information on education and outreach activities across the range.

Educational posters and pamphlets that can be used across the range of the Karner blue are needed. For instance a poster highlighting the value of oak savanna and pine barren habitats across the range and including photos of the Karner blue and other rare species associated with these habitats would provide multiply educational value and serve multiple states. Development of a template for a Karner blue pamphlet that could be used by all states to tailor make their own pamphlets is also needed. Development of a web site where Karner blue materials could be obtained and used by all would enhance and streamline outreach efforts.

4.2 Inform local governments of Karner blue RUs

Because Karner blue populations often occur on locally owned public lands which are not necessarily managed for biodiversity, it will be vital to inform the local

Enhancement Program (CREP). State stewardship and land management programs (e.g. Wisconsin) can also provide assistance. Existing and future environmental education centers, visitor's centers, etc., should be encouraged to become involved in education and outreach activities associated with the Karner blue butterfly.

4.4 Assess the needs, goals, and outcomes for public outreach

Although it is clear that public outreach programs are essential for recovery of the Karner blue butterfly, the goals of public outreach programs are often poorly defined. It is critical to define the needs, goals and outcomes of public outreach programs before substantial efforts are made. For example, development of an outreach program at IDNL could reach thousands of visitors per year and serve an important role in raising public awareness both locally in Indiana and nationally. An assessment of the best strategy to approach recovery on private lands near Miller Woods (part of IDNL) may be needed. Assessing the best way to approach public outreach in the Glacial Lake Wisconsin RU (especially around Necedah NWR, Necedah Wildlife Management Area, and Sandhill State WA) is crucial to support the recovery effort and savanna restorations in this RU. Support from the local communities, including forest owners and hunters, is essential.

5. Collect important ecological data on the Karner blue and associated habitats

Research is a crucial component of Karner blue recovery. Research activities that are necessary for successful Karner blue recovery are presented below. Table 5 includes a summary of research that the Recovery Team deemed interesting but not necessary for Karner blue recovery.

It is envisioned that research would be conducted by one or more agencies and other partners if available. Federal agencies that may assist with research include the

Hampshire), and Paleozoic Plateau (Minnesota) RUs where populations are severely declining or at risk of loss. This research should focus on: (a) developing methods to improve the habitat of occupied sites while avoiding or minimizing harm to Karner blue, and (b) developing methods to increase the size of suitable sites and promote rapid (1-2 years) colonization. Studies on effective ways to control invasive exotic (non-native) species while avoiding or minimizing impacts on the Karner blue, lupine, and nectar plants are also needed.

5.16 Glacial Lake Albany RU metapopulation decline

Determine the causes of Karner blue decline in the Glacial Lake Albany RU and how to mitigate them. This is critical in this RU because of low population numbers at most sites, and potential for the loss of some sites.

5.2 Priority 2 Research

5.21 Karner blue dispersal

Conduct research on the population structure of the Karner blue, especially focusing on dispersal rates in relation to distance between lupine sites, area of lupine sites, and the spatial distribution of the sites. Work is needed in open habitats, savanna/barrens habitat, and especially in forested and urban-suburban habitats.

5.22 Dispersal corridors and barriers

planting, amount of surface disturbance for site preparation (low/medium/high), and use of prescribed fire (feasibility and effects).

(c) What are the effects of clearcut without conversion? Emphasis should be on determining when such clearcuts occur and the influence of the season of harvest (e.g., growing season versus dormant season and frozen versus unfrozen ground).

d) Can lupine and nectar plants regenerate on lands previously supporting mature red pine stands?

(e) Can the existing shifting mosaic of habitat on Wisconsin forest lands (e.g., in Jackson, Eau Claire and Clark Counties) support viable metapopulations of Karner blues consistent with the recovery criteria?

5.26 Highly dispersed metapopulations

Develop management practices for aggregations of occupied sites that are highly dispersed geographically (many sites greater than one mile from the next nearest site), so that they can be managed as a viable metapopulation (e.g., in the Superior Outwash or Morainal Sands RU).

5.3 Priority 3 Research

5.31 Ecology of local populations

Determine the relation between habitat structure and Karner blue butterfly populations. This entails a complex set of research issues, which may include: (a) determine why some sites support extremely high densities of the Karner blue (e.g., the Crossgates Mall site and numerous sites in the western part of the species range); (b) determine how the butterflies react behaviorally to their habitat; (c) develop a better understanding of the role of ants in Karner blue butterfly populations e.g., further examine the role of ants relative to parasitism and predation of eggs and larvae, and (d) determine the relation between nectar availability and female fecundity. It is not possible to anticipate all of the needed information on the ecology of

develop positive interactions with people to enlist their support in developing and maintaining butterfly habitat.

5.33 Browse thresholds

Determine browsing thresholds on lupine by deer and woodchucks that present significant problems to persistence of lupine and acceptable Karner blue habitat in New Hampshire, New York, and Minnesota.

5.34 Re-establishment of lupine

Determine how lupine re-establishes on sites where a tree canopy has been opened and where lupine was not known to occur before the canopy was opened by evaluating the relative importance of a seed pool, rootstock survival, and recolonization. Determine how fire, light regime, and soil moisture interact to affect lupine abundance over successional time scales. This research should be designed to be directly applicable to those areas where lupine establishment has been problematic (e.g., the Albany Pine Bush).

5.35 Population structure

Determine actual/potential Karner blue metapopulation structure at highly fragmented sites to project how these metapopulations may persist as viable metapopulations, focusing on metapopulations in the Merrimack/Nashua River System RU, the Glacial Lake Albany RU, the Ionia RU, West Gary in the Indiana Dunes RU, and the Morainal Sands RU.

5.36 Taxonomic research

Determine if *Lycaeides melissa saene if*

could affect lupine growth as well (Tom Givnish, UW-Madison, pers. comm. 2002).

6. Review and track recovery progress

6.1 Develop a clearinghouse for Karner blue data, progress reports, metapopulation plans, HCPs, guidance documents, and other relevant information

Easy access to relevant Karner blue information will be essential for success of the Karner blue recovery process. A single collection and distribution point, with a commitment to providing relevant planning and educational materials will streamline this process and will facilitate Karner blue recovery. Currently, the Service's Green Bay Field Office (GBFO) in Wisconsin is maintaining a collection of research and outreach materials related to the Karner blue. The GBFO should also develop and maintain appropriate forms to track the recovery of each metapopulation.

6.2 Conduct Recovery Team meetings every 2-3 years to evaluate progress

Successful recovery of the Karner blue will require adaptive management and oversight. Meetings of the Recovery Team and interested parties will allow the Team members to review progress, learn of new research, review the impact of management practices on the Karner blue, discuss unanticipated developments, revise strategies, revise guidance documents and adjust priorities on an as needed basis. This would help ensure that Karner blue recovery stays on track. Meetings should start one year after publication of the final approved Recovery Plan. Additional meetings to address recovery-related issues as they arise may be appropriate as well (refer to Task 6.3 below).

6.3 Revise Plan as appropriate

The Karner Blue Butterfly Recovery Plan cannot address every future development and contingency. As such, it will likely need to be revised/updated at regular intervals to better reflect current conditions, and incorporate new research findings. Revisions should be made every five years or sooner as appropriate.

A priority issue is the re-evaluation of the status of the Karner blue in Wisconsin

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6.4 Hold periodic meetings to promote recovery and information sharing

Sharing information on Karner blue research, habitat management techniques, monitoring, and adaptive management efforts in a forum that allows for discussion, problem solving, and assessment of effectiveness is important to recovery. State working groups should take the lead on working on recovery goals related to their state and meet on annual basis. Recovery partners and other interested parties including private land owning stakeholders should be involved in meetings as appropriate. Put state working group leaders on a web site.

Table 5. Research that is NOT a priority for recovery.

I.	GENETIC STRUCTURE
	1. Determine the genetic structure of the Karner blue butterfly range wide.

Although there is some controversy about whether the Saratoga Airport population is a viable population, it is widely recognized that expansion of that population into nearby habitat is needed and would buffer the population against any disaster that might occur at the airport. Because current efforts are being made to expand this population into nearby habitats, the issue is probably moot. If expansion becomes difficult, it will be necessary to develop a management plan that would ensure persistence of this

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PART III. IMPLEMENTATION

The following Implementation Schedule outlines actions and estimated costs for the recovery program in the United States portion of the Karner blue butterfly's range for the next three years. It is a guide for meeting the objectives discussed in PART II, RECOVERY OBJECTIVE.

The Implementation Schedule lists and ranks recovery tasks, provides task descriptions and duration, identifies responsible agencies, and provides estimated costs. This schedule will be reviewed periodically until the recovery objective is met, and priorities and tasks will be subject to revision. Tasks are presented in order of priority.

Key to Implementation Schedule

Column 1: Task Priority

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Column 6: Other

This lists the other agencies, organizations, and participants that are expected to be involved in completing the task. A key to the acronyms is provided here. KBB = Karner blue butterfly.

AZA	American Zoological and Aquarium Association and members
APBPC	Albany Pine Bush Preserve Commission
CC	City of Concord, New Hampshire
CPBIT	Concord Pine Barrens Interagency Team (TNC, USFWS, NH Natural Heritage Inventory, and NHDFG)
DATCP	Department of Agriculture, Trade and Consumer Protection (Wisconsin)
DOD	Department of Defense (Fort McCoy and/or Air National Guard Hardwood Range)
FAA	Federal Aviation Administration
IDNL	Indiana Dunes National Lakeshore
INWG	Indiana (KBB) Working Group (USFWS, TNC, IDNL, USGS-BRD INDNR)
INDNR	Indiana Department of Natural Resources
LG	Local governments
MNDNR	Minnesota Department of Natural Resources
MIDNR	Michigan Department of Natural Resources
MIWG	Michigan (KBB) Working Group (MNFI, MIDNR, Huron-Manistee NF, USFWS, North Central Forest Experiment, TNC, Michigan State University at East Lansing)
MNFI	Michigan Natural Features Inventory
NHDFG	New Hampshire Department of Fish and Game
NPS	National Park Service
NRCS	National Resource Conservation Service (USDA)
NYDEC	New York Department of Environmental Conservation
NYWG	New York (KBB) Working Group
OFA	Other Federal Agencies (e.g., U.S. Environmental Protection Agency, U.S. Department of Housing and Urban Development, Federal Highway Administration)
OHDNR	Ohio Department of Natural Resources
OPRHP	Office of Parks, Recreation and Historic Preservation (NY)
OTHERS	Other willing landowners e.g., utility companies, highway departments, private landowners, WI HCP partners, etc.
RT	Recovery Team
TNC	The Nature Conservancy
UNIV	University(s)
USGS-BRD	U.S. Geological Survey, Biological Resource Division
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WDNR	Wisconsin Department of Natural Resources
WWPP	Wilton Wildlife Preserve and Park

Columns 7-9: FY1, FY2, and FY3

The estimated cost for carrying out the task during fiscal year 1 (FY1), fiscal year 2 (FY2), and fiscal year 3 (FY3). Costs are listed in thousands of dollars. TBD means costs are yet to be determined.

Column 10: Comments

Explanatory comments. For more detailed information, refer to RECOVERY TASKS (PART II).

HCP	Habitat Conservation Plan
P1	Priority 1 task
P2	Priority 2 task
P3	Priority 3 task
RU	Recovery Unit
TBD	To be determined
WMA	Wildlife Management Area

Table 6. Implementation table for the Karner blue butterfly recovery plan**.**

	RESPONSIBLE PARTY	COST ESTIMATES ($000)

	RESPONSIBLE PARTY	COST ESTIMATES ($000)

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				USFWS		OTHER	Year 1	Year 2	Year 3	
				REGION	PROGRAM					
1	5.11	Research – Habitat management relative to Karner blue butterfly	5+	3, 5	ES	NYDEC, CPBIT, MNDNR, WDNR, MIDNR,				

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY		COST ESTIMATES ($000)			
				USFWS					

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				USFWS		OTHER	Year 1	Year 2	Year 3	
				REGION	PROGRAM					

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				USFWS		OTHER	Year 1	Year 2	Year 3	
				REGION	PROGRAM					
2	1.315	Develop protection and management plans for Wisconsin	3	3	ES, NWR	WDNR, TNC, DOD, OTHERS	20	10	5.5	Includes revising management and/or master plans for county, state, and Federal properties
2	1.321.3	Implement the management plan in New York	5+	5	ES	NYDEC, TNC (NY), LG, OTHERS	100	100	100	Land acquisition needed
2	1.321.4	Implement the management plan in Wisconsin	5+	3	ES, NWR	WDNR, OTHERS, TNC , NPS, DOD,	48	63.5	63.5	
2	1.321.5	Implement the management plan in Indiana	5+	3	ES	IDNL, TNC, OTHERS	15	15	15	
2	1.321.6	Implement the management plan in Michigan	5+	3	ES	USFS, MNFI, DNR, OTHERS	170	170	170	Implement plan in 4 RUs
2	1.322.1	Implement long term land protection strategies in New Hampshire	3+	5	ES, NWR	NHDFG, TNC, FAA, OTHERS	5	5	250	Some land acquisition possible in 3rd year
2	1.322.3	Implement long term land protection strategies in Indiana	5+	3	ES	TNC, OTHERS, IDNL	500	500	500	Estimated land purchases

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				USFWS		OTHER	Year 1	Year 2	Year 3	
				REGION	PROGRAM					
2-3	1.322.4	Implement long term land protection strategies in Michigan	5+	3	ES	USFS, MIDNR, MNFI, OTHERS	15	56	50	Ionia RU-P2
2	2.213	Initiate translocation efforts in New York	5+	5	ES	NYDEC, TNC	0	0	50	
2	3.1	Continue development of Karner blue Forest Management Guidelines	3	3	ES	WDNR, , USFS, UNIV, OTHERS	4	3	4	

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				USFWS		OTHER	Year 1	Year 2	Year 3	
				REGION	PROGRAM					
2	5.25	Research - Forest management research	5+	3	ES	WDNR, USFS, MNFI, OTHERS, USGS-BRD, UNIV	0	32	45	Identify and implement beneficial management practices, especially in red pine
2	5.26	Research - Highly dispersed metapopulations	5+	3, 5	ES	WDNR, OTHERS, UNIV	20	20	20	Identify appropriate management
3	1.316	Develop protection and management plans for New Hampshire	3	5	ES, NWR	NHDFG, TNC, FAA, CC	2.5	0.5	0.5	Minimal cost to update existing plans
3	1.322.5	Implement long term land protection strategies in Wisconsin	5+	3	ES, NWR	WDNR, OTHERS, NPS	5	15	5	State Natural Area designations and pursuit of conservation agreements
3	1.322.6	Implement long term land protection strategies in Minnesota	5+	3	ES	MNDNR	2	2	2	Coordinate activities in Whitewater WMA
3	1.323.1	Implement the monitoring strategies in New Hampshire	5+	5	ES	TNC	1.5	1.5	1.5	

				RESPONSIBLE PARTY	**COST ESTIMATES ($000)**	

PRIORITY #	
3	

RESPONSIBLE PARTY

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				USFWS		OTHER	Year 1	Year 2	Year 3	
				REGION	PROGRAM					
3	5.32	Research - Effects of human activities	3+	3, 5	ES	NYDEC, WDNR, TNC, MNFI	15	15	15	Focus on rights-of-way and developed areas
3	5.33	Research - Browse thresholds	2	3, 5	ES	NYDEC, MNDNR, DOD, USFS, APBPC	5	5	0	Deer and woodchuck

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				USFWS		OTHER	Year 1	Year 2	Year 3	
				REGION	PROGRAM					
3	6.4	Hold periodic meetings to promote recovery and information sharing	*	3, 5	ES	AZA,WDNR, MIWG, INWG, MNDNR,				

APPENDICES

APPENDIX A

GLOSSARY

ACCELERATED COLONIZATION: Moving Karner blue butterfly eggs, larvae, pupae, or adults from an occupied site to an unoccupied site of suitable habitat within the same metapopulation. Also called accelerated dispersal (refer also to APPENDIX I).

ACT: Endangered Species Act as amended in 1973.

ADAPTIVE MANAGEMENT: A method of using known information, hypotheses, and information gained while managing a system to alter management practices so that the management objectives can be more readily attained. Adaptive management may be used to improve the management system in a relatively risk-free way, it can be used to reduce management risk and uncertainty, or it can be used to choose among management alternatives with unknown or uncertain effects. This last use is also called experimental management.

AUGMENTATION: Moving eggs, larvae, pupae, or adults from an occupied site within a metapopulation to another occupied site (subpopulation) within that same metapopulation that has low numbers in order to keep the metapopulation at viable levels (refer also to APPENDIX I).

Bt: Insecticidal formulations with *Bacillus thuringiensis*.

Btk: Insecticidal formulations with *Bacillus thuringiensis kurstaki*.

CAPTIVE REARING: Raising eggs, larvae, or pupae collected from wild subpopulations to an older stage for release back into the wild. This could also be called head-starting.

CAPTIVE PROPAGATION: Producing life stages for release from a permanently captive breeding colony. Part of the progeny would be released in the wild, part would be retained to breed and lay eggs in captivity. This method could be used when large numbers of butterflies will be needed for releases over an extended period of time, and we wish to avoid draining the source population.

CORE AREA: A large area of habitat mosaic containing occupied sites that is managed so that the Karner blue is very likely to persist indefinitely, barring unforeseen catastrophe. This area might be 320-1280 acres (0.5-2 mi^2). A core area is smaller than a large viable metapopulation (LP), and can be smaller than a minimum viable metapopulation (VP). Both LPs and VPs can be structured to have a core area that is the intensively managed part of the metapopulation, surrounded by a less intensively managed part of the metapopulation (refer to APPENDIX F).

RESTORABLE HABITAT: An area of habitat with the ecological potential to be managed to

APPENDIX B

RECOVERY UNITS, POTENTIAL RECOVERY UNITS, AND HISTORIC SITES

HISTORIC DISTRIBUTION

The historic northern limit of the butterfly corresponds roughly with the northern limit of lupine (Dirig 1994), but the current distribution indicates that the butterfly has contracted away from this limit. Many of the most northern populations of Karner blue have been

(1994) and were reported to him by Dr. A. Shapiro. The Recovery Team corresponded with Dr. Shapiro, who stated that he could not locate a specimen corresponding with any of his reported Pennsylvania localities. The only confirmed record in Pennsylvania is from Wayne County. Several of the New York records along the Delaware River are confirmed with specimens (Robert Dirig, in litt. 2002), so it is possible that Karner blues occurred in the neighboring areas in Pennsylvania. The New Jersey record may be erroneous, although labeled specimens exist. Schweitzer (Dale Schweitzer, pers. comm. 1996) suggested that the specimens were unlikely to have been collected from New Jersey and may have been mislabeled New York specimens. The record from Brooklyn, New York has been confirmed. The lack of correspondence of the southern limits of the Karner blue and lupine has not been adequately addressed. Dirig (1994) suggested that the southern limit of Karner blue may follow the band of 80-100 days continuous winter snow cover, which he hypothesized was necessary for high overwintering egg survival. Many other hypotheses could explain the southern distribution limit of the Karner blue butterfly.

Despite this uncertainty, similar to the other geographic limits, the distribution of the Karner blue has contracted away from its historic southern limit. Populations have been extirpated from southern New York, Pennsylvania, Ohio, Illinois, and Iowa. In Indiana, the distribution has contracted. Once present throughout northern Indiana, it now occurs only in a few localities in northwestern Indiana, associated with the dune fields and dune and swale complexes near the southern end of Lake Michigan.

RECOVERY UNITS

Recovery Units (RUs) are established to preserve possible geographically associated

the Karner blue, which in turn could be critical in the recovery of the species. In addition, these factors create a complex of ecological conditions that would buffer the species against regional metapopulation declines. These RUs are listed below starting from the eastern part of the butterfly's geographic range to the western part of the range.

It is generally acknowledged that Wisconsin and Michigan now harbor the largest numbers of Karner blues that occur on the greatest amount of area in the historic geographic range of the species. Consequently, these areas become key areas of concern to stabilize the species against further decline and recover the species. Because of the significance of central Wisconsin and western Michigan as the centers of Karner blue abundance, more RUs are established in these regions than in other parts of the range. These multiple RUs in the apparently most suitable habitat for the Karner blue will protect the species against wide-scale declines. In the event that a particularly severe disturbance causes extirpation of Karner blue in one of these RUs, others are likely to remain and harbor metapopulations that eventually can recolonize the extirpated RU.

The 13 RUs are described below. Information reviewed includes each RU's distinguishing ecological features, the status of the Karner blue in the RU, and potential threats to the species. Table B1, below, lists the possible locations of the metapopulations needed for recovery in each RU.

Merrimack/Nashua River System RU (New Hampshire/Massachusetts)

Location

This RU is located in southern New Hampshire and northeast Massachusetts, in six counties (Merrimack, Hillsborough, Rockingham, Belknap, Middlesex and Essex), and is associated with the pine barrens habitats near the Merrimack and Nashua River system. This is the eastern-most extant location for the Karner blue and is separated from the nearest subpopulation by over 100 miles.

Karner blue distribution

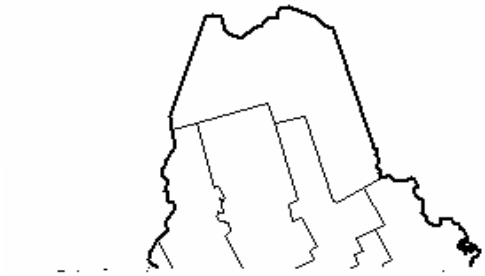
The historic distribution of the Karner blue butterfly in central New England is thought to have covered parts of all of the six counties noted above (Helmbolt and Amaral 1994), and records indicate that it occurred as far north as Webster, New Hampshire. The last native Karner blue population in New England, which occurred in the Concord Pine Barrens in Concord, New Hampshire, was extirpated in 2000.

Threats

All native habitat north and south of Concord has been converted to industrial, commercial, and residential uses that are incompatible with a viable Karner blue metapopulation. Around Concord, the 300 acres of restorable habitat continues to be threatened by development (Helmbolt and Amaral 1994, City of Concord 1996). A retail mall was constructed on the outer edges of the Concord Pine Barrens and will encourage further development of this area (USFWS

Figure B-1. Map showing range-wide recovery units for the Karner blue butterfly.

Figure B-2 Karner blue butterfly recovery units in Massachusetts, New Hampshire and New York.



1. Merrimack/Nashua River System RU
2. Glacial Lake Albany RU

Figure B-3 Karner blue butterfly recovery units in Indiana, Michigan and Ohio.

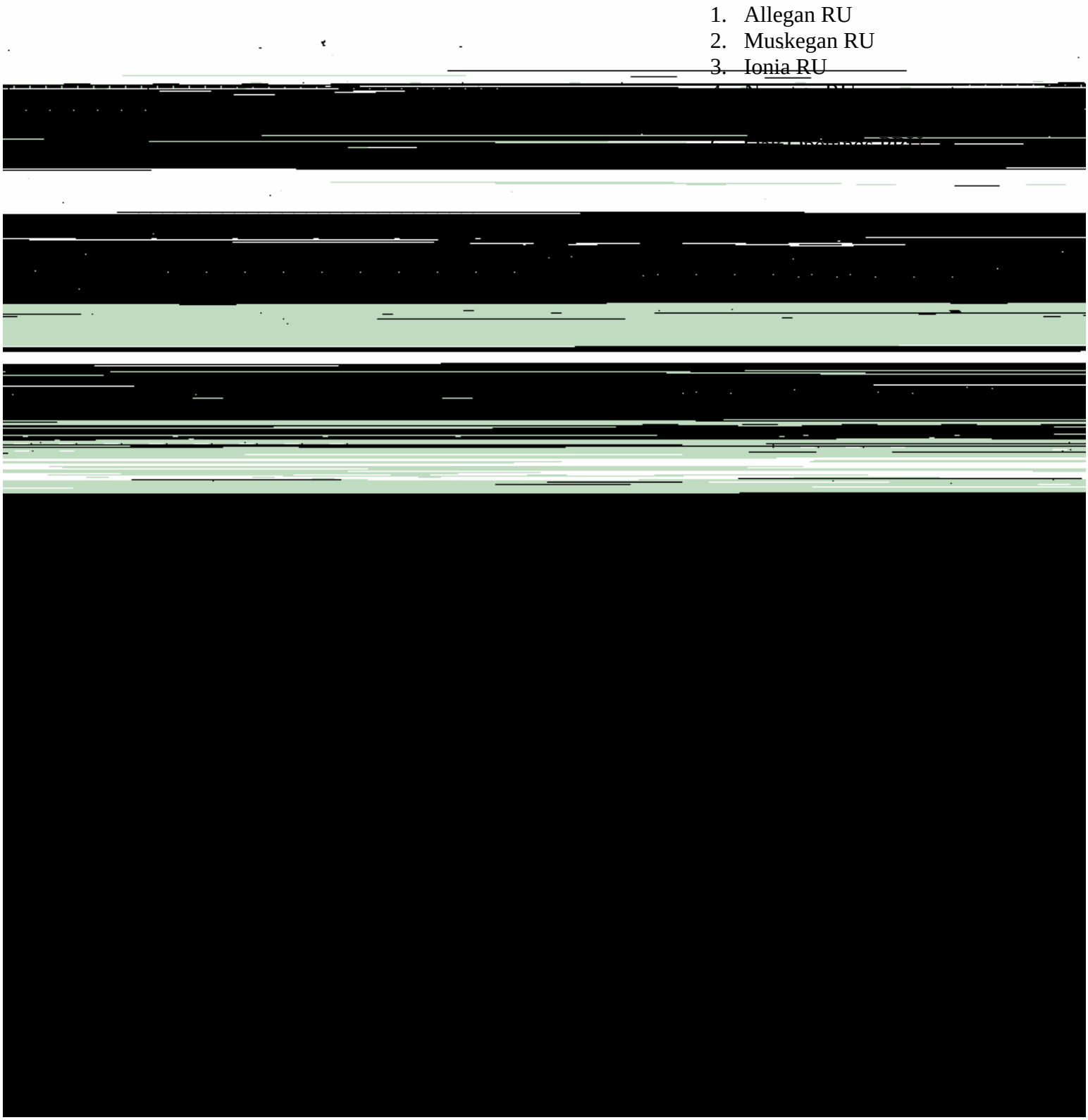
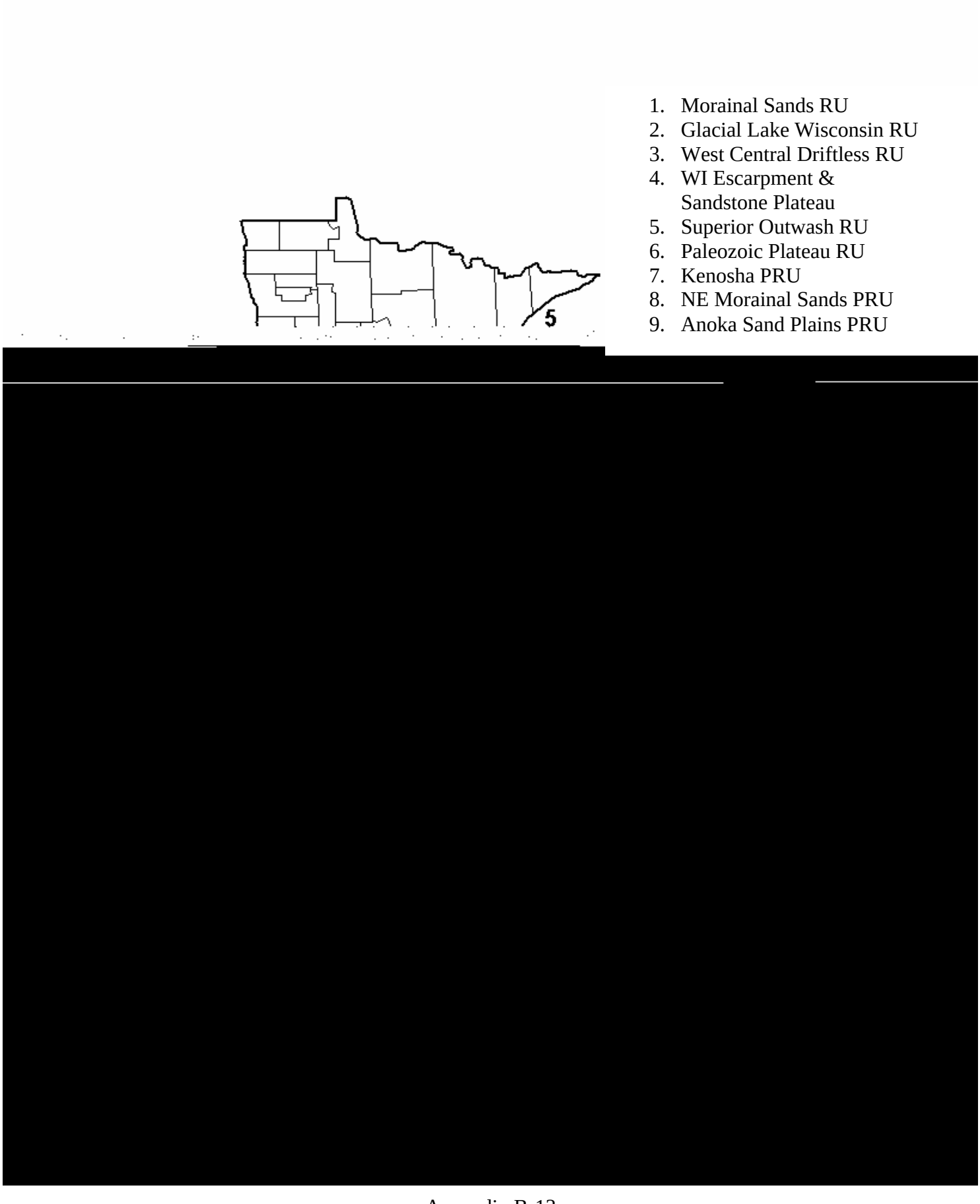


Figure B-4 Karner blue butterfly recovery units in Illinois, Minnesota and Wisconsin.



1992a and 1992b). Road extensions and industrial park expansion have further fragmented and degraded remaining habitat (Michael Amaral, USFWS, pers.comm. 1994). Construction of military facilities has also impacted the area (USFWS, in litt

can be clustered into 56 subpopulations), many of which are extremely small. Three metapopulation areas have been identified: The Albany Pine Bush, Saratoga West, and the Saratoga Sandplains.

Threats

The Saratoga Airport Site, a treeless area maintained by mowing, now supports the largest population in New York, and has remained large for several years. Efforts are underway to connect this population with nearby sites. The major threats to this subpopulation are events that would degrade the uniform habitat. It is vulnerable to weather events, such as drought or storms, or wildfire that could result from airport operations. It is also vulnerable to adverse management conducted contrary to the management agreement for the site. It is important to ensure that occupied suitable habitat occurs nearby so that the airport subpopulation could be repopulated if necessary. Other sites with small subpopulations of Karner blue, including those in the Albany Pine Bush, are threatened by development, isolation from other subpopulations, and/or degradation of habitat. Conservation in the Queensbury area may be helpful in recovering Karner blues in the Glacial Lake Albany RU. While recovering the Karner blue in the Queensbury area is not a goal of this plan it is a state recovery goal.

Protection and management

Several measures have been implemented to protect the Karner blue in the Albany Pine Bush (Pine Bush), Saratoga Sandplains, and Saratoga West areas of New York.

The Albany Pine Bush Preserve Commission (Commission) was established in 1988 by the New York State Legislature to protect the pine bush community. The Commission is cooperatively managed by the landowners in the Pine Bush including New York State DEC, New York State Office of Parks, Recreation and Historic Preservation, the City of Albany, two towns and TNC. A detailed protection and management plan has been developed for the Preserve and has undergone several revisions. An initial trust fund was established from tipping fees at the City of Albany's landfill for Preserve management. Since 1994 funding for the operation of the Commission has been provided by the New York State Environmental Protection Fund, involved municipalities, endowment income, and private and Federal sources. Funding for acquisition and management of the Preserve and review of development projects that affect it are vital contributions to the recovery of Karner blue butterfly in the Pine Bush.

There has been active management for lupine within the Albany Pine Bush for the past seven years. Lupine has been planted in several areas under experimental conditions to study methods for producing effective lupine populations and to establish new lupine populations near remnant butterfly populations. A fire management program was begun in 1990 with the main goal of restoring the pitch pine scrub oak barrens natural community, which historically supported the largest populations of Karner blues in the state. The Commission has a large workforce of volunteers who regularly assist with management and maintenance of the Preserve.

Habitat protection for the Karner blue in the Albany area is also occurring at a few sites in the Town of Guilderland and at the Crossgates Mall owned by Pyramid Corporation. As a

result of a state permit for building the Mall during the late 1980's, a five acre occupied site adjacent to the Mall was set aside and a fund established to provide for management of the site into perpetuity (this subpopulation is now the largest in the Pine Bush Preserve). Expansion of the Mall during the 1990's resulted in the dedication of an additional 10 acres for Karner blue management along a powerline right-of-way adjacent to the original five acres. Management of these sites has included removal of invasive vegetation, planting of lupine and other species associated with the habitat, and fencing to exclude deer and prevent unauthorized entry.

In the Saratoga Sandplains area, the Town of Wilton has agreed to join with the state and Federal agencies and TNC in the creation of the 3000 acre "Wilton Wildlife Preserve and Park" (WWPP), the heart of which will contain a core population of Karner blues. Protection of the butterfly is envisioned through acquisition, easements, and management agreements. The area will be managed for the butterfly and passive recreation (bike/hike/ski trails). As with Albany, the cooperation of the Town of Wilton in reviewing development that might harm recovery efforts in this area will be essential, as will their help with funding. This preserve will add to the protection measures already in place at some small localities in the Town of Wilton and at a camp previously owned by the Boy Scouts of America. The WWPP continues to forge relationships with local businesses and volunteers. Volunteers, WWPP and NYDEC staff have cleaned up two Karner blue subpopulation sites, removed woody vegetation and planted native vegetation using equipment donated by a large hardware store distribution center.

Two Saratoga West sites are protected by memorandums of understanding (MOUs) between the New York State DEC and the managing entities for these sites: Saratoga County Airport (Saratoga County Department of Public Works), and Saratoga Spa State Park (NYS Office of Parks, Recreation, and Historic Preservation). The New York State DEC advises the landowners on best management practices to limit disturbance to the butterflies. Management under the MOUs includes use regulations, mowing regimes and improvement of habitat through plantings. A third site is expected to be protected this year with a similar agreement with the Village of Ballston Spa as the site becomes part of a newly dedicated public park.

Niagara Mohawk Corporation (NIMO) along with the New York State DEC and the Albany Pine Bush Preserve Commission, are actively managing for Karner blues along powerline corridors in New York State. NIMO has undertaken research to characterize lupine habitat along powerlines and to research management impacts to lupine areas. New York is also in the midst of preparing a State Recovery and Management Plan for the Karner blue. TNC has contracted with private nurseries to grow lupine, which, along with nectar plants, is being planted near several extant Karner blue localities in the Glacial Lake Albany RU. Refer also to PART I, CONSERVATION MEASURES, Private Land Initiatives.

Ionia RU (Michigan)

Location

This RU is located in central lower Michigan, in four counties (Kent, Montcalm, Gratiot, and Ionia), and is associated with oak or jack pine barrens scattered through sandy morainal soils near the Flat River. These are medium and coarse textured ground moraines with rolling

topography. Uplands are dominated by beech-sugar maple forest and hardwood swamps that occupy poorly drained sites; this corresponds to ecoregion sub-subsection III.6.1 as described in Albert (1995). It is one of the warmer Michigan RUs, and contains the Flat River SGA.

Threats

The major threats in this RU are habitat loss from agriculture, extreme soil scarification from farming, and intensive logging followed by burning. The most immediate threat is potential disruption of occupied sites at the Flat River SGA by ORV use, especially during the winter.

Protection and management

Several management considerations have been developed for the Flat River SGA (Cuthrell and Rabe 1996). Refer also to PART I, CONSERVATION MEASURES, Private Lands Initiatives.

Allegan RU (Michigan)

Location

This RU is located in southwest Michigan, in five counties (Muskegon, Ottawa, Allegan, Van Buren, and Berrien), and is associated with oak or white pine barrens scattered through the Allegan lake plains. It corresponds to ecoregion subsection III.5 as described in Albert (1995). The climate is unique, being warm and strongly influenced by Lake Michigan. As a result, there is a long growing season with reduced daytime temperatures and considerable fall and winter precipitation. Northern floristic elements occur further south and southern floristic elements occur further north in this RU than areas further inland. Allegan SGA occurs in this RU.

Threats

Nectar may be limiting during the second flight period (Lawrence and Cook 1989). Habitat degradation from shading by closed canopies is probably the major threat (Wilsmann 1994).

Protection and management

Restoration work at the Allegan SGA has included selective diameter cuts in oak woodlands adjacent to known Karner blue populations to facilitate the restoration of oak-pine barrens and expansion of butterfly habitat (Michigan DNR 1994). Refer also to PART I, CONSERVATION MEASURES, Private Lands Initiatives.

Newaygo RU (Michigan)

Location

This RU is located in west central Michigan, in six counties (Mason, Lake, Oceana, Newaygo, Mecosta, and Montcalm), and is associated with oak or white pine barrens scattered throughout the Newaygo outwash plain and sandy terminal moraines. It corresponds to ecoregion subsection IV.3 as described in Albert (1995). Topography is relatively flat and the climate is colder and more variable than the other Michigan RUs. Oaks and pines dominate the

optimizing the 60-acre Ivanhoe dune and swale site in West Gary, last occupied by the Karner blue in 1996 or 1997 (John Shuey, TNC, pers. comm. 2002), and restoring additional unoccupied land at the preserve. Several acres of overgrown oak barrens have been thinned, over 2000

moraines to steeper, hummocky terminal moraines. Sandy soils predominate but are also diverse in glacial origin. Floristically, this RU was originally dominated by oak forest with high levels of northern pin oak, and areas of oak savanna and tallgrass prairie on outwash plains. Climatically, this area has a longer growing season (120-150 days) and more precipitation than either the Glacial Lake Wisconsin or West Central Driftless RUs.

Karner blue butterfly populations in this RU are more widely scattered, small and fragmented than in other RUs in Wisconsin. The largest population in this RU occurs in a complex of state and private lands in Portage County.

Threats

Threats include habitat fragmentation and loss from agricultural, residential and commercial developments, silvicultural activities, and succession to closed canopy resulting from lack of appropriate disturbance through management. It will be important to work with forest land managers to encourage modification of management practices to ensure persistence of the Karner blue butterfly. It will be especially important to work with private landowners in this RU to restore and manage habitat, and to create effective dispersal corridors for the butterfly.

Protection and management

Management for Karner blues is underway to restore a viable metapopulation at a complex of three properties in Waupaca County: Hartman Creek State Park, Emmons Creek Fisheries Area (FA), and on adjacent private lands (Welch Tract). A 65-acre restoration including the planting of lupine and prairie forbs is underway at Emmons Creek FA. Mr. Welch, an adjacent private landowner is actively engaged in oak savanna restoration and management for the Karner blue and other rare species on about 100 acres of land. He and the Service (through the Partners for Fish and Wildlife Program) are working successfully with other private landowner in the area on habitat restoration projects for the Karner blue as well. Mr. Welch's education and outreach activities play a significant role in the recovery of the Karner blue in this RU.

Habitat restoration work is also on-going at the White River Marsh and Greenwood State WAs to expand and/or manage habitat. The Service's Partners for Fish and Wildlife Program has provided assistance for habitat restoration work at the White River Marsh State WA.

Glacial Lake Wisconsin RU (Wisconsin)

Location

This RU is located in central Wisconsin, in seven counties (Jackson, Wood, Portage, Waushara, Adams, Juneau, and Monroe), and is associated with glaciolacustrine deposits from Glacial Lake Wisconsin. This RU corresponds to ecoregion sub-subsections V.1.2 and V.1.3 as described in Albert (1995). Topography is flat to gently rolling. Soils are formed primarily on outwash and lacustrine sand, and include large areas of poorly drained mineral and organic soils sometimes intermingled with well drained Plainfield and Friendship sands. In the eastern half,

Plainfield sands predominate. Floristically, this RU includes the most extensive areas of marsh and sedge meadow in the state, and many Atlantic Coastal Plain elements. Tamarack and black spruce were dominant in poorly drained areas. Jack pine and pin oak dominated the droughty soils, varying from closed canopy forests to open barrens. Climatically, this RU has the shortest growing season of the central Wisconsin RUs (shorter than 120 days in low areas subject to late spring and early fall frost), and lower winter snowfall.

One of the larger complexes of local populations in this RU is at Necedah NWR. Other sites with the potential to support larger populations include Meadow Valley and Sandhill State WAs. Several of the sites that support viable metapopulations are on publicly administered lands, which will facilitate long-term protection and management (Bleser 1993). Some land east

glaciated. Soils include the very droughty, infertile Tarr and Boone sands in Jackson and Monroe counties, influenced by loess deposits and underlying Cambrian sandstones. Soils in this RU are the most infertile of all the Wisconsin RUs and less productive than those of the Glacial Lake Wisconsin and Morainal Sands RUs. Floristically, jack pine–northern pin oak barrens were prevalent on the sand plains, while the sandstone plateau supported a mosaic of oak forest, oak savanna, and oak brushlands with tallgrass prairie on ridge tops and on south/southwest slopes. Climatically, this RU has a longer growing season than the Glacial Lake Wisconsin RU. The growing season can be longer than elsewhere in the central sands region of Wisconsin, as long as 170 days. Annual average precipitation is lower in this RU than it is in the

barrens; uplands surrounding these terraces supported various dry to mesic forest types, oak savanna and oak brushlands with tallgrass prairie on ridge tops and south/southwest slopes.

the Kohler-Peet Barrens area in the Governor Knowles State Forest. Several of the sites that may be supporting viable metapopulations are on publicly administered lands, which will facilitate long-term protection and management (Bleser 1993).

Threats

Habitat loss has occurred for reasons similar to those in the previous three RUs. Threats at Fish Lake and Crex Meadows WA include woody encroachment (e.g., hazel and blueberry), and frost damage.

Protection and management

Active management for the Karner blue is underway at Glacial Lakes Grantsburg Work Unit (Crex Meadow and Fish Lake State WA) in this RU.

Paleozoic Plateau RU (Minnesota)

Location

This RU is located in southeast Minnesota, in nine counties (Dakota, Goodhue, Wabasha, Dodge, Olmstead, Winona, Mower, Fillmore, and Houston), and is associated with oak savanna-barrens subtype habitat primarily on Plainfield sand deposits along river terraces in an unglaciated region with considerable topographic relief, corresponding to ecoregion subsection II.5 as described in Albert (1995). Floristically, the dominant trees in the savanna are black oak and jack pine. This is the closest locality of Karner blues to the known distribution of *Lycaeides melissa melissa*, the Melissa blue butterfly. The climate is cold and variable with high precipitation. In this RU, the Karner blue butterfly now occurs only in the Whitewater WMA (Lane and Dana 1994).

Threats

The major threat to the Whitewater WMA population is habitat degradation from succession. In other parts of the RU, such as east-central Minnesota, some habitat is protected from development or conversion, but it has not been managed in ways conducive to creating and maintaining habitat for Karner blue butterfly. Parts of these areas are being developed rapidly for commercial and residential uses that are incompatible with the Karner blue.

Protection and management

The Minnesota DNR is implementing a management plan at the Whitewater WMA (Lane 1994) to conserve and protect the Karner blue. Work thus far has included a deer browse study, and habitat restoration work including tree girdling and burning. A project to accelerate colonization was begun at the WMA in 1999 (refer to PART I, CONSERVATION MEASURES, Reintroduction/Translocation).

POTENTIAL RECOVERY UNITS

Potential RUs are areas in which the Karner blue occurred historically or may exist in low numbers [Northeast Morainal Sands (Wisconsin) and Kenosha (Wisconsin/Illinois) potential RUs], and in which sufficient restorable and suitable habitat occurs that potentially could support a viable metapopulation of Karner blue butterflies. Because the actual historic distribution of the Karner blue was probably much more extensive than that indicated by confirmed historic distribution records, this listing of potential RUs probably underestimates considerably a complete listing of potential RUs. Six potential RUs are identified in this plan (Refer to Figures B1-B4).

This plan identifies no recovery goals for potential RUs. However, recovery in these

9,000 acres within a 150 square mile area and is owned by five governmental and non-profit organizations. Four hundred acres are being actively managed to improve native habitat, but no site is larger than 100 acres. The Ohio Division of Natural Areas and Preserves, Toledo Metroparks, The Nature Conservancy, and other agencies are restoring portions of the Oak Openings.

Protection and management

In 1998, the Ohio DNR, Division of Natural Areas and Preserves finalized the "Ohio Conservation Plan for the Karner Blue Butterfly" (Ohio DNR, 1998). As part of Ohio's conservation efforts, the Ohio DNR, Toledo Zoo, Michigan DNR, and TNC are working jointly on a project to reintroduce the Karner blue to the oak openings of northwest Ohio (refer to PART I, CONSERVATION MEASURES**,** Reintroduction/Translocation).

Kenosha Potential RU (Wisconsin/Illinois)

Location

This potential RU is located in northeast Illinois and southeast Wisconsin, in Lake (Illinois) and Kenosha (Wisconsin) counties, and is associated with lake deposit sands. Seemingly high quality Karner blue habitat is protected in several state and county parks, but the total area available is limited and may not be sufficient to support a viable metapopulation. Although the Karner blue butterfly was considered extirpated from this potential RU in 1992 (when the last butterfly was seen), Melissa Pierson a butterfly surveyor, recorded one Karner blue from Illinois State Beach Park in August of 2001 (Kris Lah, USFWS, in litt. 2001).

Protection and management

Efforts are underway to restore the Karner blue to Illinois State Beach Park (Park) in Lake County, which occurs within this potential RU. The Park supports an array of habitat types including oak savannas and remnant native prairies. The Illinois Department of Natural Resources (DNR) has restored habitat at Illinois Beach State Park and the Spring Bluff Forest Preserve, located north of the Park with the goal eventually of reintroducing Karner blue butterflies to the Park. This work was funded during 1996-1998 by the U.S. Environmental Protection Agency's (EPA) Great Lakes National Program Office. Additional funding will be needed in subsequent years to continue the restoration work and to proceed with reintroduction of the Karner blue if still considered appropriate.

Northeast Morainal Sands Potential RU (Wisconsin)

Location

This potential RU is located in northeast Wisconsin, in four counties (Menominee, Oconto and Shawano and Marinette), and is associated with stagnation moraine and glacial

barrens and narrow terminal moraine ridges separated by outwash with sandy soils, has higher snowfall than other Wisconsin RUs, and very cold winters. Wild lupine reaches its northeastern geographic limits in Wisconsin in this potential RU. This is the only known contact area with *Lycaeides idas*, the northern blue butterfly. Karner blues occur on Menominee Indian Tribal lands in this RU.

Protection and management

Educational and information presentations on the Karner blue have been given to the Menominee Indian Tribe. The Service and other agencies have assisted with Karner blue butterfly surveys.

Anoka Sand Plain Potential RU (Minnesota)

Location

This potential RU is located in east central Minnesota, in fourteen counties (Morrison, Mille Lacs, Kennebec, Pine, Stearns, Benton, Sherburne, Isanti, Chisago, Anoka, Washington, Hennepin, Ramsey, and Dakota), and is associated with an outwash plain from glacial meltwaters and outwash terraces of the Mississippi River. This corresponds to ecoregion subsection II.3 as described in Albert (1995). This is the western-most historical geographic occurrence of the Karner blue. This relatively flat area is dominated by bur oak and northern pin oak on sandy soils and is floristically distinct from the Paleozoic Plateau RU and the Superior Outwash RU. Climate here is cooler and drier than the Paleozoic Plateau RU to the south.
Protection and management

Surveys for the Karner blue butterfly have been done at Sherburne NWR, but no Karner blue butterflies have been sighted here to date.

RECOGNIZED HISTORIC SITES

The historic distribution of Karner blue probably included all savanna and barrens habitats that could support lupine and that are within the historic and currently known range of Karner blue butterfly. In addition, it is possible that the distribution extended further north, east and south, at least for some periods of time. Thus, this listing of historic sites, which is based on confirmed records of existing specimens, probably underestimates considerably a realistic listing of actual historic sites. Ten recognized historic sites have been identified. The New Jersey sites, which are commonly considered to be historic sites, are not recognized here, although this decision is scientifically debatable.

There are no recovery goals for historic sites. These sites in are considered nonessential for the recovery of the species, and beyond this listing TceRwithumRmomee

Norway Barrens Historic Site (Maine)

This site is located in the former Norway Barrens near Norway, Maine. A specimen was recorded from this locality prior to 1874. No restorable communities remain, and no contemporary record of Karner blue exists in this region.

Watertown (Clayton) Historic Site (New York)

This site is located near Watertown, New York.

Brooklyn Historic Site (New York)

This site is located in Brooklyn, New York. Intense urban development eliminates the possibility for recovery at this site.

Sullivan/Delaware Historic Site (New York/Pennsylvania)

This site is located in Pennsylvania (Wayne and possibly Luzerne, Pike, and Clinton counties), and New York along the upper reaches of the eastern branch of the Susquehana River and the upper Delaware River. This site is geologically dissimilar to other sites supporting or considered to have the potential to support the Karner blue elsewhere. It is speculated that the original habitat of Karner blue was riverside gravel/ sandy areas periodically scoured by floods of the Delaware River. The headwater dams on both branches of the Delaware would have reduced this means of producing open habitat for lupine and Karner blue. Currently, the riverside lands are either very steep or flat with considerable residential and recreational use, and no suitable habitat base remains.

Maumee Lake Plain Historical Area (Michigan)

This area is located in southeast Michigan, in six counties (Monroe, Lonawee, Wayne, Washtenaw, Macomb and Oakland). It is probably ecologically continuous with the Oak Openings Potential RU and extirpated sites in Ontario. This area has sandy soils, and is heavily urbanized and suburbanized by Detroit and associated municipalities.

La Grange County Historic Site (Indiana)

eliminated almost all potential Karner blue habitat. Extensive restoration would be necessary to re-establish the Karner blue butterfly here.

Kendell County Historic Site (Illinois)

This site is located in northeast Illinois, in Kendell County.

Iowa Historic Site (Iowa)

This site is located in northeast Iowa and possibly was contiguous historically with the Paleozoic Plateau RU.

Note: Historic sites also occur in Ontario, Canada and can be noted on Figure B1.

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Table C1. (continued)

Scientific name	Common name	Location	Reference
Pedicularis canadensis L.	Lousewort	WI	2,14
Phlox pilosa L.	Downy phlox	IN	8,15
Potentilla recta L.	Rough-fruited cinquefoil	WI	2
Potentilla simplex Michx.	Common cinquefoil	WI,MI,IN	2,7,13,14,15
Potentilla sp.	Cinquefoil	MI,NY	3,11
Rosa carolina L.	Carolina rose	IN	15
Rumex acetosella L.	Sheep sorel	WI	2
Senecio pauperculus Michx.	Ragwort	WI	7
Senecio sp.	Ragwort	WI	2,9
Smilacina racemosa (L.) Desf.	False spikenard	WI	2,7
Smilacina stellata (L.) Desf.	Star-flow. fals. sol. seal	WI	2,14
Solidago sciaphila Steele	Cliff goldenrod	WI	7
Tephrosia virginiana (L.) Pers.	Goat's rue	NY	3
Tradescantia ohiensis Raf.	Spiderwort	IN	15
Trifolium hybridum L.	Alsike clover	WI	2,14
Trifolium pratense L.	Red clover	WI	7
Trifolium repens L.	White clover	WI	2
Viccia villosa Roth.	Hairy vetch	WI	2
Viola pedata L.	Bird foot violet	NY,WI	2,3,13
Zizia aurea (L.) Koch	Golden alexanders	WI	2
	----------Woody species----------		
Amelanchier sp.	Juneberry	ON	10
Ceanothus herbaceus (ovatus) Raf.	Red root	WI	7
Ceanothus sp.	New jersey tea	WI	2
Physocarpus opulifolius (L.) Maxim.	Common ninebark	WI	7
Prunus sp.	Wild plum	NY	3
Rubus allegheniensis Porter	Blackberry	WI	7
Rubus flagellaris Willd.	Dewberry	IN,MI,WI	7,6,8,13,15
Rubus sp. or sPP. (IN)	Bramble	IN,MI,MN,WI	2,5,8,11,9,14,15
Salix humilis Marsh.	Prairie willow	WI	2, 7
Vaccinium sp.	Blueberry	NY,IN	3,15
Vitis riparia Michx.	River grape	MN	5

Table C1. (continued)

Scientific name	Common name	Location	Reference
Oenothera sp.	Evening primrose	WI	2,13
Petalostemon candidum (Willd.) Michx.	White prairie clover	WI	2,7,9
Petalostemon purpureum (Vent.) Rydb.	Purple prairie clover	WI	2,7
Phlox pilosa L.	Downy phlox	IN	15
Polygala polygama Walt.	Racemed milkwort	MI	11
Polygonum sp.	Knotweed	WI	2,14
Potentilla recta			

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APPENDIX D

ASSOCIATED FEDERAL AND STATE IMPERILED SPECIES

The following tables (Tables D1-D6) list the Federal and state imperiled species associated with Karner blue habitat in each state that has a recovery goal for Karner blue. These tables were compiled by an appropriate state authority based on state records. These lists are not comparable among the states for several reasons. Each state has placed different amounts of effort into surveying Karner blue habitat, so some states have more complete information than others. Moreover, some states have limited (to some extent) their lists to those species likely to be associated with habitat actually occupied by Karner blue, while others have not. Finally, many states have listed species that are likely to occur within or adjacent to Karner blue butterfly habitat, but because the adjacent habitats are different in different states, the included species are variable. These lists indicate the tremendous biological variability that exists across the geographic range of the Karner blue, and suggests that recovery of the Karner blue might help maintain other rare and imperiled species that share its habitat.

Table D1. New Hampshire imperiled species associated with Karner blue habitats. Data provided by the New Hampshire Natural Heritage Inventory.

Scientific Name	Common Name	State Status	Federal Status
----------Rare Invertebrates----------			
Acronicta lanceolaria	a dagger moth	S3	
Agrotis stigmosa	a noctuid moth	SU	
Anomogyna elimata		S3/S4	
Aphantesis carlotta		SU	
Apharatera purpurea	a noctuid moth	S2	
Apodrepanulatrix liberaria		S1/S2	
Atrytonopsis hianna	dusted skipper	S3?	
Catacola sp.		S1/S2	
Cerma cora	a bird dropping moth	S1/S2	
Chaetaglaea cerata	a noctuid moth	S2/S3	
Chaetaglaea tremula	a noctuid moth	S?	
Chytonix sensilis	a noctuid moth	S1/S2	
Cucullia speyeri		S3	
Erastria coloraria	a bird dyi.o24.oo	S?	

Table D1 (continued). New Hampshire imperiled species associated with Karner blue habitats. Data provided by the New Hampshire Natural Heritage Inventory.

Scientific Name	Common Name	State Status	Federal Status
Incisalia irus	Frosted elfin	E	
Lapara coniferarum		S1/S2	
Lithophane thaxteri		SU	
Lycia rachelae		S2	
Metarranthis apiciaria		S1	
Papaipema lysimachiae	a noctuid moth	SU	
Platyperigea meralis		S1	
Satyrium edwardsii	Edward's hairstreak	S3	
Xylena thoracica		S2	
Xylotype capax		S2	
Zale curema		S2	
Zale submediana		S2	
Zanclognatha martha	a noctuid moth	T	
----------Rare Vascular Plants----------			
Asclepias amplexicaulis	a milkweed	T	
Hudsonia ericoides	golden heather	T	
Lupinus perennis	blue lupine	T	

State Status Codes: E=endangered, T=threatened, S1 = critically imperiled, S2 = imperiled, S3 = rare or uncommon, SH = historical, SU = possibly in peril.

Table D2. New York imperiled species associated with Karner blue habitats. Data provided by the New York Natural Heritage Program.

Scientific Name	Common Name	State Status	Federal Status
----------Rare Birds----------			
Accipiter cooperii	Cooper's hawk	SC	
Buteo lineatus	Red-shouldered hawk	SC	
Caprimulgus vociferus	Whip-poor-will	SC	
Chardeiles minor	common nighthawk	SC	
Vermivora chrysoptera	Golden-winged warbler	SC	
----------Rare Reptiles and Amphibians----------			
Carphophis amoenus	Worm snake	SC	
Clemmys guttata			

Table D3 (continued). Michigan associated imperiled species

Scientific Name	Common Name	State Status	Federal Status
Psilocarya scirpoides	bald rush	T	
Pycnathemum verticillatum			

Table D4 (continued). Indiana associated imperiled species

Scientific Name	Common Name	State Status	Federal Status
Hesperia leonardus	Leonardus skipper	R	
Lycaena xanthoides	great copper	SU	
Problema byssus	bunchgrass skipper	R	
Schinia indiana	phlox moth	SU	FSC
Schinia gloriosa	glorius flower	SU	
----------Rare Vascular Plants----------			
Amelanchier humilis	running serviceberry	E	
Arctostaphylos uva-ursi	bearberry	R	
Arenaria stricta	Michaux's stitchwort	R	
Aristida intermedia	slim-spike three-awn grass	R	
Buchnera americana	bluehearts	E	
Carex crawei	crawe sedge	SC	
Carex richardsonii	Richardson sedge	E	
Carex brunnescens	brownish sedge	E	
Carex aurea	golden-fruited sedge	R	
Carex eburnea	ebony sedge	R	
Carex garberi	elk sedge	SC	
Cirsium hillii	Hill's thistle	E	FSC
Coeloglossum viride			

Table D4 (continued). Indiana associated imperiled species

Scientific Name	Common Name	State Status	Federal Status
Triglochin palustre	marsh arrow-grass	T	
Utricularia purpurea	purple bladderwort	R	
Utricularia cornuta	horned bladderwort	T	
Utricularia minor	lesser bladderwort	E	

State Status Codes: SU=status unknown, SC=special concern, T=threatened, E=endangered, R=rare. Federal Status Codes: E=endangered, T=threatened, FSC=Federal species of concern (these are the former Federal C2 candidate species).

Table D5. Wisconsin imperiled species associated with Karner blue habitats (dry prairie,barrens and savanna habitats). Data provided by the Wisconsin Natural Heritage Program

Scientific Name	Common Name	State Status	Federal Status
----------Rare Birds----------			
Ammodramus henslowii	Henslow's sparrow	SC	FSC
Ammodramus savannarum	grasshopper sparrow	SC	
Bartramia longicauda	upland sandpiper	SC	
Chondestes grammacus	lark sparrow	SC	
*Dendroica kirtlandii**	Kirtland's warbler	SC	E
Dolichonyx oryzivorus	bobolink	SC	
Icterus spurius	orchard oriole	SC	
*Lanius ludovicianus**	loggerhead shrike	E	FSC
Oporornis agilis	Conneticut warbler	SC	
*Pedioecetes phasianellus**	sharp-tailed grouse	SC	
Pooecetes gramineus	vesper sparrow	SC	
Spiza americana	dickcissel	SC	
Spizella pusilla	field sparrow	SC	
Sturnella neglecta	western meadowlark	SC	
Tympanuchus cupido	greater prairie-chicken	T	
Tyrannus verticalis	western kingbird	SC	
Tyto alba barn owl	E		
*Vermivora peregrina**	Tennessee warbler	SC	
Vireo bellii	Bell's vireo	T	
----------Rare Reptiles & Amphibians----------			
Clemmys insculpta	wood turtle	T	
Crotalus horridus			

Table D5 (continued).

Table D5 (continued). Wisconsin associated imperiled species

Scientific Name	Common Name	State Status	Federal Status
Agastache nepetoides	yellow giant hyssop	T	
Anemone caroliniana	Carolina anemone	E	
Anemone multifida var *hudsoniana*	Hudson Bay anemone	E	
Arsitida dichotoma	poverty grass	SC	
Artemisia dracunculus	dragon sagewort	SC	
Artemisia fridgida	prairie sagewort	SC	
Asclepias lanuginosa	wooly milkweed	T	
Asclepias purpurascens	purple milkweed	E	
Astragalus crassicarpus	prairie plum	E	
*Besseya bullii**	kitten tails	T	
Botrychium rugulosum	ternate grape fern	SC	
Cacalia tuberosa	prairie indian plantian	T	
Calylophus serrulatus	toothed evening primrose	SC	
Carex richardsonii	Richardson sedge	SC	
Cirsium flodmanii	Flodman's thistle	SC	
*Cirsium hillii**	prairie thistle	T	FSC
Dalea villosa	villous prairie clover	SC	
Diodia teres var *teres*	buttonweed	SC	

Table D5 (continued). Wisconsin associated imperiled species

Scientific Name	Common Name	State Status	Federal Status
*Tomanthera auriculata**	eared false foxglove	SC	FSC
Vaccinium caespitosum	dwarf bilberry	E	
*Viola fimbriatula**	sand violet	E	

State Status Codes: SU=status unknown, SC=special concern, T=threatened, E=endangered. Federal Status Codes: E=endangered, T=threatened, FSC=Federal species of concern (these are the former Federal C2 candidate species), C=candidate.
* = priority species for consideration in Karner blue conservation planning that have been identified by the Wisconsin Department of Natural Resources.

Table D6. Minnesota imperiled species associated with Karner blue habitats. Data provided by the Minnesota Department of Natural Resources.

Scientific Name	Common Name	State Status	Federal Status
----------Rare Reptiles & Amphibians----------			
Coluber constrictor	blue racer	SC	
Emydoidea blandingii	Blanding's turtle	T	FSC
Heterodon platyrhinos	eastern hognose	SU	
Lampropeltis triangulum	milk snake	SU	
Pituophis melanoleucus	bull snake	SU	
----------Rare Invertebrates----------			
Cincindela patruela patruela	a tiger beetle.	SC	
Metaphiddippus arizonensis	a jumping spider	SC	
Sassacus papenhoei	a jumping spider	SC	
----------Rare Vascular Plants----------			
Aristida tuberculosa	sea beach needle grass	SC	
Asclepias amplexicaulis	clasping milkweed	SC	
Baptisia bracteata var *glabrescens*	prairie wild indigo	SC	
Desmodium illinoiensis	S1.TJ/TTT1247 Tf-8.8383 -1.1437 T007 Tc05 Tc0.0020( )-6143.54.7(n p)l 1 patr2(hemTjcanadT		

dispersal rates are low). Persistence of a true metapopulation requires that colonization of suitable, unoccupied habitat occurs at a greater rate

mating population) and all subpopulations fluctuate in more or less in unison. In this case, the metapopulation only superficially has spatial structure because all subpopulations are interacting strongly. Persistence of a patchy population depends on the size and stability of the whole metapopulation and not as much on the structure and relations among subpopulations. Management of a patchy metapopulation can focus on the average behavior of subpopulations across all occupied sites rather than focusing on a few to many critical sites. Indeed, in the extreme, a patchy population might merge to such an extent spatially that it becomes one large patch. With an appropriate management plan, this could be considered a viable metapopulation.

In summary, a core-satellite structure implies that at least one site will never be extirpated (Probability of extirpation = 0), whereas in a true metapopulation all sites have equal probability of going extinct (Probability of extirpation = constant ≠ 0). These idealized structures represent extremes along a continuum of extirpation probabilities (Figure E4). Both of these structures (true metapopulation and core-satellite) assume that site colonization rates are not extremely high for any site. The patchy population structure, in contrast, assumes that colonization rates are very high for all sites. Thus, the patchy population represents an extreme along a continuum of recolonization rates, with both the true metapopulation and core-satellite structures on one end, and the patchy population structure on the other end of the continuum. Again, none of these extremes are likely to be accurate representations of actual metapopulations of the Karner blue butterfly. Management of a true metapopulation is likely to be more intensive than management of either a core-satellite or a patchy metapopulation, because of the need to keep track of each subpopulation individually in a true metapopulation. Consequently, one management strategy to reduce the cost of management is to use management to change the population structure to be more like a core-satellite or patchy metapopulation.

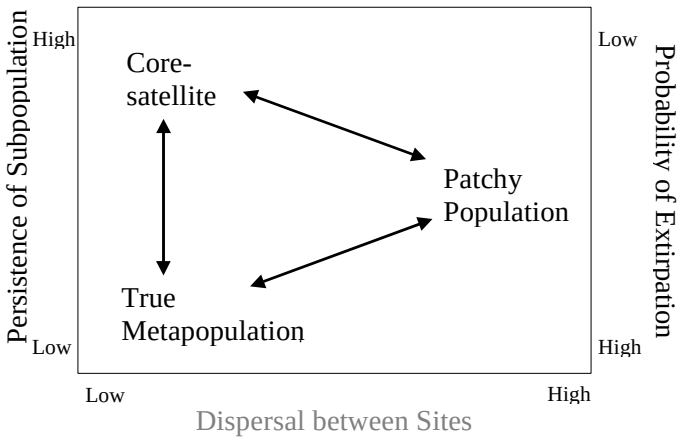
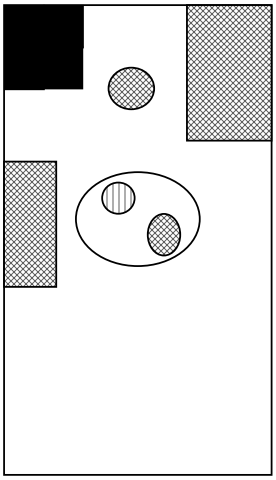


Figure E4. Dependence of population structure on local extirpation rate and between site dispersal rate.

Together these theoretical structures probably encompass all likely structures of actual Karner blue populations. Actual population structures of Karner blue butterfly are likely to be vastly more complex than any of these three common theoretical abstractions. For example, Karner blue metapopulations are unlikely to have a core-satellite structure because all sites are involved in successional processes that eliminate Karner blue followed by renewal events that rejuvenate habitat; a single site is unlikely to maintain a healthy, stable subpopulation of Karner blue butterflies indefinitely (Givnish et al. 1988). Management efforts can be used to reduce the



Extirpation

Savignano (1994) demonstrated that extirpation of subpopulations does occur. She found that in Saratoga County, New York, only 52 percent of sites that had been recorded previously

(1980) suggested that an effective population of 500 would be sufficiently large to be in mutation-drift balance for adequate long-term variability in quantitative traits. This figure has been proposed for use in managing endangered species (Frankel and Soulé 1981, Schonewald-Cox et al. 1983, Soulé and Wilcox 1980). Turelli (1984) used different and perhaps more realistic assumptions, and questioned whether mutation could maintain sufficient variability in an effective population as small as 500. Thus, our use of at least 300 individuals in a subpopulation is probably an underestimate of the number of individuals needed to maintain long-term genetic variation. Thus, if the subpopulations are as small as 300, it is essential that these subpopulations be closely linked together in the larger metapopulation. An additional consideration is that allelic diversity (the numbers of different alleles) is best preserved by subdividing a population (Parsons 1980, Lacy 1987).

3. A metapopulation with a higher density of butterflies per RU land area can have a smaller number of total butterflies and still remain viable, compared to a metapopulation with a lower density of butterflies. High densities alleviate potential problems associated with mate-location, low dispersal rates, and population fluctuations. High densities could possibly heighten risks of increased Karner blue

TRADE-OFFS BETWEEN METAPOPULATION STRUCTURE, MANAGEMENT, AND MONITORING

The three components of a viable metapopulation, viz., metapopulation structure, management, and monitoring, are not independent of each other. The following describe some of the major modes of dependency among them:

1. A metapopulation covering a large, diverse land area is better buffered against disturbance than one covering a small area. Large land bases provide buffering against catastrophic disturbances, disease, and minor climatic fluctuations. But if the metapopulation, which covers a large, diverse area, is fragmented, it is not likely to be well buffered against disturbance. Recolonization of unoccupied suitable habitat is a vital component of metapopulation persistence. Increased fragmentation slows the recolonization of unoccupied sites by decreasing the rate at which new or unoccupied sites are located and colonized successfully by dispersing females.

2. Large metapopulations covering large, diverse areas with many subpopulations should require less intensive management and monitoring. Small or isolated metapopulations will require more intensive management and monitoring. This reflects the changing importance of a particular subpopulation to the viability of a metapopulation at the two extremes. In a small or isolated metapopulation, loss of a single subpopulation could result in the loss of the entire metapopulation. In contrast, in a large metapopulation, loss of a single subpopulation may have little effect on the viability of the metapopulation.

3. The longer a metapopulation has persisted, the less intensive must be the monitoring system or the more experimental the management system can become. As experience increases in successfully managing a viable metapopulation, confidence in the management system grows, and it will be possible to either attempt to improve management efficiency through more experimental management or to reduce the level of monitoring.

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APPENDIX F

LARGE VIABLE METAPOPULATIONS

Large viable metapopulations are defined to provide managers with a greater number of suitable management and monitoring options, including the possibility of reducing costs, while simultaneously providing sufficient assurance that the metapopulation will contribute toward recovery and persist into the indefinite future. The definition and description of a metapopulation is provided in APPENDIX E, POPULATION STRUCTURE, and forms the necessary background to the discussion of large viable metapopulations below.

AREA AND HABITAT REQUIREMENTS

1. Every large viable metapopulation shall exist in an area of at least ten contiguous square miles (6,400 acres).[1] Ten square miles may be sufficient to buffer the metapopulation against many types of adverse natural disturbance. For example, of 320 naturally occurring wildfires between 1973 and 1994 in the thirteen Wisconsin counties that have Karner blue populations, the maximum wildfire size for fires greater than forty acres exceeded 6,400 acres only once. This was the spectacular 15,471 acre wildfire in Jackson County during 1977. The ten square mile area is also expected to contain diverse habitats and a variable topography that should further buffer Karner blue metapopulations against adverse natural disturbances. Finally, this area is considered large enough that extensive management practices (including any type of adaptive management), rather than intensive practices, could be effectively used.

2. Every large viable metapopulation shall have approximately ten percent of the total area (640 acres) as suitable habitat (see definition of suitable habitat). The ten percent criterion is intended to guarantee that the suitable habitat is sufficiently connected to other suitable habitat and that there is sufficient suitable habitat to justify extensive management practices. Connectivity requirements are made explicit in criterion (4) below, so the ten percent criterion acts more as a benchmark by which the amount of suitable habitat can be judged than as a strict requirement. For example, the measurement of the area of suitable habitat is sufficiently subjective that errors in measurement of twenty percent could be possible. The main source of this error is in how much of the habitat between lupine patches and between lupine and nectar patches is included in the measurement of suitable habitat. For measures that strictly define suitable habitat as that area that contains actively growing lupine, the measured area could be significantly smaller than for a measure that includes the areas between the lupine patches. For a more strict measure of suitable habitat, seven or eight percent suitable habitat may be sufficient as long as the total area is large enough so that the area of suitable habitat is large enough (for example, an area of 10,000 acres with seven percent suitable habitat would have 700 acres of suitable habitat, which would be a sufficient land base for a large viable metapopulation).

[1] The minimum area is ten square miles of contiguous land (equivalent to 6400 acres or 10 sections). More than ten square miles is acceptable. The area can be any shape, for example a 3.2 x 3.2 mile square, a 2 x 5 mile rectangle, a circle with a radius of 1.8 miles, oblongs, or any other shape. It is preferable to have an area that is compact or convex; a long skinny area, such as 0.5 x 20 miles or a starfish with long skinny arms is less preferred. This minimum area is NOT a ten mile square i.e. a square, 10 miles on a side (equal to 100 square miles).

3. Every large viable metapopulation shall have the suitable habitat distributed over two-thirds of the total area. For a minimum ten square mile area, the suitable habitat should be distributed over 6.7 square miles of the area. This requirement is essential so that suitable habitat is not all clumped into a couple of square miles. If it were clumped in this way, then the Karner blue metapopulation would also be clumped and less likely to be well-buffered against adverse natural disturbance. This requirement does not mean that suitable habitat must be permanently in place; a dynamic mosaic of suitable habitat interspersed with other habitats is also appropriate.

METAPOPULATION STRUCTURE

1. Every large viable metapopulation shall have all occupied sites no more than one kilometer (0.62 miles) from another occupied site on average. This connectivity criterion is similar to that for a minimum viable metapopulation. The main difference is that the spatial structure of dispersal corridors and barriers need not be managed explicitly, and the maximum distance separating occupied sites is no more than 2 kilometers. For example, if there are three large occupied sites, then one of the occupied sites could be 1.5 kilometers from its nearest occupied site if the other two are no more than 0.75 kilometers from each other. It is assumed that the large viable metapopulation either has many occupied sites or a few very large occupied sites. As described in APPENDIX E, these are conditions under which the connectivity requirements for a minimum viable metapopulation can be relaxed. For further guidance on dispersal considerations refer to APPENDIX G, INCREASING THE COLONIZATION RATE OF SUBPOPULATIONS WITHIN A METAPOPULATION.

2. Every large viable metapopulation shall have at least 6,000 adult butterflies. The Recovery Team deliberated at length on the minimum number of adult butterflies required for a large viable metapopulation. Suggestions ranged from 5,000 to 15,000, and the final decision was 6,000 adults. A review of Karner blue butterfly numbers and habitat information from Necedah NWR and Fort McCoy support this number as being reasonable and attainable. A minimum number is required because basing the determination of a large viable metapopulation only on habitat quality and quantity and butterfly presence/absence is insufficient to guarantee that there is a large metapopulation. It is possible for a Karner blue population to be distributed over a wide geographic area of suitable habitat, but to be rare everywhere. To avoid this possibility, it is necessary to establish some minimum metapopulation threshold to guarantee a sufficiently large metapopulation to merit designation as a large viable metapopulation. If an alternative approach can be developed that can document the existence of a large, robust metapopulation without counting butterflies it would be very useful.

   To meet the 6,000 criteria, a metapopulation larger than 6,000 should be strived for because populations can fluctuate up to 4-5 fold as demonstrated by data from Necedah

variety of methods based on extrapolation from sampling the large metapopulation could be used to demonstrate the existence of 6,000 adults (refer to APPENDIX H for additional guidance on sampling methods). The 6,000 requirement is not intended to generate a burdensome or absolute sampling requirement. For instance, if a metapopulation has somewhat under the 6,000 criteria, yet population stability has been demonstrated, and other recovery criteria are met, the metapopulation may be sufficient to qualify as a LP. Another example may be a metapopulation that generally has very high numbers (e.g., 10,000 Karner blues) and the numbers dropped to 5,000 for two years. The Service in conjunction with the recovery team will determine on a case by case basis if situations like these would qualify as LPs.

3. It is recommended, but not required that a large viable metapopulation contains a core

APPENDIX G

MANAGEMENT GUIDELINES – BALANCING TRADE-OFFS IN DEVELOPING AND IMPLEMENTING KARNER BLUE RECOVERY PLANS

To restore viable metapopulations of Karner blues to the landscape, it will be important to establish and maintain the early successional habitat on which the butterfly depends. This entails assuring that appropriate disturbance and/or management regimes (e.g., prescribed fire, mechanical management, etc.) necessary to renew existing habitat or to create new habitat are incorporated into management plans for the species. In addition, maintaining metapopulation dynamics depends upon spatially arranging subpopulations to facilitate colonization of butterflies from occupied to unoccupied sites. This appendix includes guidance and information on management of habitat for the Karner blue, and on creating conditions that will facilitate and increase the colonization rate of subpopulations within a metapopulation. These guidelines are based on currently available information on the biology of the Karner blue and its habitat. As more information is obtained, these guidelines may be updated.

All biological communities are dynamic, and localized extirpation of subpopulations is a natural phenomenon. Thus, the loss of one local subpopulation of a rare butterfly is not necessarily detrimental to the survival of the species if new local subpopulations are founded at the same rate as others become extirpated. Unfortunately, human activities have increased the rate of localized extirpation for many butterflies, while limiting the possibilities of new local subpopulations becoming established. If butterfly diversity (and all biological diversity) is to remain at its present level throughout the United States, a conscious effort must be directed towards preserving a significant percentage of the countryside in native ecosystems.

The Karner blue occurred as a series of metapopulations arrayed from Minnesota eastward through Canada to New England. Several of these metapopulations are now extirpated, and as outlined in this plan, the continuing loss of metapopulations is incompatible with recovery. However, the situation is further complicated because the Karner blue can thrive in some managed ecosystems, which can result in conflicts in management objectives that need to be resolved. Moreover, each metapopulation is composed of a series of individual local populations or subpopulations, each of which is prone to local extirpation. Metapopulations themselves depend upon a balance between subpopulation extirpation and subpopulation creation following recolonization of unoccupied habitats. Ideally, the individual occupied and unoccupied Karner blue habitat sites that together compose the metapopulation are arrayed spatially in such a way as to facilitate interchange of butterflies between the sites. Maintaining a persistent metapopulation requires that, at a minimum, dispersing butterflies find and colonize unoccupied sites at the same rate that subpopulations become extirpated. In robust metapopulations, the colonization rate greatly exceeds the local extirpation rate and most suitable habitat is occupied. In precarious metapopulations the colonization rate is only slightly larger than the extirpation rate; at equilibrium, any factor that negatively influences either rate can result the collapse of the metapopulation. Thus occupancy rate is a good measure of the robustness and fragility of a metapopulation.

There are two complementary approaches for influencing this balance: increasing the rate at which unoccupied sites are colonized, and/or decreasing the local extirpation rate. Land managers must consciously consider factors that influence both portions of the equation during both the development of the management plan for a Karner blue metapopulation, as well as during the implementation of that plan while managing Karner blue support ecosystems. As discussed in the section on population structure above, changing these rates can also affect the functioning of the metapopulation. When extirpation rates are reduced low enough at a site or cluster of sites, the metapopulation will function more like a core-satellite metapopulation, and when recolonization rates become very high, it will function more like a patchy metapopulation. When recolonization rates are not high and extirpation rates are not low, then the metapopulation will function more like a true metapopulation.

The colonization and extirpation rates will be strongly affected by local site conditions (e.g. habitat quality, dispersal corridors), the management of which will provide the mey8.2ao improve Karner blue metapopulations. Equally important, however, are broad-scale factors, such as weather, wildfire, and unregulated urban sprawl, that can influence colonization and extirpation rates across all of the local sites in an entire metapopulation. Management at this broad-scale provides buffering capacity for the metapopulation. Management plans and activities must consider both scales of management ao ensure persistence of the metapopulation.

No two Karner blue supporting ecosystems are the same, and approaches ao ensuring metapopulation viability in each area will by necessity be different. Yet the principles guiding the planning and on-the-ground management decisions at every locality are the same, and revolve around improving the colonization/extirpation balance. Other management objectives, such as forestry and wildlife management, ecosystem recovery, and management for other rare species, should be assessed for compatibility with the practices required ao sustain the Karner blue. While many of these other management objectives are anticipated ao be compatible with management for the Karner blue (e.g. sharptail grouse management at Crex Meadows WA), some management prescriptions may need modifying to enhance the recovery of the butterfly (e.g. frequency and location of prescribed burns, enhancement of corridors to ensure dispersal, etc.) or to protect other rare species. The objectives of all management programs should be integrated into the management and monitoring plan for the butterfly. No one management unit is likely ao satisfy all management objectives, but every site should attempt ao satisfy as many as possible within real world ecological, sociological and financial constraints. Refer to the recovery criteria and APPENDICES G and H for guidance on development of management and monitoring plans.

INCREASING THE COLONIZATION RATE OF SUBPOPULATIONS WITHIN A METAPOPULATION

Increasing the rate that butterflies colonize suitable habitat within a metapopulation can have a very positive effect on the viability of the metapopulation. A high colonization rate tips the recolonization-extirpation balance in favor of recolonization, because if colonization rates are high enough, nearly all suitable habitat will be colonized every year and nearly all will remain occupied every year. Indeed, if colonization rates are high enough, then the metapopulation ceases ao function as a true metapopulation and assumes the functional characteristics of a patchy metapopulation (refer to APPENDIX E, POPULATION STRUCTURE. Spatial Structure of

Karner Blue Butterfly Metapopulations). Because a patchy metapopulation will be more resilient to disturbances to subpopulations than a true metapopulation, management can shift emphasis to manage the average subpopulation rather than focus specific efforts on each subpopulation.

Between-Site Dispersal

The recovery criteria (PART II, RECOVERY OBJECTIVE, Reclassification Criteria,

1988, Lawrence and Cook 1989, Sferra et al. 1993, Welch 1993, Bidwell 1994, Lawrence 1994, Fuller 1998, Knutson et al. 1999).

Generally, the more open the habitat, the greater amount of between-site dispersal can be expected and the longer the dispersal distances. Dispersal distances up to 1.05 kilometers (0.65 miles), 1.3 kilometers (0.81 miles), and 1.6 kilometers (1 mile) have been recorded from rights-of-ways (ROWs) and/or trail areas in studies by Lawrence and Cook (1989), Schweitzer (1979), and Bidwell (1994) respectively. Welch (1993) recorded dispersal up to 1.7 kilometers (1.05 miles) in mixed (but mostly open) habitat**.** King (1998), documented the greatest amount of between-site dispersal and longest dispersal distances for the Karner blue. His study sites at Necedah NWR were each about 100 hectares (200 acres) in size, and were separated from each other by more than 1,150 meters (0.7 miles) of mostly open wetland habitat. About 11 percent of butterflies marked during the second flight made at least one inter-population dispersal of 1,150 meters (0.7 miles) or more. Of all marked butterflies, (429) 7.5 percent made at least one inter-population dispersal of 1500 meters (0.93 miles) or more. Of the Karner blues located greater than three times, movements greater than 1,500 meters (0.93 miles) were even more common (8.5 percent, n=354) (King 1998). Ten percent of all Karner blues with multiple captures were shown to travel at least 2.3 kilometers (1.4 miles) during the second flight of 1995 (less than 50 butterflies), and one individual female traveled at least 6.6 kilometers (4.1 miles) during the same flight (USFWS 2001, King unpublished data). These longer flights (1,500 meters – 6.6 kilometers) at Necedah NWR reflect the sum of within-habitat movements and between-site dispersal.

Lesser amounts of dispersal and/or dispersal distances are noted in studies where the intervening habitats are mixed or more closed or where the habitat was open but limited in extent (e.g., Sferra it al. 1993). In New York, Schweitzer (1979) captured only 4 percent of about 50 marked individuals about 1.3 kilometers (0.81 miles) away, and he observed little dispersal in the Concord, New Hampshire population, where less than one percent of the marked individuals crossed a narrow, little-used road separating two large habitat patches (Schweitzer 1979 in Givnish 1988, Dale Schweitzer, TNC, pers. comm. 1996). Fried (1987) captured only 1.3 percent of the recaptures (total recaptured = 224) dispersing between three sites that were approximately 400 to 700 meters (437 to 765 yards) apart. The habitat matrix between Fried's study sites was mixed, composed primarily of dense woods or low shrubs, although dirt paths connected them. In Wisconsin, Bidwell (1994) captured 2.9 percent of the marked individuals (total number marked = 724) dispersing between habitat sites. Two thirds of the dispersal events recorded were between the two close sites (50 meters apart); the rest were longer distances up to 1,600 meters (1 mile). In Michigan, during the second flight, Lawrence (1994) marked 538 individuals on sites 0.5 to 2.5 kilometers (0.3 to 1.6 miles) apart in a more closed habitat area and recaptured 142 butterflies. No individual was recaptured at a site other than at the original marking site during the first and second flights. Lawrence suggested that between site dispersal in his study area was probably uncommon because butterflies were marked and recaptured frequently, which would have enabled them to observe such dispersal if it had been common. Similarly, no long-distance dispersal between sites was observed during studies at the more closed IDNL sites even though large numbers of butterflies were marked (n=1959 1st flight, n=3654 2nd flight), (Knutson et al. 1999).

In studies on the Heath fritillary butterfly (*Mellicta athalia*) in England, Warren (1987) found an average of 1.5 percent dispersal between-sites. He argued that if similar rates of

Table G1. Summary of Karner blue butterfly between-site dispersal and within-habitat movement studies.

MRR = mark-release-recapture, ISD = dispersal between sites, MDM = mean distance per move, MDD = mean distance moved per day, Range = distance between two most distant captures. KBB = Karner blue butterfly. Character of canopy between habitat openings categorized as " open," "mixed," "closed," or "unknown" based on site descriptions. To convert kilometers to miles multiply the kilometers by 0.621; to convert meters to yards multiply the meters by 1.093; to convert meters to miles multiply the meters by 0.0006214.

STUDY	DATE	FLIGHT	LOCATION	STUDY SITE DESCRIPTION	CANOPY BTWN SITES	METHOD	RESULTS
King 1998	1995	1st flight 2nd flight	WI, Necedah National Wildlife Refuge, North, South and East Rynearson sites	3 sites, open landscape with oak barrens and wet meadow habitats abutting large water impoundments. Distances between sites = 1150, 1550, 2250 m (1.3 miles) of unsuitable habitat (water impoundments, wetlands with out lupine or nectar plants).	OPEN	MRR	203 marked 1st flight, 12% recapture rate 236 marked 2nd flight, 26% recapture rate ISD: 1st flight = 48 0 0 6.4e.91ldmi..72 Tm- 012 0ldm(capture ra

STUDY	DATE	FLIGHT	LOCATION	STUDY SITE DESCRIPTION	CANOPY BTWN SITES	METHOD	RESULTS
Lawrence & Cook 1989, Lawrence 1994	1989	1st flight 2nd flight	MI, Allegan SGA	1st flight: 1 site, open linear habitat – pipeline ROW, 2.1 km long, several large lupine patches 2nd fight: 8 sites – mixed oak forest and fields, 0.5 to 2.5 km apart	OPEN CLOSED	MRR	134 marked 1st flight, 29% recapture rate 538 marked 2nd flight, 26% recapture rate **Within- habitat distances moved** 1st flight: Males: 248 m ± 64 m MDM 191 m ± 52.5 m MDD Longest distance = 1.05 km *male results skewed, most movements less than the mean with a few individuals moving long distances Females: 203 m ± 41 m MDM 162 m ± 40 m MDD Longest distance = 0.55 km 2nd flight: (distance moved between-sites) No butterflies captured in sites other than where they were originally marked

STUDY	DATE	FLIGHT	LOCATION	STUDY SITE DESCRIPTION	CANOPY BTWN SITES	METHOD	RESULTS
Fried 1987	1987, July 10-27	2nd flight	NY, Albany Pine Bush, 3 sites along Willow Street	1) abandoned sand pit, 2) path along power line, 3) shady site with aspens and pitch pine. Very small sites, approx. 305-460 m apart, connected by dirt paths through dense woods or low shrubs, some nectar along paths and one opening with no lupine between 2 sites	MIXED	MRR Jolly	224 marked, 55% recapture rate 3 of 224 ISD[2] ***Between- site distances*** Males : 1 @ 460 m Females: 1 @ 150 m, 1 @ 305 m 8 males moved along dirt paths 2.4 % of recaptures were dispersing male bias in captures ***Population estimates:*** 1) 89 2) 154 3) 47
Bidwell 1994	1994, July 19 – Aug. 11	2nd flight	WI, Fort McCoy, South Post	3 sections of 30 m x 1 km training area boundary ROW. Scattered lupine, diverse nectar, open with shrubby oak. Bordered by oak woods with >75% canopy closure. Dense band of birch with >75% canopy extended across ROW for 50 m of ROW length, 5 m wide trail through birch, no lupine, little nectar	MIXED	MRR	724 marked total, 24% to 62% recapture rate ISD: 21 total (2.9%). 14 KBB (12 males, 2 females) crossed birch band, ISD between sites 1000 m apart. 1 male 1600 m over 2 days, 1 female 1195 m. ***Between- site and within-habitat distances moved:*** (dispersal distance data combined for 3 sites) Males: 91% moved < 400 m RANGE[5] 99 m $\pm$ 9m MDD Females: 91% moved < 200 m RANGE 32 m $\pm$ 3 MDD

STUDY	DATE	FLIGHT	LOCATION	STUDY SITE DESCRIPTION	CANOPY BTWN SITES	METHOD	RESULTS
Welch 1993	1993	1st flight 2nd flight	WI, Hartman Creek State Park Complex & Welch sites, 11 sites	Cluster of small-medium sized openings separated by oak forest and/or pine plantation. Barriers were mixed conifer/deciduous fence row and wooded habitat margins, 200-415 m wide	. MIXED	Focal-animal sampling (followed adults)	78 total observed: 50 were ≤ 406 m from lupine patch, 4 (5%) moved > 1 km. Worn individuals dispersed farther than fresh: Males: 65-1140 m (ave. 530 m) Females: 85-565 m (ave. 285 m) Longest distance observed = 1 male, 1.7 km from nearest lupine, 2nd flight (open habitats + shaded wooded fence line) Female observed flying through forest, 2-3 m off ground. Flying, then landing, from one sunlit branch to the next. **Relatively Closed habitats** (>50% cover, perimeter enclosed) * 4 adults 270 to 792 m from one lupine opening to another on forest trail with 85% cover, 3 were males (24 total obs.) * 7 adults moved 88 to 352 m between small openings with lupine along sunlit openings, often returning to original patch (13 total obs.) * 1 male flying into canopy and crossing 11 m high crown of trees to enter next lupine area **Open habitats**

STUDY	DATE	FLIGHT	LOCATION	STUDY SITE DESCRIPTION	CANOPY BTWN SITES	METHOD	RESULTS
Schweit-zer 1979 (in Givnish et al. 1988)			NY, Albany Pine Bush	None of the sites fully open	MIXED	MRR	Greatest distance moved = 1.3 km between Gipp Road and Crossgates Hill Dispersal observed along roads & trails, occasionally over tree tops Givnish et al. (1988) concluded effective inter-population dispersal of up to about 0.8 km (given a substantial source population)
Knutson et al. 1999	1994, 1995, 1996	1st flight 2nd flight	IN, Indiana Dunes National Lakeshore, 4 sites and supplemental survey areas	4 sites: 1) Oak savanna/marsh complex with moderately dense woody veg. and sand-mined areas, 2) oak savanna/marsh with open fields, 3) oak savanna with open understory, 4) linear habitat along former railroad track, dune ridge with moderate canopy Millers Woods - flat, homogenous site, open understory. Movements > 300m, 2 x freq. of 2 other sites	CLOSED.	MRR	1959 marked 1st flight, approx. 30-33% recapture rate 3654 marked 2nd flight, approx. 12-31% recapture rate ISD : No movements observed between study sites. ***Within-habitat distances moved:*** MDD - 50.3 m (sexes & flights pooled) Males: 51.2 ± 2.7 m Females: 48.0 ± 4.5 m 1st flight: 55.0 ± 3.5 m 2nd flight: 46.4 ± 3.0 m RANGE - 73.4 m ± 2.3 RANGE (sexes & flights) Males: 76.9 ± 2.8 m Females: 64.9 ± 4.3 m 1st flight: 84.5 ± 4.1 m 2nd flight: 65.0 ± 2.7 m 75% of movements less than 100m* Maximum distance moved = 989 m

Number of Dispersing Female Karner Blue Butterflies

Larger numbers of butterflies will disperse from larger subpopulations of Karner blues if

Identification and Protection of Refugia

A viable Karner blue metapopulation will be comprised of many subpopulations on sites with suitable habitat. A minimum number of colonists could be ensured if refugia, where Karner blue subpopulations persist for long periods of time at high densities, can be identified and protected. These refugia will provide a continual supply of colonists for the entire metapopulation and could serve to ensure that some colonists will be available to recolonize unoccupied suitable habitat. In any metapopulation some of the sites are more likely to persist for longer periods of time than other sites. These sites might be identified as management experience accumulates. If these sites were managed to produce maximal numbers of butterflies, then they could function as refugia. Sites where subpopulations persist for long periods of time at low density might be called low-density refugia. Low-density refugia will not contribute substantially to recolonization.

REDUCING LOCAL EXTIRPATION RATES

The probability that a subpopulation will be extirpated is related to the size of the subpopulation (larger subpopulations are less likely to be extirpated than smaller subpopulations), and the temporal variation in subpopulation size (more variable subpopulations are more likely to be extirpated). For example, if for some reason 99% of the eggs fail to overwinter, a subpopulation of 1000 eggs will produce only 10 first instar larvae, while a subpopulation of 10,000 eggs will produce 100. Larger subpopulations simply have a better chance of surviving density independent sources of mortality because ultimately, there are more survivors. Consequently, there are two basic strategies for reducing local extirpation rates. The first is to improve and maintain the suitability of the habitat for Karner blue so that they are less likely to be extirpated, and the second is to manage disturbances on site so they do not inadvertently cause the extirpation of the butterfly and indeed, may contribute to the improvement or renewal of suitable habitat.

Managing subpopulations and their associated suitable habitat to reduce extirpation rates is most readily done on a subpopulation by subpopulation basis. This implies that for most metapopulations, this approach will not be used on all subpopulations in a metapopulation, but only on selected ones. For minimum viable metapopulations, it would be beneficial to reduce the likelihood of extirpation associated with the more precarious subpopulations so that most subpopulations are maintained. In larger metapopulations, however, effort could be shifted to reduce the likelihood of extirpation in some of the larger, healthier subpopulations or clusters of subpopulations. If the likelihood of extirpation can be reduced so that the subpopulation or cluster is likely to persist for a long time into the future, then the metapopulation will function less like a true metapopulation and assume some of the functional characteristics of a core-satellite metapopulation. Because persistence of a core-satellite metapopulation depends mostly on the fate of the core subpopulation or core cluster, management efforts may be able to shift to focusing on maintaining the core subpopulations and the means of dispersal (close enough distances, dispersal corridors, etc.) to the surrounding constellation of satellite subpopulations. It would no longer be necessary to manage each satellite subpopulation individually, but it would be possible to set up management to maintain a balance between the creation and destruction or degradation of suitable habitat associated with those satellite subpopulations.

site; refer to Habitat heterogeneity below). Thus, succession should be managed to maintain a diverse, relatively open canopy.

Mechanical management (e.g., mowing or cutting), as well as grazing can be used to enhance lupine if it is done at the right time, however precautions should be taken to minimize the effects of such activities on the Karner blue and its habitat (refer to Alternatives to fire management, below).

Off-road vehicle (ORV) traffic can have a positive or negative effect on lupine depending on whether the ORV paths destroy lupine (potentially negative effect) or function to keep the canopy open and create germination sites (potentially positive effects). Exotic invaders may reduce lupine (some sedges in relatively mesic habitats), but other may be significant nectar sources (white clover). There are no simple rules for increasing lupine.

Nectar resources

Make several potential nectar sources available for each generation because annual variation in flowering phenology means that a particular species may not be available for adults in every year. Adult butterflies require food to survive. While it is likely that in the absence of nectar sources, adults will manage to mate and lay some eggs, without food the number of eggs laid will be greatly diminished. It is also possible that inadequate nectar at a site could result in increased dispersal of butterflies to find nectar (Loertscher et al. 1995). Because mortality of immature caterpillars is very high and most die, subpopulations that chronically experience low fecundity (actual number of eggs laid) because there is no adult food are at risk of extirpation. Thus, the absence of adult nectar sources can be limiting and jeopardize a subpopulation. This problem is most pronounced during the summer flight period, when the number of flowers blooming is reduced because of summer dry spells in oak and pine barrens and savannas. Excellent Karner blue habitats have a variety of potential nectar sources available for both the spring and summer broods. Poor habitats should be enhanced by planting or encouraging suitable nectar plant species (native forbs and others) that will provide nectar during both flight periods under the range of foreseeable environmental conditions (droughts, cool springs, cool summers, etc). Alternately, habitats adjacent to Karner blue habitats, such as wetlands and mesic prairies and other mesic or xeric habitat, can be managed to provide nectar-producing flowers.

Many of the comments under the lupine density section above apply in a similar way to nectar plant management. Nectar plants, however, will flower more abundantly and produce more copious amounts of nectar in sunny. Thus encouragement of nectar will require a more open habitat than that needed to improve lupine. Grazing, succession, mowing, ORV traffic, and exotic invaders may detrimentally affect nectar plant species, but there are no simple rules for

Habitat heterogeneity

habitat include habitat protection using conservation easements, negotiated conservation plans, purchases of land from willing owners, or protective legislative or legal remedies. Conversion to agricultural and grazing lands has also resulted in substantial loss of native habitat and harm to the Karner blue. Conversion to some silvicultural land uses may be the main human uses that can be compatible with Karner blue; while some silvicultural practices are clearly beneficial to the butterfly and others are clearly harmful, the majority of these practices have uncertain effects (Lane 1997).

Where the habitat is managed for native vegetation or recreational human use, unimpeded succession is the leading contributor to habitat loss. Barrens/savanna communities are among the most dynamic in the northeast and Midwest United States. The open habitats that support Karner blue were originally maintained by a steady procession of wildfires and other periodic disturbances. The wildfires top-killed woody invasive plants while favoring fire-adapted dune and savanna communities. Other disturbances, such as grazing, oak wilt, late frosts, and local outbreaks of defoliating insects helped to create a mosaic of habitats ranging from open xeric grasslands to oak woodland. Without these disturbances, shade-tolerant and fire-sensitive species increase in density, and open barrens and savanna species decline. Moreover, management aimed mainly at enhancing certain game species has resulted in large areas of potentially suitable habitat to be rendered relatively poor habitat for Karner blues. The Wisconsin DNR Wildlife Management Guidelines provide additional suggestions that managers interested in barrens and savanna maintenance and restoration may be interested in considering (WDNR 1998, WDNR 2000). Guidelines for managing Karner blue metapopulations associated with silvicultural practices can be found in Lane (1997).

General guidance: (1) Plan not to use any management practice that is likely to have an adverse effect on an entire Karner blue subpopulation repeatedly within a time frame of two generations. (2) If a subpopulation is critical for the maintenance of the metapopulation, then subdivide the subpopulation into separate management areas. The number, design, and rotation of management areas should allow effective Karner blue re-colonization after the management practice from nearby unaffected areas. (3) On very small, isolated sites that have small populations of Karner blue, use management practices that are unlikely to harm the existing subpopulation, e.g., tree girdling instead of fire.

Size of management unit relative to size of habitat site

For small metapopulations near the minimum viable metapopulation criteria, suitable habitat sites, which support Karner blues, should be large enough so that each site could be divided into three or more management units. This would minimize the probability of local extirpation from management error while maintaining suitable habitat in the site. At the other extreme, with large viable metapopulation that occupy large areas of suitable habitat over several square kilometers, swaths of the habitat mosaic (occupied sites and surrounding matrix of habitat) may be managed as single management unit as long as adequate precautions are taken to ensure that there are nearby occupied habitats which can act as sources of potential colonists.inly at enhancing cı

Fire management

In using prescribed fire as a management tool, two general guidelines apply. The first is that the positive effects of fire on Karner blue habitat must be weighed against any negative impacts to the butterfly. Fire is known to be an important component in maintaining savanna/barrens habitat that acts by reducing accumulated plant litter, exposing bare soil, reducing nitrogen content of the soil, promoting increased soil temperatures, and setting back growth of plants that compete with native, desirable vegetation. However, fire can also have negative effects on the butterfly (and other invertebrates) such as direct mortality and/or reduction of food plants.

The second general guideline is that prescribed fire methods for restoring habitat will typically vary from those used for maintenance of habitat. For example, sites where lack of disturbance has allowed succession from savanna to forest to occur, more intensive methods will be needed in order to restore savanna/barrens structure than for maintaining sites where suitable habitat structure is present.

To adhere to the general guidelines and to develop appropriate site specific restoration/maintenance plans, many factors will need to be considered. As an aid in developing prescribed fire plans, an overview of relevant literature, followed by recommendations based on that literature, are provided below. Information is grouped in the following categories: 1) site history and current condition, 2) amount of direct Karner blue mortality likely to occur during

native species that compete with lupine and nectar plants. Some rare plant species may respond adversely to fire and should be protected during burns.

Recommendations:

Prescribed fire plans should be site specific and based on the structure and composition of the current vegetation, and the spatial characteristics of Karner blue habitat patches. Site inventories should be conducted prior to developing the management plans and include information on species composition (native and non-native), canopy structure, soil type, slope and aspect, etc. For example, sites with dense vegetation between patches will require different considerations than those interspersed with open canopied vegetation types. Areas/sites with exposed and dry soils should be burned less frequently than those with more mesic conditions.

2. Amount of direct Karner blue mortality likely to occur:

Fire can result in the mortality of Karner blue eggs, larvae and and adults (Maxwell and Givnish 1994, Swengel 1994, Maxwell 1998, Kwilosz and Knutson 1999). Available evidence suggests that eggs and larvae do not survive fire, but they can survive in burn units because burns are uneven or because areas within the burn unit have been excluded from fire (Bleser 1993, Swengel 1994, Swengel 1995, Kwilosz and Knutson 1999). Research by Maxwell and Givnish (1996) estimated 50 to 80 percent Karner blue larval mortality on burned plots. The areas where larvae survived in the burned plots were at the bases of tree boles and around downed logs, where the fires skipped. As part of prescribed fire management/research at IDNL, 50 to 300 meter squared areas were excluded from fire within several burn units at several sites. Even with these refugia, adult counts dropped substantially within the partially burned portions of one of the sites as compared with unburned portions of the same site following fire (Kwilosz and Knutson 1999). However, there were no net population declines at fire-managed sites, and the authors suggested that adults either survive fire within the burn unit or move into the burned area from nearby or adjacent unburned units. Further, monitoring has shown that the number of Karner blue butterflies counted per site has increased on sites managed with prescribed fire (Kwilosz and Knutson 1999). It is important to note that because of the large number of factors than can potentially influence Karner blue population fluctuations, and limitations in the experimental designs used, it is not possible in any current studies to determine whether the Karner blue population fluctuations observed were a result of prescribed fire.

Some adults are known to survive fire by moving. A study on two habitat sites at Necedah NWR showed that some Karner blue adults survived prescribed burns (King 1994, King 2002). Adult Karner blues were observed at Necedah NWR flying immediately in front of the flames. Other Karner blues may avoid fire by moving to nearby adjacent habitat or because of they are in areas skipped by the fire within the burn unit. King (1994) notes that because the level of mortality of Karner blues remains untested, prescribed burns should be used with caution.

Recommendations:

Direct mortality to Karner blues can be reduced by burning less frequently, burning only one portion of a site at a time, conducting “patchy” burns, and creating refugia prior to

even when source populations are nearby, fire can reduce populations for at least one year post-fire. At Fort McCoy, burns were conducted in an area surrounded by sites occupied by Karner blue (Maxwell 1998). First brood larval damage and adult populations were reduced, but the burn stimulated lupine growth, and second brood larval densities were 20 to 50 percent higher in the burned areas. The following year, adult populations were similar in the burned and unburned areas. Thus, when recolonization is high, Karner blue populations can recover rapidly from fires (Maxwell 1998).

It is expected that burned areas within dispersal distance of other large populations of Karner blues will be recolonized more quickly than those areas where butterfly populations are sparse. This is based on the fact that the percentage of butterflies dispersing between sites varies with site characteristics and it is likely that larger populations will have a larger number of individuals moving between sites.

Recommendations:

Recolonization of the burned area can be facilitated by burning only a fraction of the occupied portion of a site and by ensuring that occupied habitat is within dispersal distance. Since dispersal distances between sites vary considerably with habitat type, it will be important to evaluate recolonization distances on a site-specific basis (refer to Table G1)

Management plans should identify the number, design, and rotation of burn units that will allow effective Karner blue re-colonization, i.e. insure Karner blues are within easy dispersal distance of the area to be burned. Never burn an entire metapopulation or important subpopulation at one time. If a subpopulation is essential for the maintenance of a metapopulation, then subdivide the subpopulation into separate management areas. Use existing breaks in the vegetation, such as roads, trails, and wetlands as firebreaks. If possible, avoid scarifying the soil to create mineral soil firebreaks and mow instead. On very small, isolated sites that have small Karner blue populations or are important to maintaining the metapopulation, use alternative management practices such as tree girdling, brush hogging, tree cutting, or mowing instead of fire. For medium to large, isolated sites, dividing the site into a minimum of 3 burn units may be sufficient to insure Karner blue populations persist following fire. On very large sites, with abundant Karner blue butterflies, large sections of habitat can be burned as long as the burns are incomplete (areas are left unburned), and unburned occupied habitat occurs (preferably) adjacent to, or within easy dispersal distance of the burned site.

4. <u>Characteristics of prescribed fire</u>:

Frequency:

Prescribed fire frequency ranges from once every year (for restoring habitat) to once every few decades (for maintaining habitat). Givnish et al. (1988) provide a historical perspective on the issue of burn frequency. They analyzed historical fire records associated with the Albany Pine Bush and suggested that fires returned once every 6 to 18 years, with once in 10 years a likely average. Research at the IDNL suggests a fire interval of 3 to 4 years will create

recommended that when and where possible, other methods to reduce woody vegetation, such as mowing, also be incorporated into habitat maintenance plans.

It is important that management plans are designed so that habitat patches within a metapopulation differ in time since fire, or other disturbance, to prevent all habitat patches from transitioning to unfavorable successional states simultaneously (Thomas Givnish, University of Wisconsin-Madison, pers. comm. 2002). Ideally, neighboring habitat patches should be managed so that they are at varying successional stages. This will allow the maintenance of suitable habitat within dispersal distance of habitat patches that are being lost due to succession. This results in a metapopulation structure that is a landscape mosaic of different aged vegetational states.

The season and intensity of burns should be varied. Season can be varied by alternating between conducting spring, summer and fall burns when possible, as dictated by the condition of the habitat and desired results. Similarly it will be advantageous to vary the intensity of burns, ranging from low to high intensity fires, depending upon what type of fire will best restore/maintain habitat and result in the least Karner blue mortality.

5. <u>The response of lupine and nectar plants to fire</u>:

The immediate, direct effects of fire on lupine plants and seeds may be positive, negative, or neutral. At the Oak Openings in Ohio, the short-term effects of a moderate intensity fire on established lupine plants were increased vegetative growth, flowering, and seed set (Grigore 1992). Nearly all of the seeds on the soil surface and new seedlings were killed. Seeds buried in the soil germinated at similar rates as those in unburned plots (Grigore 1992). At Fort McCoy, prescribed fire resulted in a short-term increase in the number of immature and flowering lupine (Maxwell 1998). Both of these studies indicate that burning may enhance flowering of established plants, and existing data suggest that germination of surviving seeds is not detrimentally affected by moderately intense burning.

Nectar plant species vary in their response to fire, in some cases influenced by the

Prescribed fire may also influence the phenology of Karner blue nectar plants. Preliminary research examining the affects of growing season burns at IDNL suggests that flowering of some nectar plants may be delayed in comparison to unburned plants (Noel Pavlovic, IDNL, pers. comm. 2002). It is unclear whether or how delayed flowering might impact the Karner blue.

Recommendations:

Plant surveys should be done and the information incorporated into management planning. When known, and where possible, time prescribe fire to reduce undesirable, and promote desirable species. If possible, vary the seasonal timing of burns at a site. Fire has a different effect upon any given plant species depending on when it occurs, and repeated application of fire at the same time of the year may select for only a subset of the savanna/barrens plant community. Spring and fall burns will suppress many cool-season grasses, but spring burns may reduce lupine.

For many nectar plants the effects of fire on presence and abundance are not known. Therefore, prescribed fire should be applied within an adaptive management framework, and include pre- and post-treatment monitoring of the effects of fire on nectar plant species.

6. Other habitat responses*:*

Prescribed fire is often used to reduce the cover of woody or invasive species, and increase the cover of savanna/prairie species. Based on 20 years of prescribed fire management at Cedar Creek Natural History Area in Minnesota, Tester (1989) documented a reduction in tree density and total basal area/hectare – although the changes were not significant. He also detected an increase in prairie species and a decrease in forest species with fire management. At the Konza prairie in Kansas, fire frequency had a strong influence on plant species composition and diversity (Gibson and Hurlbert 1987), and frequent burning doubled the abundance of legumes (Towne and Knapp 1996).

However, not all fires are effective at reducing canopy cover in these ecosystems. Three growing season wildfires at the INDL over the last 15 years have shown that lower branches of oaks are killed and leaves can be scorched up to ten meters into the canopy (Noel Pavlovic**,** U.S. Geological Survey, pers. comm. 2002). In addition, while one of the wildfires (1986) top killed numerous large oaks, subsequent root sprouting of the oaks and other woody species resulted in very dense woody thickets (Martin 1994). Prescribed fires studies in Wisconsin and Minnesota

resprouted. Most adult oaks only had lower branches killed, whereas many older black oaks (which are prone to heart rot that results in hollow trunk centers) were completely killed by fire entering and burning inside the tree. Individual jack pine are unlikely to survive fire, but conditions following fire are often conducive to seed germination.

Alternatives to fire management

In some habitat sites, the local situation may preclude the use of fire as a management tool. For example, some Karner blue subpopulations may be too important to risk extirpation from fire, or some sites may be located where burning is prohibited or is infeasible e.g., more urban areas. Moreover, in some sites other management practices may be more useful and effective or more economical than fire, e.g. mowing (refer to ***NOTE*** above).

Mowing has been used extensively in some states (e.g., New York and Wisconsin) to maintain suitable habitat, however mowing at the wrong time of year could result in reductions in lupine, nectar plants, and Karner blues. Lupine is an early season legume and usually completes its annual life cycle by early to mid-August. Karner blue butterfly eggs are frequently laid on the lower part of lupine plants and second flight adults are known to fly through most of August in many locales. Therefore, in order to minimize harm to the butterfly, mowing should generally be done after August 31 with the mower blade set at 6 - preferably 8 inches from the ground (this will minimize impacts on eggs that will be in the duff layer or on the lower part of lupine plants). If possible mowing should not be done until October or the first hard frost (at least in alternate years) so late-season flowering nectar plants can set seed and reproduce. Annual mowing should also be avoided if possible. To avoid impacts on Karner blues consider: 1) mowing in the winter over frozen ground conditions, 2) using a hand held weed whacker and hand cutting in small areas while avoiding Karner blue occupied lupine patches, or 3) using a side-mounted sickle-bar mower operated from the roadside or outside habitat areas. Mowing during the lupine life cycle will generally have a detrimental effect on lupine and the butterfly and should not be done at that time. The New York DEC is working on a management agreement with Saratoga County that will limit mowing of the airport to after October 15 and before December 31 to help conserve the Karner blue and the frosted elfin butterflies (NYSDEC, in litt. 2001). Karner blue habitat was probably maintained in the past at the airport because county mowers did not mow the airport until after they had finished all mowing responsibilities associated with road maintenance.

Mechanical and hand pruning of shrubs and small trees has also been used to open up Karner blue habitats. However, both of these methods generally require follow-up treatments to control root sprouting (using either prescribed fire or herbicides). Tree girdling, selective herbicide applications, tree harvest, and tree thinning can also be used to open up habitat. To minimize or avoid impacting the Karner blue, these types of activities are best done in occupied habitat during the winter under frozen ground conditions and snow cover.

Rotational grazing may be useful for suppressing competing vegetation, but probably not in the spring when larvae could be consumed with the vegetation.

All of these alternatives to fire management may have some adverse effects on Karner blue metapopulations, although some of these effects are likely to be minor. The greater the adverse effect of the management practice, the more attention should be paid to the disturbance return interval. If the adverse effect is quite large, as it probably is for fire, then return intervals must be carefully managed. If the adverse effect is minor, as it may be for hand pruning of low-density shrubs, then this is not as great a concern.

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APPENDIX H

MONITORING REQUIREMENTS AND GUIDELINES

MINIMUM VIABLE METAPOPULATION (VP)

Monitoring Requirements

A minimum viable population (VP) will have at least 3,000 individuals and a management and monitoring plan that buffers the VP against adverse disturbance and threats, maintains suitable habitat, and has appropriate responses to potential declines. The monitoring procedures will need to be designed specifically for each VP, so detailed monitoring requirements cannot be specified. Despite the variation in design, each monitoring system must provide the following information.

1. Karner blue butterfly relative abundance

   All subpopulations shall be monitored annually during either the first or second flight. Preference should be given to monitoring during the second flight unless monitoring during the first flight is more convenient. Preference should also be given to monitoring the same flight every year. In most cases, butterflies will be more abundant and easier to count during the second flight. Transect walks following standardized protocols are a suitable method. Ideally, they can be calibrated with mark-release-recapture estimates so that subpopulation size can be estimated, but this is not essential.

2. Habitat suitability in relation to disturbances and threats

   The monitoring system shall be developed in relation to identified adverse disturbances and threats to survival of the metapopulation. The monitoring system shall monitor the causes, if known, of the disturbances and threats, the subpopulation and habitat response to these disturbances and threats, or both. Monitoring of habitat in relation to potential threats shall be done initially and then every three years.

3. Connectivity

   The connectivity of subpopulations shall be monitored initially and every three years to confirm that subpopulations remain connected and that dispersal corridors remain functional. For example, lupine and nectar plant abundance might be recorded in relevant areas between subpopulations. Distances between subpopulations shall be monitored. The average nearest-neighbor distance between subpopulations should be no more than 1 kilometer (0.62 miles), and the maximum distance between subpopulations no greater than 2 kilometers (1.24 miles). In some cases the 1 kilometer distance may be too far (PART II, RECOVERY OBJECTIVE). Refer to APPENDIX G for guidance on establishing connectivity between subpopulations.

4. Quantity of suitable habitat

The area of suitable habitat in occupied and occupiable sites in the metapopulation shall be monitored annually. This minimally will involve estimating the area of lupine and adult nectar plants in occupied and occupiable habitat (refer to APPENDIX A, definitions of suitable habitat and occupiable sites). Use of aerial photography may be a suitable method for monitoring the area of habitat once the methods are confirmed. The

management to enhance Karner blue subpopulations should be initiated. Under these kinds of conditions, communication with managers of other metapopulations would be particularly useful.

Unknown cause of metapopulation decline

The metapopulation decline itself is the action trigger. Because of natural fluctuations in metapopulation size, an observed decline in metapopulation from one year to the next may or may not imply that the metapopulation is actually in decline. Thus, the action trigger should be related to the observed annual variation in the metapopulation, and an unexplained decline that persists over several years should trigger more serious actions. For a metapopulation with many subpopulations (more than ten), a potential trigger could be a decline in occupancy that persists for three years or an annual decline that exceeds two times the standard deviation of typical variation in occupancy (an occurrence of once in twenty years). For a larger metapopulation that has few subpopulations (less than or equal to ten), a potential trigger could be a decline in metapopulation density that persists for three years or an annual decline that exceeds two times the standard deviation of typical annual variation in metapopulation size (an occurrence of once every twenty years). For a minimum viable metapopulation, a potential trigger could be a decline in metapopulation density that persists for two years or an annual decline that exceeds 1.7 times the standard deviation of typical annual variation in metapopulation size (an occurrence of once every ten years). The response to these triggers may vary among metapopulations in the different recovery units.

LARGE VIABLE METAPOPULATION (LP)

Monitoring Requirements

The purpose of monitoring a large viable metapopulation (LP) is to determine that 1) the metapopulation is a LP for reclassification purposes, 2) that it remains large enough that it still can be considered a LP and qualify for delisting and 3) to determine when it no longer can be considered a LP. Action triggers are needed to determine when it is necessary to intensify management and monitoring efforts of the LP, and to determine when the metapopulation is just a VP and no longer a LP.

Minimally, the size of the LP and the habitat of the LP must be monitored.

1. Monitoring the size of the LP for reclassification purposes:

To qualify for reclassification, the metapopulation should have at least 6,000 butterflies (confirmed by having demonstrated through monitoring that 6,000 butterflies are present 4 out of 5 years, or as otherwise approved by the Service in conjunction with the Recovery Team). In addition, the area of the metapopulation should be distributed over 6.67 contiguous square miles (of an approximate ten square miles total area), and about 640 acres (one square mile) of suitable habitat is present (refer to PART II, RECOVERY OBJECTIVE, Reclassification Criteria). To qualify for delisting, the LP should be monitored sufficiently to demonstrate that the LP is being maintained. In addition there must be a management plan in place that is implemented on the ground to

maintain the metapopulation and a monitoring plan to detect trends in the metapopulation. The 6,000 requirement is not intended to generate a burdensome or

the need to increase the sampling effort to confirm the minimum 6,000 butterflies), then analysis of the cause of the decline should be made and implementation of reliable and feasible alterations in management to improve the metapopulation undertaken as appropriate.

c. If the four-year running average metapopulation is smaller than the minimum criterion for an LP (6,000) then determine the cause and alter management and associated monitoring appropriately. During the next year, alter management to increase the metapopulation. Continue monitoring and estimating the four-year running average. Intensified monitoring can be implemented to improve precision.

d. If the four-year running average metapopulation size remains below the minimum for five sequential years, then the metapopulation must be considered a minimum viable metapopulation. Management and monitoring must be changed to conform to the requirements for a minimum viable metapopulation or steps taken to reestablish the LP.

Table H1. Examples of four-4 year running averages

Reclassification Monitoring				Delisting Monitoring					
	Year -3	Year -2	Year -1	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Estimated population	9,000	5,000	10,000	8,000	6,000	NA	7,000	NA	11,000
Four-year average	--	--	--	8,000	7,250	8,000	7,000	6,500	9,000

Note: The use of other streamlined monitoring methods for documenting the presence of 6,000 butterflies may be appropriate as well. Recovery tasks in this plan include the further development of monitoring protocols (refer to PART II, RECOVERY

METHODS FOR ESTIMATING ABUNDANCE OF BUTTERFLIES

Mark-release-recapture and four types of transect monitoring methods are described below for consideration by managers when designing a Karner blue monitoring program. There are no methods that provide absolute estimates of butterfly abundance. No method is very precise except when conducted nearly to the point of being a census of the population. Most of the methods have a high degree of repeatability, especially when conducted under similar environmental conditions.

Mark-Release-Recapture

Mark-release-recapture (MRR) research involves capturing and marking individuals on one occasion and returning to the site and capturing individuals on at least one additional occasion and counting the number of unmarked and marked animals which are captured. Some researchers believe the MRR method is the most accurate method used to estimate butterfly numbers in most situations (Gall 1985; Schweitzer 1994). This method is also viewed as cost prohibitive for most situations because it requires multiple sample efforts (Thomas 1983, Schweitzer 1994).

When MRR is used to obtain population estimates, caution is urged when interpreting the results because MRR requires a number of assumptions (Opler 1995). One significant

Generally MRR should not be used annually for population monitoring because of the expense and effort involved. MRR must be used to calibrate transect counts when greater accuracy is needed (Dale Schweitzer, TNC, in litt. 2002), but most monitoring probably will rely on transect methods. Directly comparing data collected using the same methods rather than comparing them to MRR estimates will often lead to more accurate inferences, especially if the MRR period is brief. MRR is recommended only when an accurate population size estimate is needed.

Only experienced persons should do MRR because it involves handling individuals at least once and often several times. Schweitzer (1994) considers an injury rate of 1% of all individuals processed one or more times to be "high" and 5% "excessive." Refer to Schweitzer (1994) for several suggestions for keeping the injury rate low.

A variety of software packages exist for estimating absolute population estimates from MRR data. If the software is available analyses by two or more models should be attempted. The Jolly-Seber method should be included, and the software “Jolly” (Pollock et al. 1990) has received wide use among Karner blue researchers. Capture histories are entered into this software to provide a population estimate.

When MRR is used one should either cover most of the flight period for at least one sex, or concentrate sampling near the known peak of the flight. Sampling the entire flight period will require more than two weeks of daily sampling. MMR data should always be recorded and analyzed by sex. A pooled sex analysis can also be conducted. Sampling should be conducted every day, and if the sample period is five days or less, no days should be missed, except for bad weather. On the first day, sampling should start early to mark intensely. Throughout the period, a mark intensity of at least 50% should be maintained. Substantial recapture sample sizes should be attained every day, but excessive amounts of time should not be wasted in small sites, unless necessary on the first day. Spending too much time in small sites could cause excessive disturbance to the butterfly (and its habitat) and disrupt normal activity. Schweitzer (1994**)** provides suggestions pertaining to Karner blue MRR, and Gall (1985) provides references for a general review of the topic. Schweitzer, however, has observed that if almost all individuals are marked shortly after eclosion (emergence from pupae as adults), population estimates can be less than the actual number marked (Dale Schweitzer, pers. comm. 2000).

MRR will estimate population size only from the second day of sampling until the end. No estimate can be made for the first day, and the estimate on the last day is usually not very reliable, so good estimates can be obtained only from days two through n-1. If the sample period is not the entire flight period (at least for the sex being analyzed) then the brood size estimate will not be for the entire brood. Schweitzer (1994) suggested that the actual brood size could be estimated by tripling the mean daily estimate for the peak of the flight period. Schweitzer

Transect Counts

Various types of transect counts are used commonly to monitor butterfly populations. They are excellent when relative population size needs to be known. They can be quite reliable

3. Straight-line Transects

Straight-line (SL) transects are established on each unit at random, and transects run in a straight line crossing any or all cover types that lay in the direction that the transect is run. Although used widely for songbird surveys, SL transects have not received much use among lepidopterists. SL transects offer the advantage of being unbiased in regard to cover type. SL transects provide observers with the ability to compare between units because the samples are unbiased. The unbiased samples provided by SL transects are the opposite of PY counts that only provide samples of what the observer deemed good habitat. Thomas transects also provide an unbiased sample of the entire unit but in a more cumbersome way. When conducting research where comparisons between units are required, SL transects can be effective. The main weakness of SL transects is that it is not unusual to miss large aggregations of butterflies. Consequently, for butterfly sampling, SL transects provide accurate information only when the coverage of the habitat is high (perhaps >50%).

4. Meandering Transects

Meandering transects have not been compared to the other methods, but they may combine some of the advantages of the other methods. A permanent transect that meanders through the habitat like a PY transect is established, and sampling is conducted along those marked transects. Permanent transects enable count data to be compared across observers. Establishing the transects requires skill, much like the PY transects, but

transect is then multiplied by the fixed width to determine the sampled area. The sample area for a transect that was 1,000 meters long and had a fixed width of 3 meters would be 6,000 meters^2 because 3,000 meters^2 are sampled on each side of the transect. If 100 individuals were counted on this transect, the density estimate would be 0.017 individuals/meter^2 (100/6000).

Density estimates obtained from unlimited distance counts require that the observer determine the perpendicular distances to each individual. Counts of this type have been used widely by ornithologists and as a result there are several methods that can be used to estimate the size of the surveyed area. As it relates to the Karner blue butterfly, only the Effective-Strip-Width (ESW) method has received much use (Brown and Boyce 1996, Richard S. King, in litt. 1999). This method requires that the observer estimate the effective-strip-width (w_e), which is

EXAMPLES OF MONITORING FORMS AND METHODS CURRENTLY IN USE

Examples of several data forms and survey protocols used to monitor the Karner blue butterfly and its habitat are noted below. They may not meet all of the necessary monitoring requirements listed in this appendix, and some may go beyond these requirements. They are not specifically endorsed by the Recovery Team, but are provided as a guide and to indicate the diversity of approaches that are being used for monitoring.

1. Pollard-Yates Butterfly Monitoring Method. This is a summary of the Wisconsin DNR's adaptation of the Pollard-Yates method for monitoring the Karner blue butterfly. It includes detailed methods for pre-survey as well as survey work, a discussion of its strengths and limitations, and recommended weather conditions appropriate for monitoring.

2. Karner Blue Transect Count Form. This is a one-page data form that is used to record the data taken during a Pollard-Yates survey developed by the Wisconsin DNR. It includes space to record butterfly behaviors as well as numbers.

3. Karner Blue Habitat Evaluation Form. This is a two-page data form that is used to record habitat characteristics of the Karner blue developed by the Huron-Manistee NF in Michigan. It includes space to describe lupine, nectar plants, and canopy cover.

4. Karner Blue Butterfly Habitat Evaluation Form. This is a one-page form that is used to record Karner blue habitat characteristics. It includes space to sketch the site, describe threats to the site, and recommend management, and is used by the Huron-Manistee NF.

5. Karner Blue Butterfly Presence/Absence Survey Protocol. This is a protocol for

8. Monitoring Protocol and Estimated Survey and Time Requirements for Monitoring Karner Blue Metapopulations at Fort McCoy, Wisconsin. This describes the straight-line transect monitoring protocol that is being used at Fort McCoy, Wisconsin, and provides estimates

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APPENDIX I

TRANSLOCATION GUIDELINES FOR THE KARNER BLUE BUTTERFLY

These guidelines are meant to assist agencies and organizations working on recovery of the Karner blue. Each instance where translocation is considered will be different, and it is hoped that these guidelines will encourage a hard look at what will be involved, the expected benefit to the species, and whether the expenditure of limited resources is warranted. In the early stages of recovery, some of these guidelines may apply more as states work toward viability than later. After viability is achieved, there should be monitoring and management in place that should substantially reduce the need for additional translocation or captive breeding.

Translocation in any form should be seen as a tool in recovery, but as with any tool, the need for it should be carefully considered. The actions taken should clearly further the goals for recovery within the particular recovery unit. Any translocation program should be done according to a plan that lays out clearly what the goals of the translocation are and how success will be defined (e.g. a self-sustaining population that does not need further artificial immigration of animals, some defined increase in the population, etc.). It must define how long the action will be done, what the evaluation period will be, and what steps will be taken if success is not achieved (i.e. continue or not continue). There should be sufficient funding to achieve the goals set forth in the plan. All captive rearing or captive propagation actions should be done in accordance with the U.S. Fish and Wildlife Service's (Service's) policy on controlled propagation, and appropriate state and Federal permits should be obtained prior to proceeding. The plan should include monitoring of the source populations for any detrimental effects of the translocation action.

Three types of translocations are discussed below: 1) accelerated colonization, 2) reintroduction, and 3) augmentation.

TRANSLOCATION TO UNOCCUPIED SITES

In the following scenarios, sites are <u>not currently occupied</u> by Karner blues although they may have been in the recent past or historically (sites are within historic range).

Accelerated Colonization

<u>Objective</u>

The objective is to speed up colonization of new or unoccupied suitable habitat to help create a viable metapopulation. This is especially appropriate where recovery actions are concentrated on increasing habitat and the number of occupied sites. This action should not take the place of establishing corridors and proper spatial arrangement of sites. The sources of

animals for accelerated colonization are generally expected to be from within the particular

2. When the area historically had Karner blues but currently does not (e.g.. Tonawanda, New York, Ohio, Ontario, other historic or potential recovery units). All necessary resources for viability must be present or achievable. Further, the problems leading to the extirpation of the Karner blue must have been identified and addressed. Efforts should also be made to encourage local support for the project.

3. Within the historic range of the Karner blue but where definitive evidence of its past existence is lacking (e.g. Rome Sandplains, NY has anecdotal evidence but no specimen). As in No. 2 above, the criteria for viability must be present or achievable, and there must be support for the project.

   Note: It would be inappropriate to attempt to establish the Karner blue outside of its historic range (e.g.. Texas), where the landscape is not suitable for viability, or where there is not a firm commitment to long-term Karner blue management.

TRANSLOCATION TO OCCUPIED SITES

In the following scenarios, sites are currently occupied by the Karner blue butterfly:

Augmentation

Objective

The objective of translocation is to keep a metapopulation from becoming non-viable and to prevent a metapopulation within a recovery unit from disappearing.

The question of whether the number of Karner blues in a subpopulation has become too low will be determined by the manager most familiar with the history and environmental conditions of the subpopulation. In general, if a subpopulation shows a persistent drop in numbers over time, there should be a trigger-point identified that when reached, should trigger corrective action to address the decline. Augmentation may be a tool among several that can be used to address the decline.

Scenarios when augmentation of a subpopulation would be appropriate

1. When the subpopulation has become so low that it most certainly will be lost *and* there is no subpopulation connected or within dispersal distance to recolonize the site *and* loss of this subpopulation will bring the metapopulation below minimum viability criteria.

   Further conditions:

   a. Steps must be taken to identify and rectify the cause of the decline. Translocated animalspulat

b. The translocation plan for the population should include what will signal the end point for the action. Augmentation alone should not be viewed as the solution to a chronic decline problem.

c. The goals for the metapopulation must support the use of augmentation.

2. A subpopulation has been determined to be nonessential to the metapopulation (outlier, extremely marginal, etc) and/or has been slated for destruction by development. In addition to the required mitigation for "taking" Karner blues, it may be desirable to salvage some of the population and move them to a low or stressed subpopulation in the metapopulation or to start or augment a captive propagation colony.

SOURCE POPULATIONS FOR TRANSLOCATION

The choice of source populations for translocation programs will depend on many factors, four of which follow:

1. The Size of the Donor Subpopulations

Source subpopulations should be large enough so that the removal of animals will not impair their long-term viability. It is also desirable to take animals from more than one subpopulation for translocation to any particular site. Unless the source subpopulations are very large, they should be monitored both before and after animals are removed so that the effect, if any, can be evaluated. The translocation plan should include methods to monitor and evaluate the sources, and identify appropriate actions to correct adverse impacts, should they occur. In rare circumstances, a relatively small population may be the only alternative source. In this case, extreme precautions should be taken to assure that the numbers taken will not harm the subpopulation.

2. The Habitat Characteristics of the Source Compared to the Recipient Site

Animals from a source population whose local climatic conditions and microclimate are similar to the conditions at the recipient site may have a better chance of survival than animals from very different environments. This will often mean that subpopulations from within a metapopulation will be better suited for translocation within that metapopulation than ones from outside it, assuming they are large enough.

3. Genetics Information (whole section new)

If available, genetics information should be used to help identify the appropriate donor population. Generally, genetic studies of the Karner blue and differences in populations across its range are not complete and currently are not considered necessary for recovery (refer to PART I, RECOVERY TASKS, Table 5). Until there is contradictory information on the effects of genetic mixing, managers should try to use suitably sized sources from within the subject metapopulation. When this is not possible, the donor subpopulations should always come from

areas that are most similar to the recipient local habitat conditions (e.g., soil moisture, temperature, etc) and geographically close to the habitat where introduction is planned.

Considerations regarding donor populations for captive breeding programs should be the same as discussed above. Donor subpopulations should not be put at risk to supply the program, and the progeny generated for a particular translocation should come from populations, which match the recipient habitat conditions.

Because it cannot be assumed that first and second brood Karner blues are genetically similar (Hugh Britten, University of South Dakota, in litt. 2002), it may be advantageous, in order to insure more genetic heterogeneity, to consider obtaining donor Karner blues from not only first, but second flight populations (Hugh Britten, pers.comm. 2002).

4. Permit Requirements

The translocation of insects across state lines is regulated by the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS), and any such translocation of Karner blues would require a permit from APHIS. Permits are also required from the Service and affected state agencies.

A Service export permit and Canadian import permit would be necessary to allow transfer of the Karner blues from the United States to Ontario, Canada.

CAPTIVE REARING AND CAPTIVE PROPAGATION

Many endangered species recovery programs have involved the release of animals born or head-started in captivity. This type of program may become useful for Karner blue recovery as a source for translocation in the future, especially if large, suitably matched source colonies are not available or practical to use for a translocation.

Head-starting, or *captive rearing* of Karner blue eggs taken from wild individuals to older life stages for release, has been done successfully (refer to PART I, CONSERVATION MEASURES, Reintroduction/Translocation). Captive rearing may be a necessary part of many translocation programs. Experts must make the decisions as to what life stage should be transported and released (i.e. maybe it is safest to transport eggs or larva, but adults may survive better when released), which brood period should be targeted for the releases, what the best techniques for release might be, and how to monitor the fate of the releases. Managers should look to those with experience in this type of program, as the potential for failure and loss of Karner blues is very real. The Toledo Zoo (Ohio), The Nature Conservancy (Indiana Office), the New Hampshire Fish and Game Department, and Minnesota DNR, are actively involved in translocation efforts and can be contacted for more information on their release methods which vary from the release of adults in Ohio (The Toledo Zoo 2002) to pupae (in release tents) in Indiana (Labus et al. 2002).

Captive propagation techniques for the Karner blue have been developed by the Toledo Zoo and are anticipated to evolve further. Captive propagation involves producing Karner blues for release from a permanently captive breeding population. Getting Karner blues to mate and

new food source. This is a risk adverse strategy - mixing lupines is irreversible, and any risks associated with mixing lupines would most likely be irreversibly as well. Reintroductions of the Karner blue in Ohio and New Hampshire have demonstrated that larvae produced from out-of-state donor populations grew and metamorphosed successfully on native lupine. Lupine is relatively easy to grow, and obtaining suitable amounts of native lupine for translocation work is doable.

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APPENDIX J

EDUCATIONAL AND OUTREACH ACTIVITIES

This appendix provides information on educational and outreach activities ongoing in the various states that have recovery goals for the Karner blue.

New Hampshire

The Karner blue has been designated the official butterfly of the City of Concord as well as the state. Outreach efforts include a traveling display, a puppet show for children, a fact sheet and many meetings and contacts with local media and officials.

New York

Several outreach activities have taken place at the Crossgate Shopping Mall in Albany, New York including a puppet show for pre-schoolers and a public display on Karner blue and lupine barrens ecology. TNC has hosted a Karner blue "Awareness Event" (mailing and media). There are numerous public walks and talks focused on the Karner blue in the Pine Bush and at the Saratoga Spa State Park. Throughout the year, there is regular coverage of Karner blue butterfly issues in the local newspapers.

The Town of Wilton held a press conference to announce the "Wilton Wildlife Preserve and Park," (WWPP) and to honor two landowners protecting the Karner blue. TNC's newsletter has featured the voluntary efforts of a private landowner to protect Karner blue and its habitat. A Boy Scouts of America camp in the Wilton, New York area developed a interpretative trail and merit badge program focused on Karner blue. A visitors' center is planned for the Wilton Wildlife Preserve and Park with a butterfly garden and interpretive materials related to the Karner blue butterfly and the area's natural and cultural history.

The Albany Pine Bush Commission has developed a brochure describing their Native Plant Restoration Program and providing a list of nurseries where local stocks of native species can be obtained. Plans are in motion to revise the brochure to be appropriate for the entire Glacial Lake Albany area.

Teachers and students at the Farnsworth Middle School in Albany are very active in habitat management programs within the Albany Pine Bush Preserve, and have established a native plant butterfly garden at the school. Teachers there would like to be able to raise Karner blues some time in the future. The NYDEC and WWPP have established contacts with two local schools to involve children in habitat management and education about the Karner blue. The Geyser Road School in Saratoga West already has part of a Karner blue subpopulation on its property, and with guidance from DEC, will enlarge this habitat on school grounds. The Ballard Road School in Saratoga Sandplains has had educational presentations from WWPP staff and will be visiting the WWPP for educational trips and to help with habitat management projects.

The New York DEC distributes Karner blue fact sheets to interested teachers, students, and the public. Niagara Mohawk Power Corporation (NIMO) has erected signs identifying Karner blue habitat in their powerline rights-of-way to alert crews to these sensitive areas; they have also included Karner blue in a small field guide they have produced.

Michigan

The Huron-Manistee NF has developed an information and education plan that targets a variety of audiences to disseminate partnership and educational material. Focus groups include schools, the general public, local, state and Federal government agencies and commissions, conservation partners, the "Friends of the Huron-Manistee NF" group, and fellow forest service personnel. The effort is aimed at building support and educating the public about planned activities and to develop partnerships for future work. To accomplish these tasks the NF is using slide presentations, newspaper articles, radio and television spots, field trips and public meetings.

Other outreach efforts by the Michigan Natural Features Inventory have included a workshop on dry sand prairie and oak-pine barrens ecosystems targeted at site planners and resource professionals, and two slide/tape programs that have been developed for a general audience and professional biologists (John Paskus, Michigan NFI, pers. comm. 1997).

Indiana

Some of the Partners to the developing Wisconsin Statewide HCP are contributing significantly to education and outreach efforts focused on the Karner blue. Thilmany (a

Web Sites

Noted below are web sites with Karner blue butterfly informational materials that can be used for educational purposes**:**

* Wisconsin DNR
  Environmental Education for Kids (EEK)!
  Karner Blue Butterfly

  http://www.dnr.state.wi.us/org/caer/ce/eek/critter/insect/Karner.htm

* The Roosevelt Wild Life Station (State University of New York - Syracuse)
  Conservation and Education Research
  Karner blue and the Pine-oak Barrens: Educational Modules

  http://www.esf.edu/resorg/rooseveltwildlife/research/karnerblue/karnermodules.htm

* U. S. Fish and Wildlife Service

  http://midwest.fws.gov/Endangered/insects/index.html#/karner

* The Nature Conservancy (West Gary, Indiana, Karner blue butterfly reintroduction)

  http://nature.org/wherewework/northamerica/states/indiana/preserves/art9126.html

APPENDIX K

PUBLIC COMMENTS ON THE TECHNICAL/AGENCY DRAFT RECOVERY PLAN

Following is the list of individuals and agencies that submitted comments on the Karner Blue Butterfly Technical/Agency Draft Recovery Plan. All comments have been reviewed and incorporated, as appropriate, into this recovery plan. Comments are on file in the Service's Green Bay Ecological Services Field Office, New Franken, Wisconsin. A review of the comments received from peer reviewers and responses to them are reviewed below as well.

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* IOC = Implementation and Oversight Committee, Wisconsin Statewide HCP for the Karner Blue Butterfly. One letter received from the IOC, signed by the seven members of the committee noted above.

SUMMARY OF PEER REVIEWERS COMMENTS AND RESPONSES TO THEM

Comment: A concern was expressed about the downplaying of fire because of the role it plays in maintaining the early successional habitat of the Karner blue. The commenter questioned whether this is due to unsuccessful regeneration of lupine after prescribed burns in areas where fire has been long suppressed, and if so that additional intervention (i.e. seeding to replace depleted seed banks) is needed.

Response: APPENDIX G of this plan has been expanded to include and consolidate information on the impacts of fire on the Karner blue and to clarify management recommendations relative to prescribed burns. The management guidelines recognize the use of prescribed fire as well as other management tools for maintaining the early successional habitat of the Karner blue and identifies measures that can be taken to minimize the impacts of these management tools on the butterfly. This plan also recognizes the need of restoring and maintaining a mosaic of early successional habitat for the Karner blue in order to establish viable populations of the butterfly (e.g., PART I, HABITAT/ECOSYSTEM and APPENDIX G). Lupine regeneration and recolonization in areas where fire has been long suppressed may be problematic and additional language, as well as a recovery task, have been added to the plan to reflect this (refer to PART I, LIFE HISTORY AND ECOLOGY, Lupine Food Resource, Other factors affecting lupine, and PART II, RECOVERY TASKS, Task 5.25).

Comment: One commenter expressed the need for clarity regarding the dispersal ability of the Karner blue and the definitions of "site" and "patch" in APPENDIX A (GLOSSARY).

Response: Table G1 summarizing Karner blue dispersal research has been incorporated into APPENDIX G of this plan and a more thorough discussion of dispersal provided. The studies demonstrate that there is a fair amount of variation in dispersal ability between sites depending on the canopy cover of the intervening habitat. The definition of "site" in APPENDIX A has also been revised for clarity and for compatibility with APPENDIX G.

Comment: One commenter expressed concern that there was no reference to lupine genetic structure relative to translocation of the host plant and pointed out that, as with the Karner blue, genetic considerations could affect the outcome of translocation efforts relative to lupine.

Response: Guidance has been added to APPENDIX I of this plan to clarify the Recovery Team's recommendations regarding the translocation of lupine to reintroduction sites. The information summarizes why such translocations are not considered desirable at this time, one of the reasons is related to genetics concerns**.**

Comment: One commenter expressed the concern that genetics should play a stronger role in recovery planning, that the mtDNA data (from Nice et al. 2000) suggests a disjunction among Karner blue population in the eastern and western portion of the range and that translocations between these areas should not take place. The commenter also stated that translocation and

management guidance should address genetic differences in first and second brood adults and that there was no mechanism in the plan to allow for monitoring the genetic health of Karner blue populations.

Response: Most of these concerns were addressed by adding language to the Taxonomy section of this plan (refer to PART I, TAXONOMY AND DESCRIPTION) and/or to APPENDIX I. The Recovery Team did not think monitoring the genetic health of the population was important to recovery. The guidance in this plan developed for establishing and managing viable metapopulations is anticipated to maintain the genetic health of Karner blue metapopulations. That guidance can be found in APPENDICES B, E, F, G, and I.

Comment: One commenter stated that the plan lacked concern for the population genetic structure of the Karner blue expressing some concern that translocations could be done with stock from "environmentally similar" regions if necessary. The commenter points out that there is a minor degree of concern for local adaptation, but almost none for maintaining the geographic architecture of neutral genetic variation that could be key to reconstructing the history of dispersal and evolution in the butterfly.

Response: The primary goal of this recovery plan is to perpetuate viable metapopulations of the Karner blue in the major ecological regions throughout its geographic range. Thirteen ecological regions are identified in this plan called "recovery units" and are based on known variation in physiography, climate, vegetation, and potential geographic genetic variation in the Karner blue populations [refer to APPENDIX B, and PART I, RECOVERY STRATEGY). The Recovery Team anticipates that this strategy will preserve the genetic variation of Karner blues throughout its range. Translocation guidelines (Appendix I) were also incorporated into this plan to help insure the genetic integrity of Karner blue butterfly populations.

Comment: One commenter expressed concerns about the broad definition of metapopulation adopted for this plan in that it lacked an explicit statement about spatial dispersion and connectivity among habitat patches for any given metapopulation. The commenter noted that all Karner blue metapopulations appear to be treated the same when it is clear that their potentially different metapopulation structures suggest that they should not be. The commenter suggested including a hypothesized metapopulation structure in the metapopulation description to provide a starting point for considering the impact of specific management activities.

Response: Additional language has been added to PART II, RECOVERY, RATIONALE**,** Population Structure and APPENDIX E of this plan noting that viable metapopulations and large viable metapopulations are likely to have their own unique population structure and that this plan is not prescribing an particular "ideal" structure. Guidance on establishing connectivity among habitat patches (subpopulations) is provided in APPENDIX G.

Comment: One commenter noted that the use of metapopulation dynamics as a conceptual

that are so far apart that they are cut off from recolonization should they go extinct. The commenter also noted that in cases where habitats are lost and do not leave behind suitable habitats, the "rules" of metapopulation dynamics are less important than the "rules" of habitat dynamics (e.g. rates, intensities, and spatial patterns of disturbance and recovery).

Response: A "nonequilibrium" metapopulation was not mentioned in this plan as it is not a metapopulation structure we wish to aim for. We agree with the latter statement and language has been added to APPENDIX G of this plan recognizing the importance of maintaining a suitable array of habitat for the butterfly with appropriate disturbance to insure metapopulation persistence.

Comment: One commenter wondered if there was evidence for "random" local extinctions, i.e. ones that occur within still-suitable habitat, and if so whether these involve populations that are so small they have little bearing on the regional survival of the species.

Response: We think this is possible, especially in Wisconsin where many small populations are known to occur.

Comment: One commenter noted that it may be possible that single occurrences of the Karner blue are viable populations as long as there are processes (e.g. mowing) that can continuously maintain early-successional habitat.

Response: This may be possible and language has been added to APPENDIX E (POPULATION STRUCTURE**,** Spatial Structure of a Minimum Viable Metapopulation) noting this.

Comment: One commenter supported the plan's emphasis on monitoring noting that every 2-3 years the Recovery Team needs to determine what practices have had a demonstrably positive effect and which seem to be ineffectual or even detrimental to the recovery of the Karner blue.

Response: Recovery Task 6.2 (PART II, STEPDOWN RECOVERY OUTLINE) entails the holding of Recovery Team meetings every 2-3 years. Language has been added to this task to include review of the impact of management practices on the Karner blue at these meetings.

Comment: One commenter expressed the concern that understanding dispersal is critical to Karner blue butterfly management, that research items dealing with dispersal, corridors, and individual movements should be given a priority 1 rating and that high resolution genetic assays could aid these tasks.

Response: This plan assigns priority 2 and 3 ratings to these research tasks. Much is known about Karner blue butterfly dispersal and can be found summarized in APPENDIX G of this plan. The Recovery Team's view is that genetics plays a small role in the research items noted.

Comment: One commenter noted that it was unclear what role the potential recovery units play in the recovery process and suggested that translocations to potential recovery units be given a priority 3 rating.

Response: The role of the potential recovery units has been clarified in this plan and because they may play a role in recovery of the species, recovery tasks related to them have been assigned a priority 3 rating (refer to APPENDIX B)

Comment: One commenter suggested assigning a priority 2 rating to captive rearing and translocation tasks, as they are largely reserved for "emergency" situations.

Response: Because captive rearing and translocation are actions needed to prevent extinction or an irreversible decline in the species, these tasks were assigned a priority 1 rating.

Comment: One commenter noted that it may be worth considering recovery criteria that more strongly emphasizes the amount, quality, and spatiotemporal dynamics of the habitat

Response: The Recovery Team believes that sufficient information is available that demonstrates that deer browse can negatively affect Karner blues which is reflected in this plan. Language has been added to this plan noting the availability of new economically solar powered electric fencing (refer to PART I, THREATS TO SURVIVAL).

Comment: One commenter stated that explicit translocation protocols need to be developed that include identifying source populations.

Response: The Translocation Guidelines in APPENDIX I of this plan provide recommendations on source populations for translocation efforts. Recovery tasks have also been identified to further develop translocation protocols (refer to Task 5.14). In addition researchers can review protocols currently being used in translocation projects in New Hampshire, Indiana, Minnesota, and Ohio.

Comment: One commenter noted that the recovery target of 29 self-sustaining and permanently protected and managed metapopulations appears to be a reasonable goal for full recovery noting that while stochastic processes makes assignment of hard target numbers somewhat arbitrary, it appeared the plan used available data to propose a conservative
ent0 Tg