



Comprehensive Population and Habitat Surveys for the Karner Blue (*Lycaeides melissa samuelis*) in Michigan: 2004 Progress Report



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Cover Photo Identification and Credits:

Clockwise from Upper left: Karner blue working group field trip to occupied habitat, mating Karner blues, Occupied habitat, Karner blue female dorsal view.

All photos in this report are by the author.

TABLE OF CONTENTS

Introduction	1
Purpose of the Study	2
Project Objectives	3
Methods	3
Deductive Habitat Model	3
Population and Habitat Surveys	4
Data Transcription and Digitizing	11
Distribution and Abundance	11
Associated Species Surveys	12
Results	13
Deductive Habitat Model	13
Population and Habitat Surveys	13
Data Transcription and Digitizing	25
Distribution and Abundance	25
Associated Species Surveys	26
Meetings and Conferences	29
Inter-Agency Cooperation and Outreach Efforts	29
Discussion	30
Deductive Habitat Model	30
Population and Habitat Surveys	30
Distribution and Abundance	33
Opportunities for Translocation/Reintroduction	33
Acknowledgments	34
Literature Cited.....	35

LIST OF TABLES

Table 1. Public lands surveyed for Karner blue and lupine, 2004..... 7

Table 2. Site description variables, their categories, and how categories were identified during Karner blue surveys, 2004. 9

Table 3. Habitat variables and their components collected at all Karner blue butterfly survey sites, 2004. 10

Table 4. Rare species associated with barrens and savannas targeted during Karner blue butterfly surveys, 2004. 13

Table 5. Plant species on which barrens-and savanna-associated rare insect species depend. 13

Table 6. Results of 2004 Karner blue butterfly surveys classified by owner type and element occurrence (EO) status. 22

Table 7. Percent of Karner blue absent, lupine only, and present sites surveyed in 2004 having general site characteristics present. 23

Table 8. Percent of Karner blue absent, lupine only, and present sites surveyed in 2004 having habitat components present. 24

Table 9. Location and element occurrence (EO) status of rare species observed during 2004 Karner blue butterfly surveys. 29

LIST OF FIGURES

Figure 1. Spatial data layers and their weighted categories used in building a predictive Karner blue butterfly habitat model..... 5

Figure 2. Study area for 2004 Karner blue surveys derived from the known range of Karner blue, unverified Karner blue records, and records of sympatric lupine-obligate Lepidoptera species..... 6

Figure 3. Deductive model predicting areas with predicted suitable Karner blue butterfly habitat (lupine present)..... 14

Figure 4. Graphical representation of a confusion matrix depicting Karner blue habitat (lupine) observation in 2004 compared to deductive habitat model prediction. 15

Figure 5. Graphical representation of a confusion matrix depicting Karner blue observation in 2004 compared to deductive model prediction of habitat (lupine) presence..... 15

Figure 6. Map showing routes driven during roadside lupine surveys, 2004..... 16

Figure 7. Map highlighting townships surveyed for Karner blue butterflies, 2004..... 17

Figure 8. Karner blue butterfly survey efforts among ownership and owner types during 2004 surveys. 18

Figure 9. Lupine locations collected along survey routes during 2004 roadside lupine surveys. 20

Figure 10. 2004 Karner blue butterfly survey results by township..... 21

Figure 11. Known Karner blue distribution within Michigan townships prior to 2002-2004 MNFI surveys. 27

Figure 12. Known Karner blue distribution within Michigan townships after the final year of 2002-2004 MNFI surveys..... 28

LIST OF APPENDICES

Appendix 1. Karner blue butterfly survey protocol adapted from Wisconsin Habitat Conservation Plan.....	- 1 -
Appendix 2. Survey form and instructions used in MNFI Karner blue butterfly surveys, 2004.....	- 3 -
Appendix 3. Survey form and instructions used in MNFI Karner blue butterfly surveys, 2004.....	- 3 -

INTRODUCTION

The Karner blue butterfly (*Lycaeides melissa samuelis* Nabokov) was listed as endangered by the U.S. Fish and Wildlife Service (USFWS) in 1992. Once known from 12 states and the Canadian province of Ontario, the butterflies currently occur in just seven states - Indiana, Michigan, Minnesota, New Hampshire, New York, Ohio (reintroduced population), and Wisconsin (USFWS 2003). Michigan and Wisconsin contain the greatest numbers of butterflies and populated habitat patches (USFWS 2003). The species was once present in 11 Michigan counties and is now found in 10 western Lower Peninsula counties, half of which support just 1 to five small, isolated sites at risk for extinction from habitat degradation and fragmentation (Wilsmann 1994, Rabe 2001).

The Karner blue butterfly is associated with barrens and savanna communities throughout its range. A variety of habitat characteristics unique to these systems influence Karner blue population viability. Wild or blue lupine (*Lupinus perennis* L.), a legume associated with prairies and savannas, is the only known food plant for the Karner blue caterpillar and must be present for Karner blue to persist in an area. Lupine density, abundance, and quality influence Karner blue population levels (Bernays and Chapman 1994, Savignano 1994, Herms 1996, Swengel and Swengel 1996, Grundel et al. 1998a, 1998b, Maxwell 1998, Lane 1999a). Nectar of flowering plants serves as a food source for adult butterflies; nectar plant diversity and availability also impact Karner blue populations (Fried 1987, Lawrence and Cook 1989, Bidwell 1994, Grundel et al. 2000). Lupine and preferred nectar plant species are associated with semi-open to open areas, making the amount of canopy closure an important factor in determining habitat quality (Packer 1987, Lawrence and Cook 1989, Lane 1994, Maxwell and Givnish 1994, Smallidge et al. 1996, Maxwell 1998, Grundel et al. 1998b). In addition, a variety of microhabitats are used

by Karner blue adults throughout the day, and butterflies are often more abundant in areas with diverse vegetation structure (Lane 1993, 1999b). The presence of mutualistic ant species appears to benefit Karner blue larvae, and areas with ant mounds often contain more butterflies than comparable habitats without ants (Savignano 1990, 1994, Lane 1999b). Finally, the distribution of habitat patches across the landscape will determine long-term viability of Karner blue metapopulations. A single site likely cannot maintain a subpopulation indefinitely (Givnish et al. 1988, Packer 1994); multiple habitat patches help spread the risk of extinction from a catastrophic event.

Declines in Karner blue populations are driven by the loss of barrens and savanna systems that meet Karner blue habitat requirements (USFWS 2003). Karner blue habitat patches were historically maintained by fires (Chapman 1984), which helped maintain the characteristic vegetative structure and species composition (Tester 1989). However, fire suppression efforts have led to succession of barrens and savanna to woodlots and forests in many areas. This, coupled with conversion of lands to agriculture, pine plantations, residential areas, and other uses have drastically reduced the quality and availability of habitats in Michigan (Wilsmann 1994). As a result, remaining Karner blue populations are now found only in remnant native oak savannas, barrens, and man-made habitats with conditions suitable for lupine growth. Man-made Karner blue habitat results from timber harvest, road and utility right-of-way maintenance, or direct management (e.g. mowing or prescribed burning) aimed at maintaining an open canopy (Evers 1994). A comprehensive understanding of the distribution and characteristics of Karner blue occupied, available, and potential habitats is needed to determine the current status and guide future management efforts for the species in Michigan.

Purpose of the Study

The USFWS and MDNR have initiated the development of a statewide Habitat Conservation Plan (HCP) for the Karner blue butterfly. Once the agreement is in place, the MDNR will be able to conduct management that might result in the incidental take of Karner blue, but will ultimately be of benefit to the species. MDNR aspires to protect occupied sites, increase habitat availability, and increase butterfly populations to recovery levels, using the latitude of management options afforded by the HCP agreement (John Lerg personal communication). Important steps in the creation of a statewide HCP are to determine the current species distribution, define threats to population viability, and identify opportunities for enhancement of populations.

Although surveys have been conducted for Karner blue through much of the known range in Michigan, there are still large gaps in our knowledge of the current species distribution. First, not all recovery units (RUs) identified in the Karner blue Recovery Plan have received comprehensive surveys (USFWS 2003). Surveys over the last 10 years focused on large, relatively contiguous tracts of state- and federally-owned lands, namely Allegan State Game Area (SGA) in the Allegan Recovery Unit and the Huron-Manistee National Forest (HMNF) in the Muskegon and Newaygo RUs (USFWS 2003). These surveys have undeniably added to the understanding of Karner blue distribution within those areas. However, the Ionia, Muskegon, and Newaygo RUs fragmented ownership, making comprehensive surveys difficult. As a result, fewer surveys have been conducted there, meaning much less is known about the Karner blue distribution across ownership types in those RUs (USFWS 2003). Re-survey of known sites is also needed in much of the Ionia, Muskegon, and Newaygo RUs. Many Karner blue records have not been verified for several years and therefore may no longer represent occupied habitat. These “old” records should be re-surveyed to determine whether Karner blue are

currently present or absence, and to identify threats to the persistence of extant subpopulations. Filling these knowledge gaps will lead to a better understanding of how the species is distributed across the landscape, facilitating informed management decisions and increasing the potential for species recovery.

The amount and distribution of Karner blue habitat across the state has not been determined. Karner blue habitat has been characterized in terms of site-specific habitat in portions of the state and throughout the species range. Lupine density and abundance, nectar source availability, and canopy closure have been identified as some of the most important site-level factors determining habitat quality (Celebrezze 1996, Grundel et al. 1998b, Grundel et al. 2000). However, Karner blue recovery efforts must occur across a wide range of site-specific habitat conditions at the landscape scale. A comparison of landscape-level habitat characteristics at occupied and unoccupied sites in Michigan is needed to identify and prioritize areas for conservation, management, and restoration efforts. Because the Karner blue RUs were created based on ecological classifications completed by Albert (1995) and known records of Karner blue, they represent a range of environmental conditions in which Karner blue are found. Creation of a model characterizing landscape-level habitat across these RUs will help managers quickly predict whether habitat is present, identify opportunities for restoration, and influence management priorities. A landscape-level model will also be useful in determining which environmental conditions are suitable for lupine. Such a characterization would be useful in predicting the historic distribution of lupine and Karner blue. A comparison of the historic and current distributions will give insight into which areas may have experienced the greatest population declines, guide decisions on where to focus conservation efforts, help locate areas with potential for restoration, and identify areas with potential for translocation or introduction.

In 2002, the Michigan Natural Features Inventory (MNFI) began a three-year project with funding from the MDNR to determine the status and distribution of the Karner blue butterfly in Michigan. The project goals are to identify the locations and extent of the most significant Karner blue metapopulations in Michigan, describe their current condition, identify threats to persistence, and locate opportunities for enhancement through habitat protection, expansion, reintroduction, or translocation. MNFI activities related to these goals include presence-absence surveys on private and public land, habitat modeling, and database support. This report summarizes the final year of activities conducted by the MNFI related to this project.

Project Objectives

The objectives for the final year of this project are to:

1. Model potential habitat.
2. Complete comprehensive population and habitat surveys for the Karner blue in Michigan.
3. Provide information on butterfly distribution and abundance.

4. Transcribe and digitize new occurrence data
5. As time permits, document and survey other rare species that occur in association with Karner blue and are most likely to be affected by management activities. These may include eastern massasauga, black rat snake, eastern box turtle, frosted elfin, Ottoe skipper, Persius duskywing, dusted skipper, Culver's root borer, Great Plains spittlebug, phlox moth, and leadplant flower moth.
6. Participate in meetings and conferences with HCP partners, EIS team and the federal recovery team as needed.
7. Provide updates to regulatory agencies, ecoregion planning teams, landowner contact and private lands management programs and other appropriate management, protection and conservation efforts.

METHODS

Deductive Habitat Model

Model Creation

We created a spatial model in a Geographic Information System (GIS) to predict Karner blue habitat distribution in Michigan. The model was designed to reveal areas with potential for Karner blue habitat (i.e. lupine) and prioritize survey locations. We selected spatial data layers that represent factors influencing habitat suitability using the literature and expert knowledge as a guide. We combined and weighted the data layers to highlight areas with the most potential for lupine presence. No Karner blue locations were used in creating the habitat model. Final model layers included IFMAP 2000 Michigan Land Cover, Michigan Land Use Circa 1800 (Comer et al. 1995), and Geology (Figure 1). Other

data layers may have been useful in the model, but we chose to exclude them for various reasons (e.g. NRCS soils data not available for all counties). Additionally, time constraints limited the creation and use of derived variables (e.g. habitat connectivity, patch size). We extracted relevant information from each spatial layer, and weighted those variables according to their influence on lupine presence (Figure 1). The areas with the highest combined weight served as priorities for spring lupine surveys and guided summer Karner blue surveys.

We conducted all of the GIS work using ArcGIS Desktop (ArcMap, ArcCatalog and ArcToolbox) and the ArcGIS Spatial Analyst extension (ESRI 2001, 2002). Spatial layers were re-projected to the UTM

4 - Karner blue butterfly surveys 2004

coordinate system and assigned weights using the reclassify command in Spatial Analyst. Layers were then added together using the raster calculator in Spatial Analyst. We reclassified the resulting grid layer into two categories, potential Karner blue habitat and unsuitable for Karner blue, using the combined layer values as a guide. Cells with a value of 889 and higher (roughly one-third of all cells) were considered potential habitat while cells 888 and lower received an unsuitable characterization.

Model Validation

We validated models by comparing Karner blue occurrence locations (determined from surveys) with model-predicted presence and absence. This analysis was possible Karner blue occurrences were not used in model creation.

Several steps were needed to conduct model validation using GIS. First, we converted polygons delimiting surveyed areas and current Karner blue occurrences to a grid layer in Spatial Analyst using the polygon identifier (PI) for the cell value. We then used the Tabulate Areas command to create a table of model cell values present within each PI. The resulting table showed the range of predicted habitat suitability within each polygon. We exported the table to an Excel spreadsheet and polygons were then queried to determine whether they contained cells predicting habitat presence (i.e. having a value of 889 or greater). If so, the polygon was characterized as having potential Karner blue habitat, unsuitable for Karner blue if not. We then assigned the observed value of potential habitat (lupine or lupine and Karner blue present) or unsuitable (no lupine observed) to each polygon. Using these data, we constructed a confusion matrix (table showing the predicted and actual classifications) that compared predicted versus observed results.

Population and Habitat Surveys

Survey Priorities

We conducted lupine and Karner blue presence-absence (detection—non-

detection) surveys on private and public lands during the Karner blue flight periods, 2004. Previous surveys were successful in locating several occupied locations that were previously unknown; however, the extent of the metapopulations on the landscape had not been determined. Therefore, we designed 2004 surveys to define metapopulation extents, distribution of lupine, and identify outlier populations. The deductive habitat model described above aided in survey site selection.

Survey Area

The study area for 2004 Karner blue surveys included the known range of the species, counties with unverified Karner blue records, and some counties with records for other lupine-obligate Lepidoptera species (Figure 2). We considered private properties survey priorities if they would contribute to the goal of defining metapopulation extents or outliers and were identified as having potential for Karner blue habitat by the deductive model. State-owned and other public lands were considered priorities because they held the most potential for Karner blue conservation and management.

Public Land Surveys

We included portions of State Game Areas (SGA), State Forests (SF), Recreation Areas (RA), Linear Parks (LP) and other managed areas within the known range of Karner blue in our surveys of state-owned lands (Table 1). Federal lands within the Huron-Manistee National Forest (HMNF) were also surveyed if a Karner blue occurrence (element occurrence or EO) was present, had not been verified extant for over 4 years, and the EO was near private or state lands.

Private Lands Surveys

We surveyed private lands owned by local governments or municipalities, along with those owned by organizations, businesses, power companies, and individual landowners. We only surveyed private lands for which we gained permission during

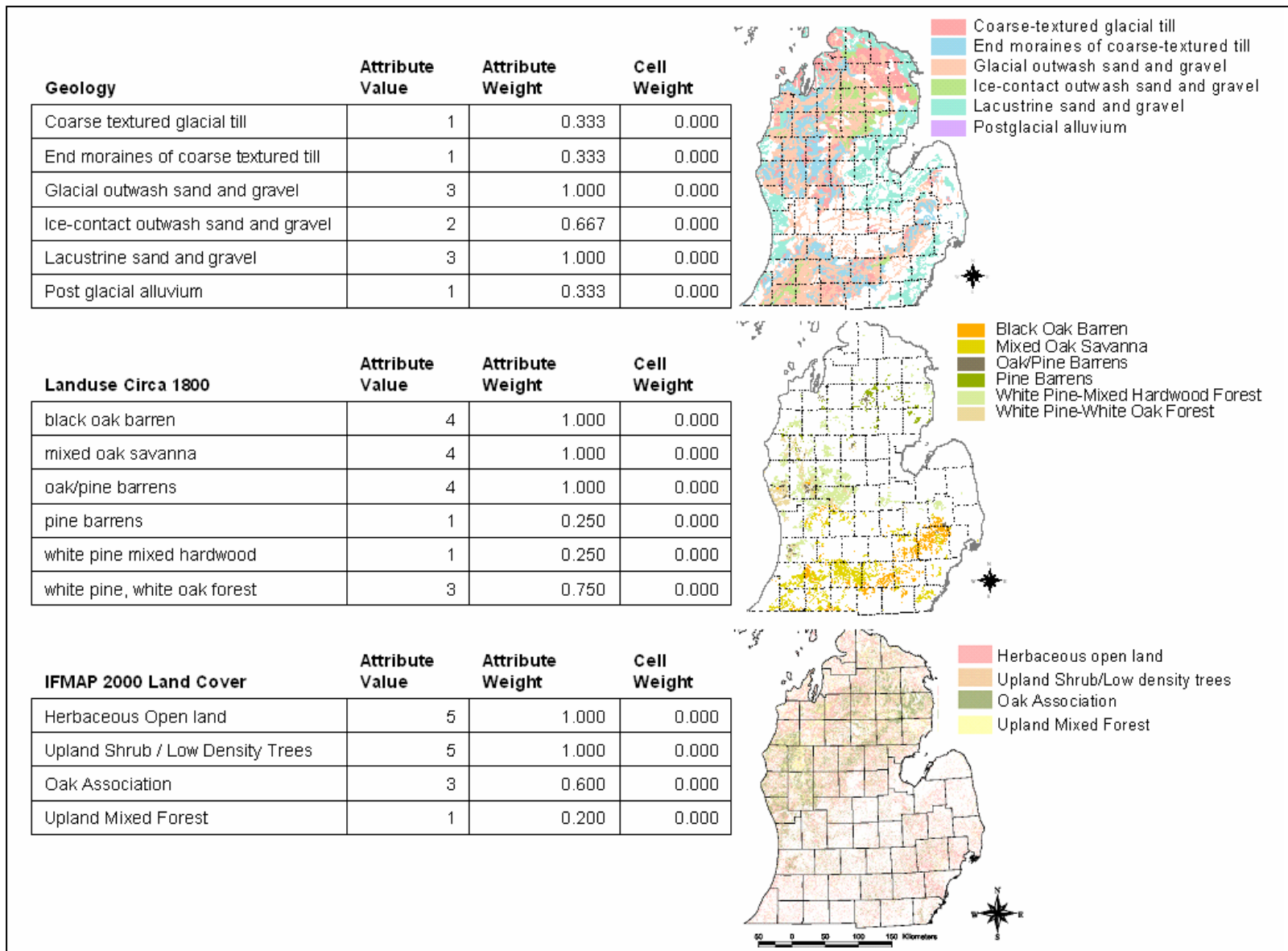


Figure 1. Spatial data layers and their weighted categories used in building a predictive Karner blue butterfly habitat model.

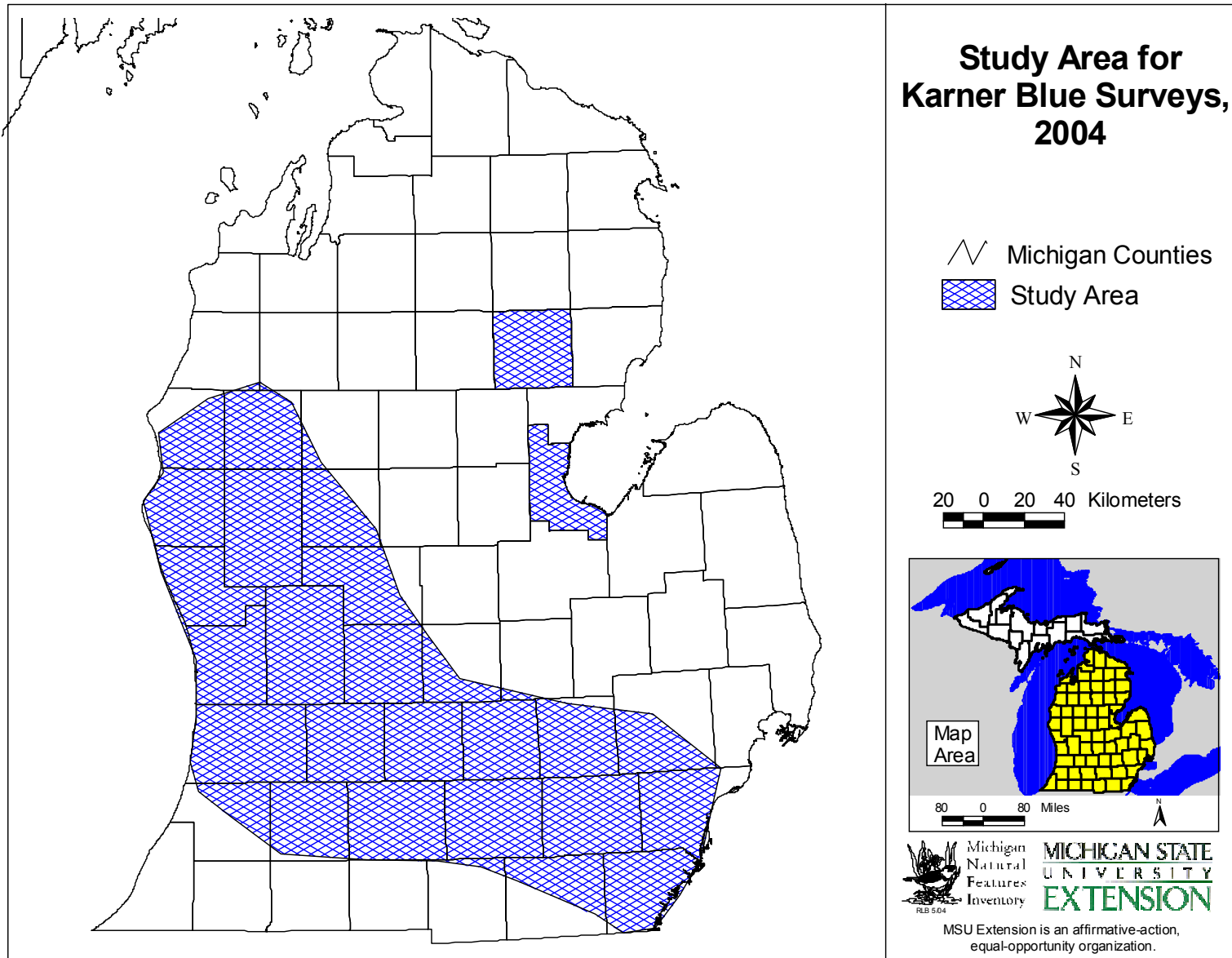


Figure 2. Study area for 2004 Karner blue surveys derived from the known range of Karner blue, unverified Karner blue records, and records of sympatric lupine-obligate Lepidoptera species.

Table 1. Public lands surveyed for Karner blue and lupine, 2004.

Recovery Unit	Public Lands Surveyed	County
Allegan RU	Bass River Recreation Area	Ottawa
	Duck Lake State Park	Muskegon
	Muskegon State Game Area	Muskegon/Newaygo
	Musketawa Trail Linear Park	Muskegon
Ionia RU	Cannonsburg State Game Area	Kent
	Edmore State Game Area	Montcalm
	Flat River State Game Area	Ionia/Montcalm
	White Pine Trail Linear Park	Kent
Muskegon RU	Huron-Manistee National Forest	Muskegon
Newaygo RU	Huron-Manistee National Forest	Newaygo/Montcalm
	Newaygo State Park	Newaygo
	Pere Marquette State Forest	Lake
	White Pine Trail Linear Park	Montcalm/Mecosta
No RU	Barry State Game Area	Barry
	Bay City State Park	Bay
	Gourdneck State Game Area	Kalamazoo
	Highland Recreation Area	Oakland
	Island Lake Recreation Area	Livingston
	Lakelands Trail Linear Park	Livingston
	Proud Lake Recreation Area	Oakland
	Petersburg State Game Area	Monroe

2004. Spring (May and June) surveys had the purpose of locating and describing the distribution of lupine. Summer (July and August) surveys were aimed at locating Karner blue. The time span covered during 2004 surveys often resulted in repeated visits and multiple contacts to landowners. Survey protocols remained consistent across owner types, although specific landowner requests to avoid certain areas or refrain from collecting plant or insect samples were upheld.

Landowner Contact

We secured permission to access private property prior to conducting surveys on private lands. We contacted landowners to obtain permission by phone or in person before or at the time of the survey. We considered properties contact priorities if surveys would help define metapopulation boundaries, locate an outlier population, and/or the property met survey criteria: the area was indicated in the habitat model as having good to excellent potential for lupine; the property appeared suitable in

aerial photos and lupine was observed nearby; if the property appeared suitable from the road; or if the owner allowed previous surveys in which lupine but no Karner blue were observed.

We informed all owners of survey findings. Direct contact after the survey provided an avenue for further discussion regarding options for management. This contact also gave us the ability to expand on opportunities for conservation if lupine and/of Karner blue were found, disseminate contact information for regulatory agencies and Landowner Incentive Program biologists, and extend invitations to meet with or contact MNFI biologists to discuss questions or concerns. Similar information was distributed when we placed follow-up phone calls to owners who were not present at the survey site.

Survey Protocols

Lupine surveys documented locations of the host plant in order to give a more complete understanding of the distribution of potential Karner blue habitat throughout

the state and to locate areas for Karner blue surveys. Lupine surveys consisted of both roadside surveys (conducted while driving to survey areas) and actual site visits. We selected spring lupine survey areas based on our deductive habitat model, and using site leads previously gathered from the public and field biologists.

Roadside surveys were carried out during a time when we knew lupine was blooming and detectable from a distance in the region of the state being surveyed. We visited sites known to have lupine present, and commenced roadside surveys if lupine was visible from a distance of 10-15 m within that area. We georeferenced observed lupine patches observed during roadside surveys using Garmin 12X Global Positioning System (GPS) units by recording the latitude and longitude when lupine was visible while driving. Unique names or numbers were assigned to each point and notes about the number and location of plants were made (e.g. >20 plnts ~10m from road on N side at point #098).

Site surveys for lupine consisted of walking through areas lupine and visually scanning the ground for the plant. Surveys occurred as long as the leaves were visible. We delimited areas with lupine using a GPS to create points at concentrations of lupine (five or more plants present) and tracks around lupine and survey area boundaries. Unique identifiers were then assigned to each track or point.

Second flight surveys on public and private lands were aimed at locating previously unknown sites occupied by Karner blue. We selected sites for summer surveys if spring lupine surveys detected lupine, if the area was classified by the habitat model as having good to excellent potential for lupine, and/or aerial photos showed potential habitat nearby. Karner blue presence-absence surveys were conducted using a protocol adapted from the Wisconsin Habitat Conservation Plan (WI DNR 2000, Appendix 1). We visited sites during favorable weather (>65deg, <90deg, wind <15mph, partly sunny to sunny skies) and searched for Karner blue while meandering

through areas with lupine and the surrounding flowering plants and grasses. Areas were searched for approximately 25 minutes per hectare (10 minutes per acre) of habitat. Most surveys were conducted by two individuals, one watching for and counting butterflies and the other recording habitat data. If we did not observe butterflies, surveys were repeated in order to reduce the probability of reporting false absences due to non-detection, generally three to seven days later. We took GPS points at Karner blue locations when one or more individuals were present. Points were given unique names, and the number and sex (if determined) of individuals observed at each point was recorded on field forms.

Data Collection

We completed “KBB and Lupine Survey” field forms during the first visit to a site within each season of survey (Appendix 2). “Follow-up KBB Survey” forms were filled out for each repeat visit to a site in a season (Appendix 3). Forms were completed during all site visits by trained surveyors. We filled out separate survey forms in the field at sites separated by 100m of unsuitable habitat, 200m of suitable habitat, or a perceived Karner blue dispersal barrier (Nature Serve 2003, USFWS 2003). Survey location and weather conditions at the beginning and end of the survey were noted on the form, along with beginning and end time of the survey. Number, sex, and GPS location for all Karner blue butterflies observed were also noted. We then described current and potential threats, management of the land, opening type, surrounding environment, and canopy closure (Table 2). We described habitat characteristics using ocular estimation. Habitat parameters included lupine density and abundance, percent of lupine blooming or in seed, presence of Karner blue caterpillar feeding damage, deer browse on lupine, ant mounds, woody plant and exotic species and amount of encroachment, dominant ground cover, preferred nectar plant species and abundance, and other flowering plants (Table 3).

Table 2. Site description variables, their categories, and how categories were identified during Karner blue surveys, 2004.

Characteristic	Variable	Indicated by
Current Threat	ORV	Two-tracks or ruts through site
	Vehicles	Site adjacent to busy road, roadkill probable
	Exotic	Exotic species are dominant vegetation
	Succession	Woody species encroaching on site
	Management	Unregulated disturbance that may result in take, but otherwise may benefit Karner blue (mowing, burning, hand cutting woody vegetation)
	Dumping	Piles of trash or yard waste present
	Development Other	Evidence of building or road construction within or adjacent to the site
Management	Cut	Evidence of timber harvest
	Burned	Evidence of burn or presence of fire-obligate plant species
	Mowed	Evidence of mechanical brush removal or mowing
	Herbicide	Absence of vegetation susceptible to common herbicides, or where known herbiciding has taken place (e.g. right-of-way)
	Hand Cut	Area known to receive woody species removal via hand-cutting
	Planted	Pine plantation or evidence of past planting
	Other	
Opening Type	Right-of-way	Power line transmission or distribution line, gas pipeline
	Field	Abandoned agricultural field
	Clearing	Open area that appears to have been cleared for purpose other than agriculture
	Barrens	Site supporting barrens, dry sand prairie, or savanna indicator species and vegetative structure
	Openings	Openings in woods created by natural disturbance or environmental factors
	Roadside	Site along a road with two or more lanes
Surrounding Environment	Hardwoods	Deciduous woods in one or more cardinal directions
	Pines	Pine woods or plantation in one or more cardinal directions
	Agriculture	Row crops or pasture in one or more cardinal directions
	Residential	Assemblage of houses in one or more cardinal directions
	Potential habitat	Open or semi-open area with lupine or nectar species likely present in one or more cardinal directions, but not surveyed due to lack of permission
	Wetland	Area of mesic soils with wetland vegetation in one or more cardinal directions
	Other	
Canopy Closure	Open	0-24% canopy closure
	Partial	25-49% canopy closure
	Most	50-74% canopy closure
	Closed	75-100% canopy closure

Table 3. Habitat variables and their components collected at all Karner blue butterfly survey sites, 2004.

Variable	Components	
Dominant Ground Cover	Grass Sedge (<i>Carex</i> spp.) Forb Fern	
Lupine Density and Distribution	0 - no lupine present 1 - scattered plants sparsely distributed in the area 2 - scattered plants common 3 - scattered plants abundant 4 - clumps of plants sparsely distributed in the area 5 - clumps of plants common 6 - clumps of plants abundant 7 - dense sparsely distributed in the area 8 - dense areas of lupine common 9 - dense areas of lupine abundant	
Lupine Density	Scattered - lupine was predominantly in groupings of 1-3 plants and the groupings were separated by groundcover other than lupine Clumped - lupine was predominantly in groupings of 4-20 plants with some space or other groundcover between individual plants Dense - lupine was predominantly in groupings of >20 plants in a group with little or no space or other groundcover between plants	
Lupine Distribution	Sparse - lupine plants present in <33% of the area Common - lupine present in 33-66% of the area Abundant - lupine present in 67-100% of the area	
% Lupine in bloom or seed	0-24% 25-49% 50-74% 75-100%	
Deer Browse	Present/Absent	
Ant Mounds	Present/Absent	
Woody Species	Oak (<i>Quercus</i> spp.) Cherry (<i>Prunus</i> spp.) Sassafras (<i>Sassafras albidum</i>) Hazelnut (<i>Corylus americana</i>) Aspen (<i>Populus</i> spp.)	Maple (<i>Acer</i> spp.) White pine (<i>Pinus alba</i>) Other deciduous Other evergreen
Exotic Species	Spotted knapweed (<i>Centaurea biebersteinii</i>) St. John's wort (<i>Hypericum perforatum</i>) Hoary alyssum (<i>Berteroa incana</i>) Sweetclover (<i>Melilotus</i> spp.) Queen Anne's lace (<i>Ammi majus</i>)	Hawkweed (<i>Hieracium</i> spp.) Autumn olive (<i>Elaeagnus umbellata</i>) Honeysuckle (<i>Lonicera japonica</i>) Other exotics
Preferred Nectar Species (Grundel and Pavlovic 2000)	Butterfly weed (<i>Asclepias tuberosa</i>) Dewberry (<i>Rubus flagellaris</i>) Dotted horsemint (<i>Monarda punctata</i>) Flowering spurge (<i>Euphorbia corollata</i>)	Goldenrod (<i>Solidago</i> spp.) Lance-leaf coreopsis (<i>Coreopsis lanceolata</i>) New Jersey tea (<i>Ceanothus americanum</i>)
Other Flowering Species	Aster (<i>Aster</i> sp.) Blackberry (<i>Rubus</i> sp.) Black-eyed susan (<i>Rudbeckia hirta</i>) Blazing star (<i>Liatris</i> spp.) Blueberry (<i>Vaccinium</i> spp.) Downy phlox (<i>Phlox pilosa</i>) Dwarf dandelion (<i>Krigia biflora</i>) Fleabane (<i>Erigeron</i> spp.)	Primrose (<i>Oenothera lamarckiana</i>) Puccoon (<i>Lithospermum</i> spp.) Sunflower (<i>Helianthus</i> spp.) Violet (<i>Viola</i> spp.) Wild bergamot (<i>Monarda fistulosa</i>) Yarrow (<i>Achillea millefolium</i>) Other

Data Analysis

We classified survey sites into one of four categories in order to summarize 2004 survey efforts. Sites with Karner blue were classified as either new Karner blue EOs (sites where Karner blues had not been previously documented but were present in 2004) or present updates (sites where Karner blue had been previously documented and 2004 surveys verified that Karner blue was present). Sites where Karner blue were not observed were classified as either lupine only (Karner blue were not observed but lupine was present) or absent (no Karner blue or lupine was found within the survey area). We summarized habitat data in tables showing the percentage of sites with Karner blue present, lupine only, and absent sites having each habitat characteristic. Pearson Chi-square (χ^2) tests were used to test whether the distribution of the observed habitat characteristics across sites was different from expected by chance. Associations were considered significant when the probability (P) of obtaining the observed table frequencies by chance was less than 0.05. Characteristics associated with lupine were compared between Karner blue present versus lupine only sites, because the definition of absence depended on the absence of lupine.

We digitized all sites surveyed in 2004 as polygons in ArcView GIS using aerial photos, topographic maps, and GPS points and tracks taken in the field as a guide. We assigned unique identifying numbers to each polygon. Habitat data was then entered from field forms into a Microsoft Excel spreadsheet containing ownership, contact, and permission data. Each data record was then assigned the number associated with the polygon it represented in GIS. We then saved the habitat data as a database file (.dbf) and imported it into ArcView as a new table. The polygon attribute table containing the polygon identifier was then linked to the habitat table, thereby allowing representation of habitat data spatially and facilitating spatial analyses.

Data Transcription and Digitizing

Element Occurrence Determination

We considered occupied habitat patches separate if they were separated by 100m of unsuitable habitat, 200m of suitable habitat, or a significant barrier to dispersal (NatureServe 2003, USFWS 2003). In order to determine whether a site was an extension of a pre-existing Karner blue EO or was a new record, we calculated the distance to a known EO in GIS for each site. In addition, we gave sites 100m buffer to determine whether multiple occupied sites were part of the same EO. We noted barriers to dispersal (e.g. large river basin or dense woods) using aerial photos, and separated EOs if barriers could be assumed to prevent dispersal between sites.

Database Updates

Prior to 2002 MNFI surveys, most EOs were represented by buffered points or section records in the Database. We digitized all existing and new Karner blue EOs surveyed in 2004 as polygons in BioTICs according to Natural Heritage Methodology in order to enhance the usefulness of the Database for land managers and conservation planners. Aerial photos, topographic maps, and GPS points and tracks taken in the field aided polygon creation. EO polygons represent the extent of suitable habitat (lupine and nectar species) potentially used by the butterflies observed during surveys and their progeny.

We transcribed data associated with EOs into the Database from field survey forms. Information including survey dates, the number and sex of Karner blues observed, a general habitat description, and directions to the site is included and can be utilized by those with access to the Database.

Distribution and Abundance

A map of Karner blue distribution in Michigan was created using survey results from the last three years. We queried each Michigan township to determine whether Karner blue are currently present, were known to be present prior to 2002, or were once present but are now presumed

extirpated. We then color-coded townships on a map to represent the current and historic presence of Karner blue. A second township map was created to illustrate the known current distribution of lupine, from MNFI surveys and consultations with field biologists. We combined the two maps to show the current distribution of Karner blue and distribution of potential habitat within the state, at the township level.

Associated Species Surveys

Surveys, although focused on Karner blues, included several other rare barrens-associated species as targets (Table 4). Spring surveys included other lupine-obligate Lepidoptera species – the Frosted elfin (*Incisalia irus*, state threatened), and Persius duskywing (*Erynnis persius*, state threatened). Frosted elfin is dependant on lupine as the only larval food source, and occurs in oak savannas, open areas, and wooded edges where blueberry (*Vaccinium* spp.) is the only known adult nectar source (Nielsen 1999). Persius duskywings lay eggs on lupine in Michigan, and commonly feed on several barrens and prairie associated flowering species (Nielsen 1999). *E. persius* is similar to several other members of the *Erynnis* genus that fly in similar habitats at the same time. For this reason, voucher specimens are necessary for identification, which must be made by an expert. Dusted skipper (*Atrytonopsis hianna*, state threatened) was targeted during spring surveys by visually scanning sites with its host plant, little bluestem (*Schizachyrium scoparium*, Nielsen 1999).

Great Plains spittlebug (*Lepyronia gibbosa*, state threatened), was targeted during spring surveys by searching for spittle masses at the base of prairie plants and grasses, and during summer surveys by sweep-netting big bluestem grasses (*Andropogon gerardii*). Summer surveys targeted the state threatened Ottoe skipper

(*Hesperia ottoe*, state threatened), a large yellow skipper that depends on native prairie grasses such as big bluestem (*A. gerardii*), fall witchgrass (*Leptoloma cognatum*), and nectars on prickly pear cactus (*Opuntia humifusa*) and other flowering species characteristic of dry sand prairies and oak barrens communities (Cuthrell 2001). Eastern box turtles (*Terrapene carolina carolina*, state special concern) and Blanding's turtles (*Emys blandingii*, state special concern) were also observed accidentally during surveys, usually crossing roads near wet areas (*E. blandingii*) or in uplands with sandy soils (*T. c. carolina*) (Hyde 1999).

When possible, we identified rare species using voucher photos. However, voucher specimens of *A. hianna* and *L. gibbosa* were taken in the field when voucher photos for identification were not possible, or the observations were at new locations. Voucher specimens were collected under the authority of a Threatened/Endangered Species Permit granted by the MDNR Wildlife Division (Permit Number 1397). We collected specimens using standard techniques, did not significantly reduce the size of the local population (one specimen taken/site/year), and had them curated in the Michigan State University (MSU) insect collection after identification by Dr. Mogens Nielsen.

Barrens, savanna, and dry sand prairie indicator plant species and several species that serve as host plants for rare insects were noted when encountered (Table 5). We documented observations were for prairie smoke (*Geum triflorum*, state threatened), little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), fall witchgrass (*Leptoloma cognatum*), Culver's root (*Veronicastrum virginicum*), various blazing star species (*Liatris* spp.), downy phlox (*Phlox pilosa*), and prickly pear cactus (*Opuntia humifusa*).

Table 4. Rare species associated with barrens and savannas targeted during Karner blue butterfly surveys, 2004.

Species Common Name	Scientific Name	Occurrence Type	State Rank
Dusted skipper	<i>Atrytonopsis hianna</i>	Insect	Threatened
Eastern box turtle	<i>Terrapene carolina carolina</i>	Reptile	Special Concern
Frosted elfin *	<i>Incisalia irus</i>	Insect	Threatened
Great Plains Spittlebug	<i>Lepyronia gibbosa</i>	Insect	Threatened
Ottoo skipper	<i>Hesperia ottoe</i>	Insect	Threatened
Persius duskywing *	<i>Erynnis persius</i>	Insect	Threatened
Prairie smoke	<i>Geum triflorum</i>	Plant	Threatened
Red Shouldered Hawk	<i>Buteo lineatus</i>	Bird	Threatened

* Lupine obligate species

Table 5. Plant species on which barrens-and savanna-associated rare insect species depend.

Species Common Name	Scientific Name	Associated rare insect species
Big bluestem	<i>Andropogon gerardii</i>	Dusted skipper, Great Plains spittlebug, Ottoo skipper
Blazing star	<i>Liatris</i> spp.	Blazing star borer moth
Culvers root	<i>Veronicastrum virginicum</i>	Culver's root borer moth
Downy phlox	<i>Phlox pilosa</i>	Phlox moth
Fall witchgrass	<i>Leptoloma cognatum</i>	Ottoo skipper
Little bluestem	<i>Schizachyrium scoparium</i>	Dusted skipper, Great Plains spittlebug, Ottoo skipper
Prickly Pear	<i>Opuntia</i> sp.	Ottoo skipper

RESULTS

Deductive Habitat Model

The predictive habitat model uncovered several areas with potential for lupine and Karner blue (Figure 3). The model successfully predicted habitat (lupine) presence at 69% of all sites that were surveyed (true positives) but predicted unsuitable habitat (no lupine) correctly at slightly less than half of the sites surveyed (true negatives, Figure 4). Although the model was built to predict the presence of Karner blue habitat, an estimate of how well it predicted species presence was also of interest. The model successfully predicted Karner blue presence at over 60% of the sites surveyed and correctly identified unsuitable habitat at 72% of sites surveyed where Karner blue (and lupine) were absent (true negatives, Figure 5).

Population and Habitat Surveys

Survey Effort

Two MNFI employees conducted lupine surveys between 20 April and 18 June, 2004. We drove over 4,300 km (2,671 mi) within 20 counties during surveys searching for lupine (Figure 6). Karner blue surveys were conducted by seven MNFI employees between 12 July and 13 August in portions of 48 townships within 18 Counties (Figure 7).

A majority of the area surveyed (65 sites, 634.1 ha) was on private lands including those owned by local governments, power companies, and private individuals (Figure 8). Public land surveys made up 37% (57 sites, 376 ha) of the area surveyed during 2004. Nearly half of the public land surveyed was on State Game Areas (23 sites, 179 ha).

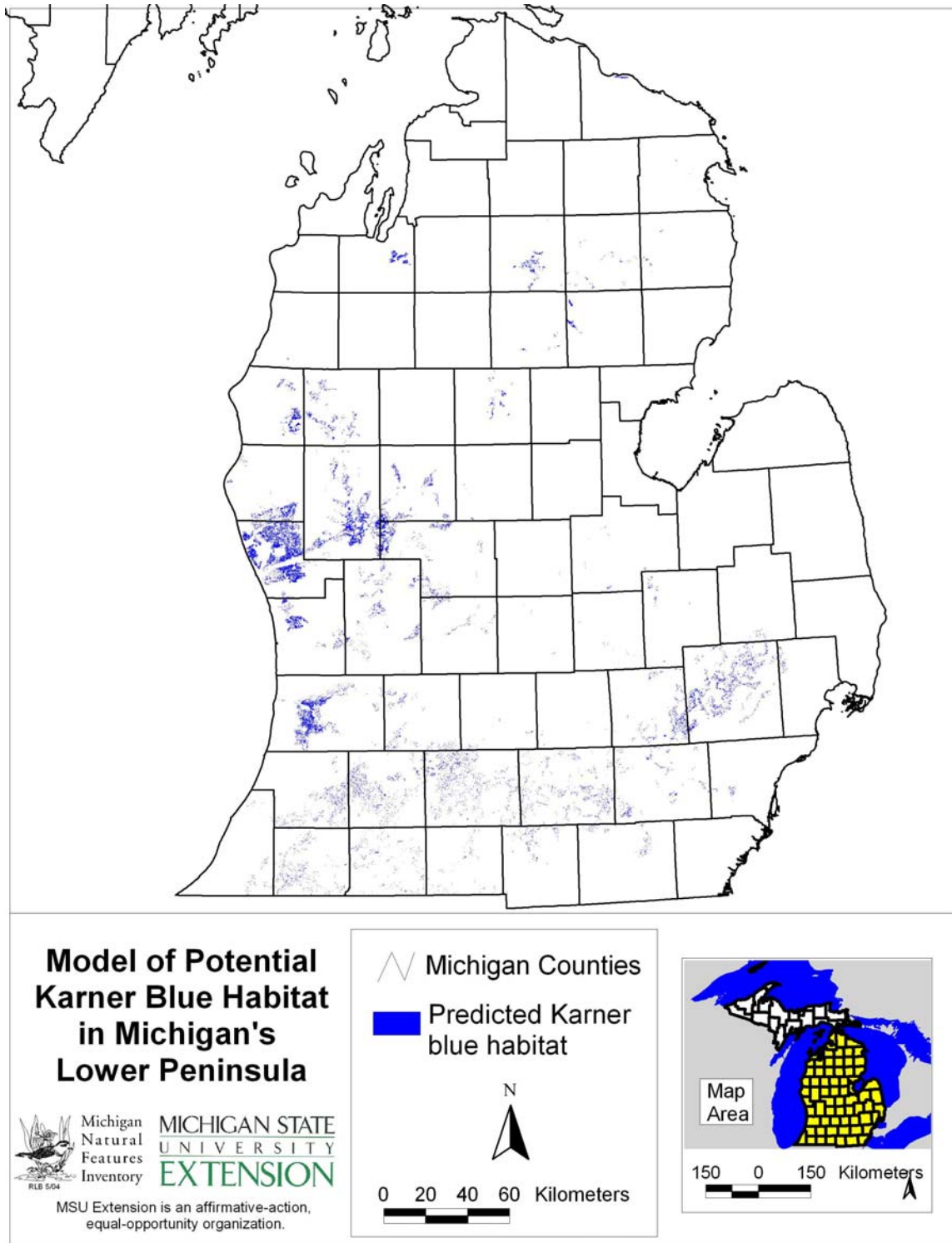


Figure 3. Deductive model predicting areas with predicted suitable Karner blue butterfly habitat (lupine present).

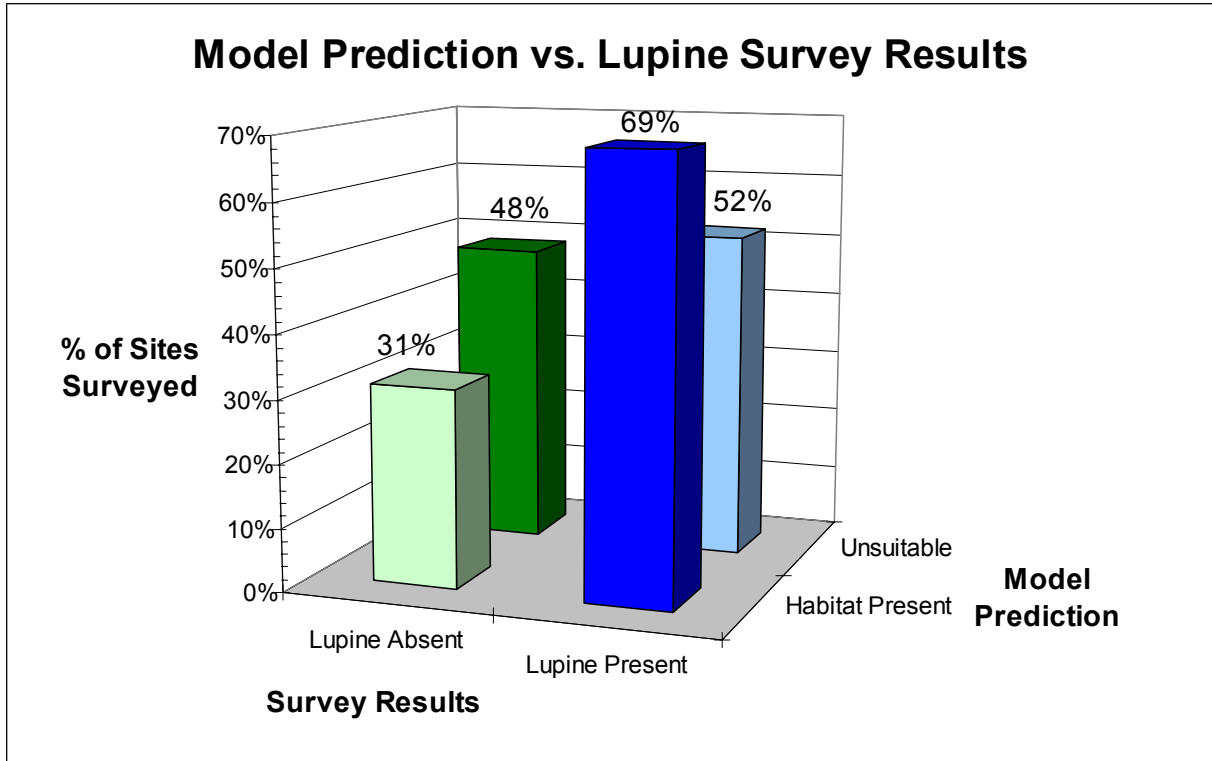


Figure 4. Graphical representation of a confusion matrix depicting Karner blue habitat (lupine) observation in 2004 compared to deductive habitat model prediction.

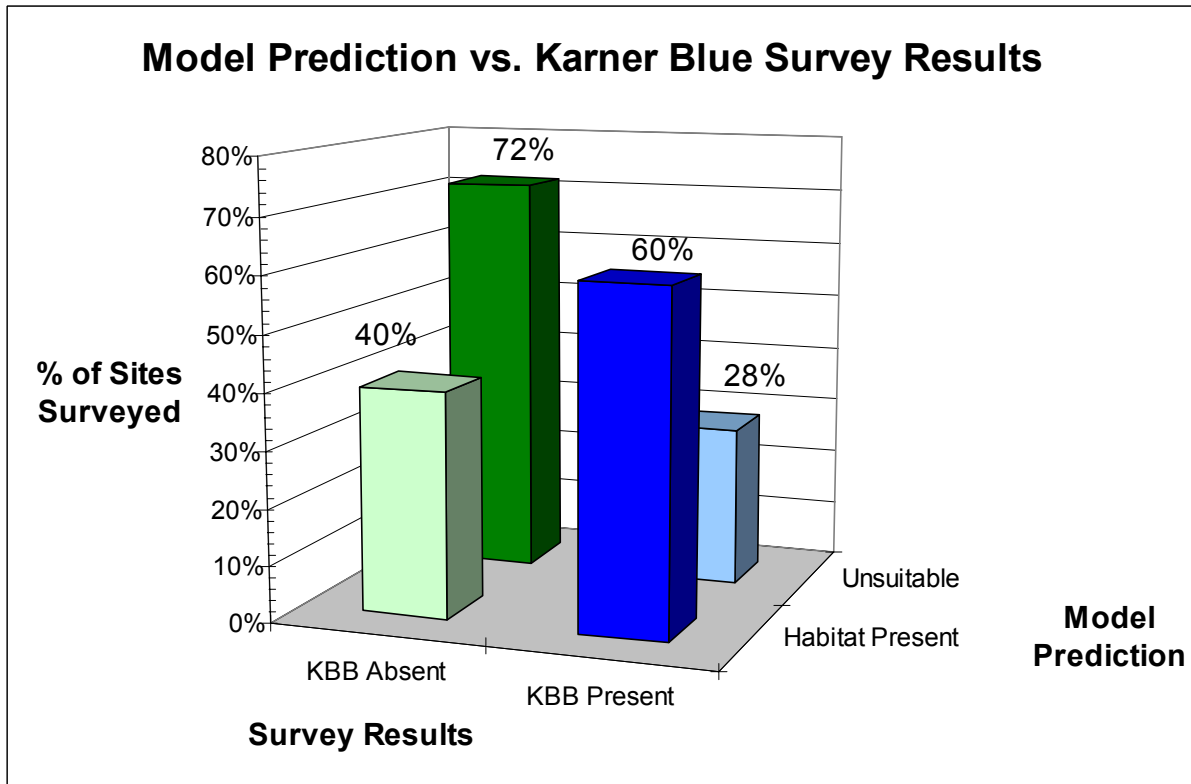


Figure 5. Graphical representation of a confusion matrix depicting Karner blue observation in 2004 compared to deductive model prediction of habitat (lupine) presence.

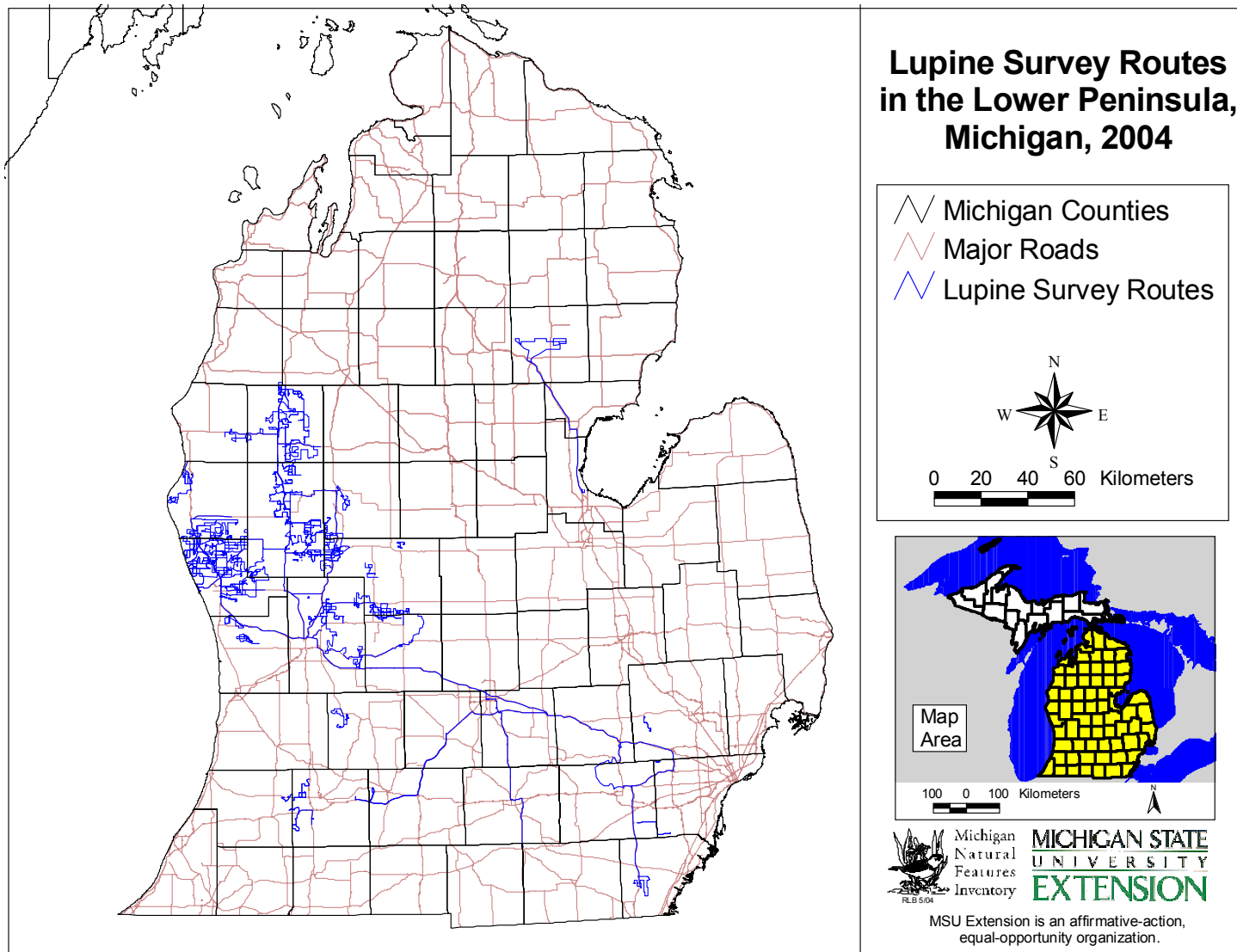


Figure 6. Map showing routes driven during roadside lupine surveys, 2004.

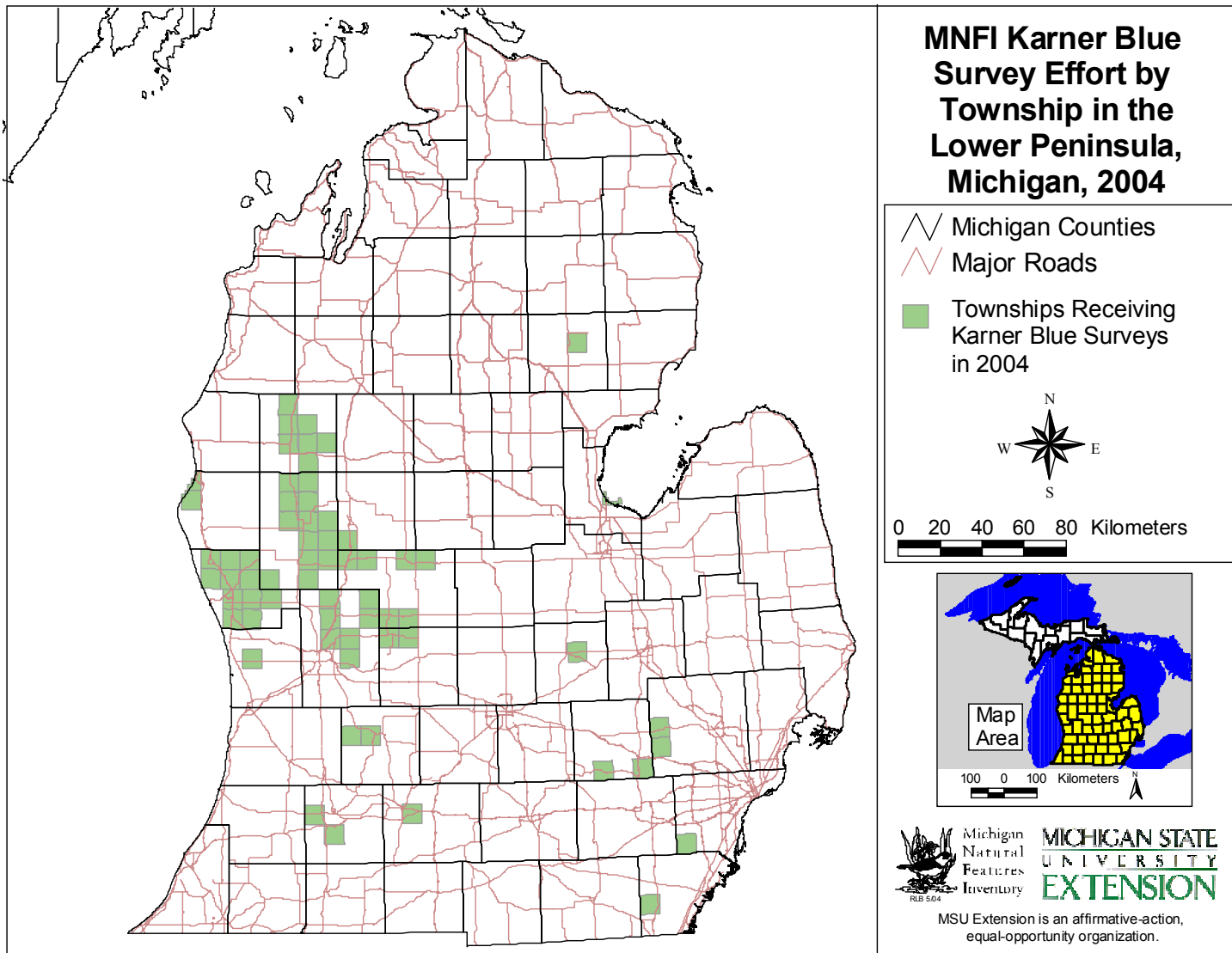


Figure 7. Map highlighting townships surveyed for Karner blue butterflies, 2004.

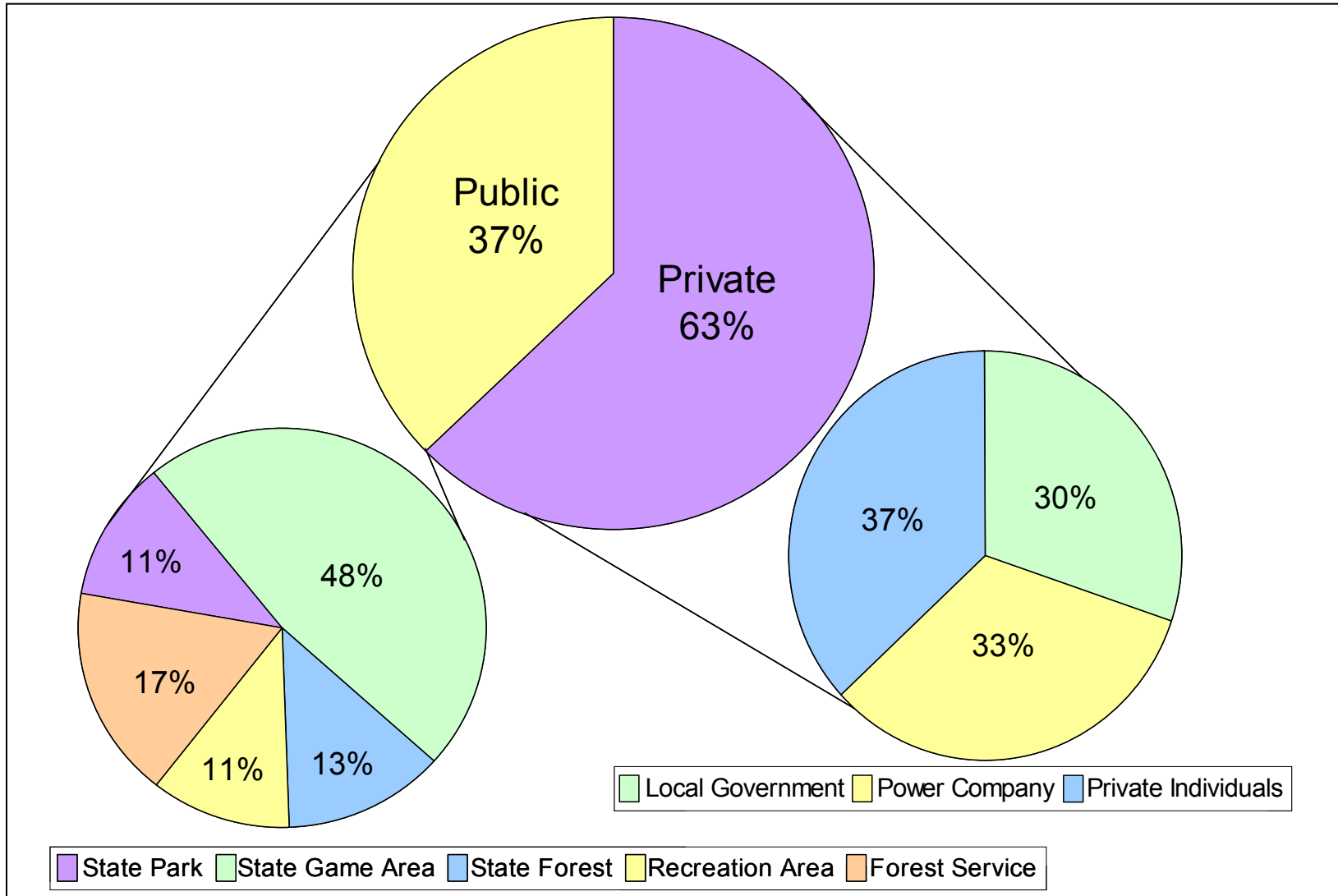


Figure 8. Karner blue butterfly survey efforts among ownership and owner types during 2004 surveys.

Survey Results

We recorded a total of 879 GPS points representing lupine locations during roadside surveys and site visits (Figure 9). Summer Karner blue and lupine surveys included 1010 hectares (2496 acres) within 122 sites. We visited sites one to eight times depending on whether lupine and Karner blue were observed. We observed lupine within 50 townships and Karner blue in 17, including two new township records (Figure 10). Sites within an additional 14 townships turned up neither lupine nor Karner blue. Summer surveys resulted in the discovery of 11 new Karner blue occurrences (30.4 ha), all on private lands. Of 22 sites that had Karner blue observed in past years, 10 (203.2 ha) had Karner blue observed in 2004, 7 (38.8 ha) had only lupine, and 5 (33.6 ha) had neither lupine nor Karner blue observed. We observed lupine, but not Karner blue, at an additional 41 sites (307.2 ha), with the remaining 48 sites having neither lupine nor Karner blue (469.4 ha, Table 6).

We found lupine on 36% (n=17, 101.2 ha) of the state lands surveyed, but we observed Karner blue on only one site (Table 6). In contrast, Karner blue were present on 34% of private lands surveyed (n=19 properties, 217.7 ha), and we found lupine on an additional 26% (n=23 properties, 165 ha). All new Karner blue EOs were found on private lands (n=11, 30.4 ha), reflecting the lack of prior survey efforts. Sites (3 EOs, 2.5 ha) indicating presence of potentially new Karner blue metapopulation were discovered on the Montcalm/Kent County border in Eureka and Oakfield Townships (Ionia RU).

We discovered the new occupied habitat late in the second Karner blue flight and it was not possible to determine whether the sites are connected to the metapopulation found within the Flat River State Game Area, though this is possible. Further surveys within the surrounding private lands are needed to determine size and distribution of subpopulations in this area, which is rapidly being converted to residential land use.

Several general site and habitat characteristics appear to be associated with Karner blue and lupine presence based on 2004 surveys (n=101 sites). Results of habitat surveys revealed that a higher percent of sites with Karner blue and/or lupine were threatened by management activities and development than expected based on chance (Table 7). This is potentially related to the frequent occurrence of Karner blue and lupine along rights-of-way and near residential areas. We frequently observed Karner blue in areas with forbs as the dominant ground cover, and both Karner blue and lupine were found in areas with ant mounds more frequently than random (Table 8). Lupine density appears to be a major factor in whether Karner blue were observed at a site. We found Karner blue more frequently in areas with denser lupine, and less frequently in areas with clumped or scattered lupine. Both lupine and Karner blue seem to be associated with a variety of flowering plants including butterfly weed, horsemint, coreopsis, flowering spurge, black-eyed susan, and blazing star – all prairie and savanna associates.

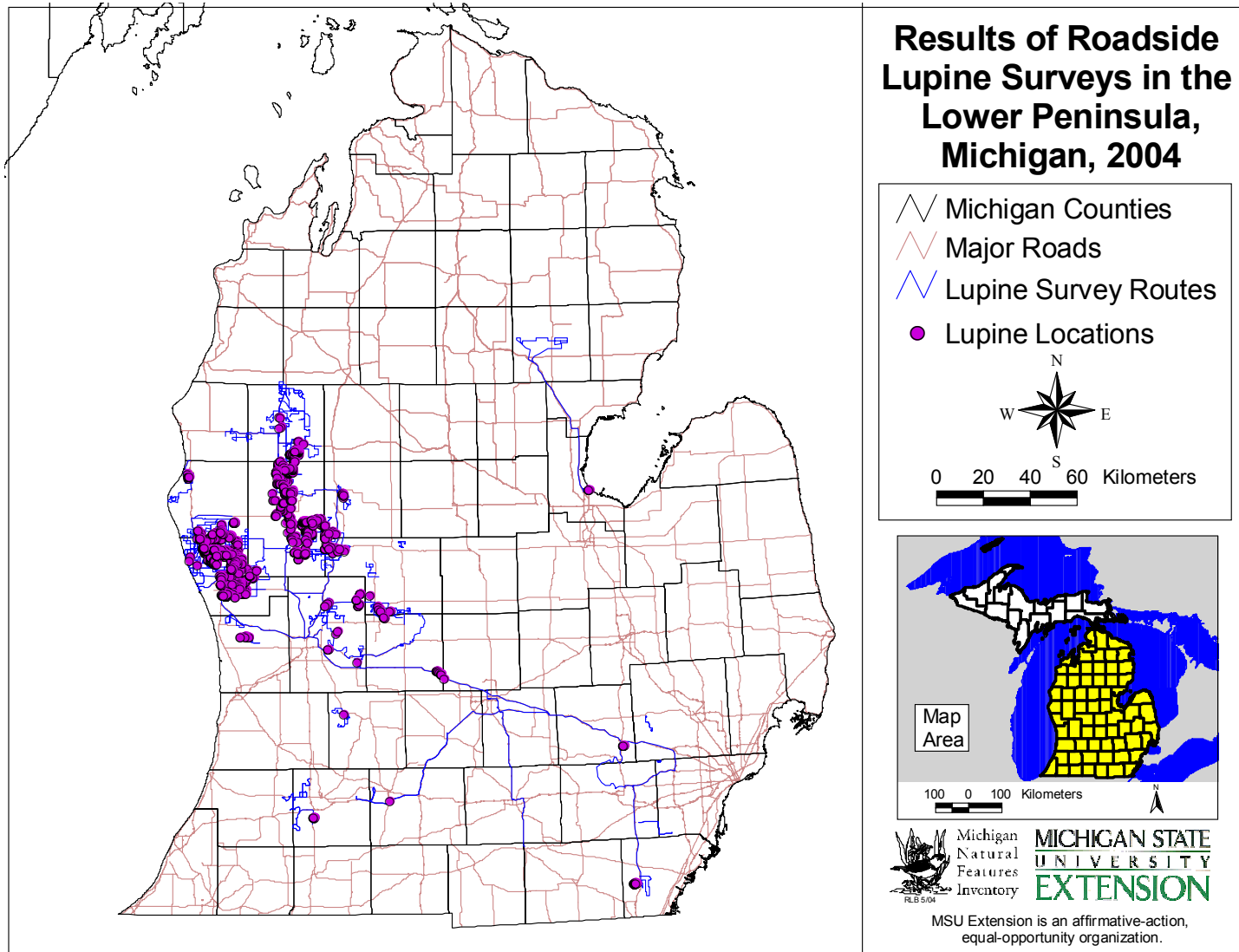


Figure 9. Lupine locations collected along survey routes during 2004 roadside lupine surveys.

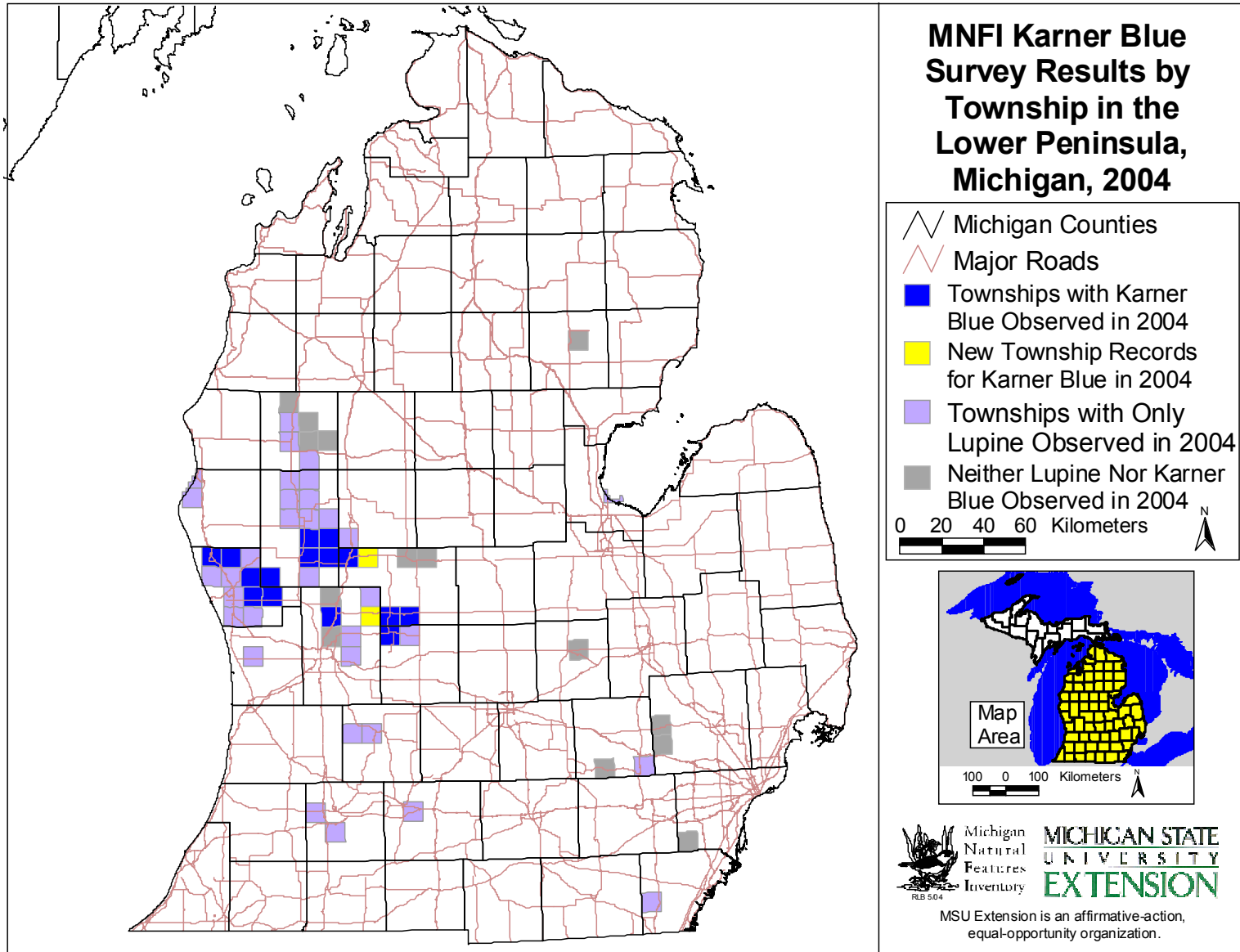


Figure 10. 2004 Karner blue butterfly survey results by township.

Table 6. Results of 2004 Karner blue butterfly surveys classified by owner type and element occurrence (EO) status.

Owner	Lands Surveyed	New EOs		Present Update		Lupine Only		Absent		Total	
		Sites	Ha. (Ac.)	Sites	Ha. (Ac.)	Sites	Ha. (Ac.)	Sites	Ha. (Ac.)	Sites	Ha. (Ac.)
State	Barry State Game Area	-	-	-	-	1	0.4 (1)	4	27.1 (67)	5	27.5 (68)
	Bass River Recreation Area	-	-	-	-	2	0.4 (1)	1	4.9 (12)	3	5.3 (13)
	Bay City State Park	-	-	-	-	1	0.4 (1)	2	11.7 (29)	3	12.1 (30)
	Cannonsburg State Game Area	-	-	-	-	1	2.8 (7)	-	-	1	2.8 (7)
	Duck Lake State Park	-	-	-	-	-	-	1	10.1 (25)	1	10.1 (25)
	Edmore State Game Area	-	-	-	-	-	-	5	31.6 (78)	5	31.6 (78)
	Flat River State Game Area	-	-	1	9.3 (23)	3	10.5 (26)	2	16.6 (41)	6	36.4 (90)
	Gourdneck State Game Area	-	-	-	-	1	0.8 (2)	-	-	1	0.8 (2)
	Highlands Recreation Area	-	-	-	-	-	-	1	27.5 (68)	1	27.5 (68)
	Island Lake Recreation Area	-	-	-	-	1	6.5 (16)	-	-	1	6.5 (16)
	Lakelands Trail Linear Park	-	-	-	-	-	-	1	0.8 (2)	1	0.8 (2)
	Muskegon State Game Area	-	-	-	-	1	37.6 (93)	1	29.9 (74)	2	67.6 (167)
	Musketawa Trail Linear Park	-	-	-	-	1	15.8 (39)	-	-	1	15.8 (39)
	Pere Marquette State Forest	-	-	-	-	1	6.1 (15)	7	42.1 (104)	8	48.2 (119)
	Petersburg State Game Area	-	-	-	-	2	7.3(18)	1	5.3 (13)	3	12.5 (31)
Proud Lake Recreation Area	-	-	-	-	-	-	1	1.6 (4)	1	1.6 (4)	
White Pine Trail Linear Park	-	-	-	-	1	3.6 (9)	-	-	1	3.6 (9)	
Private	Local Government	2	2.8 (7)	1	8.5 (21)	3	57.1 (141)	7	123.5 (305)	13	191.8 (474)
	Power Company	5	15.0 (37)	2	114.1 (282)	9	59.5 (147)	6	19.8 (49)	22	208.4 (515)
	Private Individuals	4	12.5 (31)	5	64.7 (160)	11	48.6 (120)	10	108.1 (267)	30	233.9 (578)
Federal	HMNF	-	-	1	6.5 (16)	9	49.8 (123)	3	8.9 (22)	13	65.2 (161)
Total		11	30.4 (75)	10	203.2 (502)	48	307.2 (759)	53	469.4 (1160)	122	1010.1 (2496)

Table 7. Percent of Karner blue absent, lupine only, and present sites surveyed in 2004 having general site characteristics present.

Characteristic	Variable	Absent (%)	Lupine Only (%)	Present (%)
Current Threat	ORV	45	47	65
	Vehicles	13	19	15
	Exotic	61	42	80
	Succession	47	63	70
	Management*	29	49	85
	Dumping	11	7	10
	Development*	8	12	35
	Other	11	9	5
Management	Cut	79	88	85
	Burned	11	30	20
	Mowed	47	49	55
	Herbicide	13	5	5
	Hand Cut	3	5	5
	Planted	18	23	15
	Other	26	23	15
Opening Type	Right-of-way*	29	47	65
	Field**	32	12	15
	Clearing	29	19	15
	Barrens	32	33	30
	Openings	8	16	10
	Roadside	0	2	0
Surrounding Environment	Hardwoods	84	86	85
	Pines	39	37	20
	Agriculture	16	2	10
	Residential*	13	40	45
	Potential habitat*	16	30	60
	Wetland	18	23	30
	Other	5	14	5
Canopy Closure	Open	50	40	60
	Partial	47	47	40
	Most**	3	14	0
	Closed	0	0	0

* Significant χ^2 value at $P < 0.05$

**Significant χ^2 value at $P < 0.1$

Table 8. Percent of Karner blue absent, lupine only, and present sites surveyed in 2004 having habitat components present.

Variable	Components	Absent	Lupine Only	Present
Dominant Ground Cover	Grass	47	37	25
	Sedge	26	28	15
	Forb*	26	28	60
	Fern	0	2	0
Lupine Density and Distribution	0	100	0	0
	1**	0	16	0
	2	0	7	5
	3	0	0	0
	4	0	35	20
	5	0	12	10
	6	0	7	0
	7	0	16	20
	8*	0	7	30
9*	0	0	15	
Lupine Density	Scattered**	0	23	5
	Clumped**	0	53	30
	Dense*	0	23	65
Lupine Distribution	Sparse*	0	67	40
	Common	0	26	45
	Abundant	0	7	15
% Lupine in bloom or seed	0-24%	0	42	25
	25-49%	0	16	5
	50-74%	0	21	25
	75-100%*	0	21	45
Deer Browse	Present	0	79	85
Ant Mounds	Present*	42	81	85
Woody Species	Oak**	79	93	21
	Cherry**	79	72	50
	Sassafras*	21	49	60
	Hazelnut	11	12	10
	Aspen	18	12	10
	Maple	13	14	10
	White pine	40	49	55
	Other deciduous	24	33	20
	Other evergreen	53	42	35
Exotic Species	Spotted knapweed	90	91	100
	St. John's wort**	55	79	75
	Hoary alyssum**	24	33	55
	Sweetclover *	11	30	45
	Queen Anne's lace	18	21	10
	Hawkweed**	40	28	60
	Autumn olive**	29	16	5
	Honeysuckle	18	19	5
	Other exotics	21	30	45

Table 8 (continued). Percent of Karner blue absent, lupine only, and present sites surveyed in 2004 having habitat components present.

Variable	Components	Absent	Lupine Only	Present
Preferred Nectar Species (Grundel and Pavlovic 2000)	Butterfly weed*	11	49	50
	Dewberry	68	67	90
	Dotted horsemint*	26	51	60
	Flowering spurge*	18	54	85
	Goldenrod	53	58	45
	Lance-leaf coreopsis*	5	28	50
	New Jersey tea**	8	26	10
Other Flowering Species	Aster	5	12	5
	Blackberry**	24	23	0
	Black-eyed susan*	26	51	55
	Blazing star *	21	56	70
	Blueberry**	16	37	25
	Cinquefoil*	8	35	20
	Downy phlox**	3	0	10
	Dwarf dandelion*	11	12	35
	Fleabane**	29	49	55
	Goat's Rue*	3	23	30
	Primrose**	8	21	30
	Puccoon	5	12	5
	Sunflower	5	44	40
	Violet	13	18	20
	Wild bergamot**	29	54	40
	Yarrow	45	42	30
Other	8	5	15	

* Significant χ^2 value at $P < 0.05$

**Significant χ^2 value at $P < 0.1$

Data Transcription and Digitizing

We entered all new and updated occurrence information obtained during 2004 MNFI surveys into the Heritage Database and digitized in BioTICS. New EOs were digitized as polygons representing occupied lupine patches and associated surrounding nectar sources. Data were entered for all EOs, and included information on the number and sex of Karner blue or associated species observed along with a description of the habitat and location of the occurrence. In all, we entered data for 33 Karner blue EOs (11 new EOs, 10 present updates, seven lupine only updates, and 5 absent updates), seven Great Plains spittlebug EOs (four new EOs, three present updates), two dusted skipper EOs (both new), two eastern box turtle EOs (one new, one present update), one Blanding's

turtle EO (present update), and one spotted turtle EO (new EO). The updated Karner blue and associated species information is now available for use by those with access to the Heritage Database.

Distribution and Abundance

Updated Karner blue distribution maps resulting from MNFI surveys in 2002-2004 reveal areas where Karner blue have disappeared and have been discovered. Prior to the first year of MNFI surveys, Karner blue were known from 33 townships in the Lower Peninsula, mainly in the western half of the state (Figure 11). MNFI surveys verified that the core distribution of Karner blue is in the western Lower Peninsula of Michigan. This distribution pattern roughly mimics that of lupine within the state, but Karner blue is notably absent from the areas

where lupine is more scattered in distribution (e.g. southeast Michigan, Figure 12). Although Karner blue are now known to occur within 34 townships, Karner blue is now presumed extirpated in three previously occupied townships (Figure 12). MNFI surveys therefore discovered occupied habitat within seven townships where Karner blue had not been previously recorded.

Population levels were not determined during 2004 surveys, but general observations related to butterfly numbers were made. Overall butterfly numbers appeared to vary with latitude and distance to Lake Michigan in 2004. Populations in Allegan and Flat River State Game Areas seemed robust, and the first flight began in mid-May in most southern areas. The first flight period in this region was quite long in some areas with high populations; Karner blue were observed through late June and early July. In other areas to the north and west, butterfly numbers seemed similar to 2003, below 2002 levels. The flights were delayed between 10 and 15 days compared to the southern populations, and only sites with high numbers reliably produced Karner blue observations. Surveys revealed that although several townships currently have Karner blue present, some sites in Muskegon County and northern Newaygo Counties, and entire townships in Lake County may no longer be occupied, in spite of lupine presence (Fettinger 2003). Low biodiversity (e.g. monocultures of Pennsylvania sedge) and high deer populations have lead to low nectar plant availability and heavy browsing on lupine, potentially impacting Karner blue populations.

Associated Species Surveys

We discovered a total of eight new EOs for five species during 2004 Karner blue and lupine surveys (Table 9). Species presence was re-verified, or the known extent of a population was extended, for Great Plains spittlebug, eastern box turtle, and Blanding's turtle. All spittlebug and skipper observations were along powerline rights-of-way where prairie grasses were present, particularly big and little bluestem grasses. We collected a dusted skipper voucher specimen at new EO #36, and voucher photos were taken at EO #35. A Great Plains spittlebug voucher specimen was taken at new EO #43 and voucher photos were taken at all other EOs. We also took voucher photos of all other species EOs.

Several turtle observations were made during Karner blue surveys. We discovered a new box turtle occurrence on private property during Karner blue surveys. The property had several prairie/barrens indicators present, including prickly pear cactus, big and little bluestem, lance-leaf coreopsis, rough blazing star, and round-headed bush clover. A second box turtle observation was made along a powerline along with lupine and several prairie indicators and was within two kilometers of a previous box turtle observation. Six Blanding's turtles were observed basking on a log within a roadside pond adjacent to dry-mesic southern forest, within two kilometers of previous Blanding's turtle sightings. Finally, a spotted turtle shell was observed along a Powerline right-of-way that had recently been mowed. The turtle was apparently killed by the mower, as the top of its shell was sheared off cleanly. The shell was within 20m of a small pond within the right-of way, its presumed habitat. Two depredated turtle nests were also observed within 20m of the pond, although species was not determined.

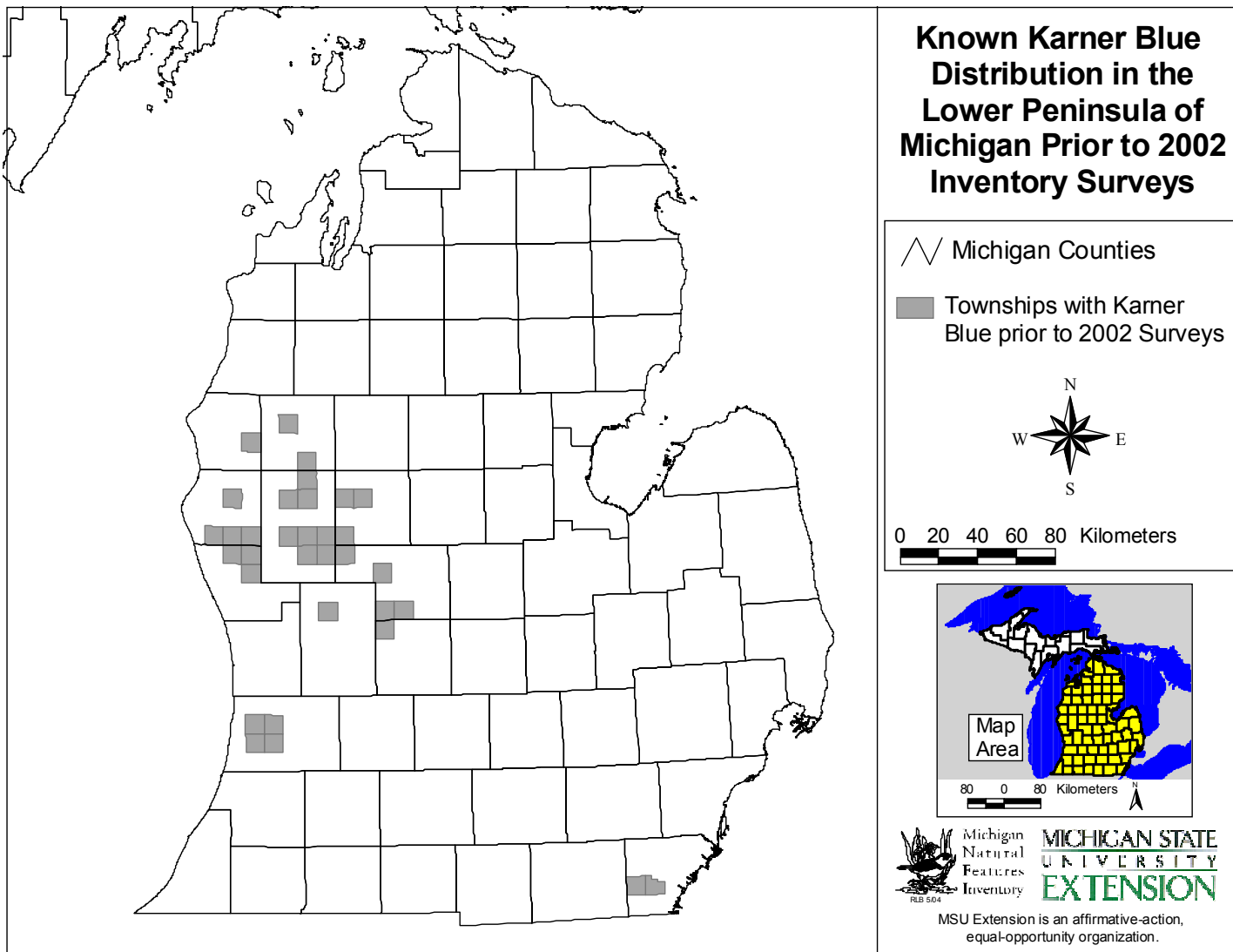


Figure 11. Known Karner blue distribution within Michigan townships prior to 2002-2004 MNFI surveys.

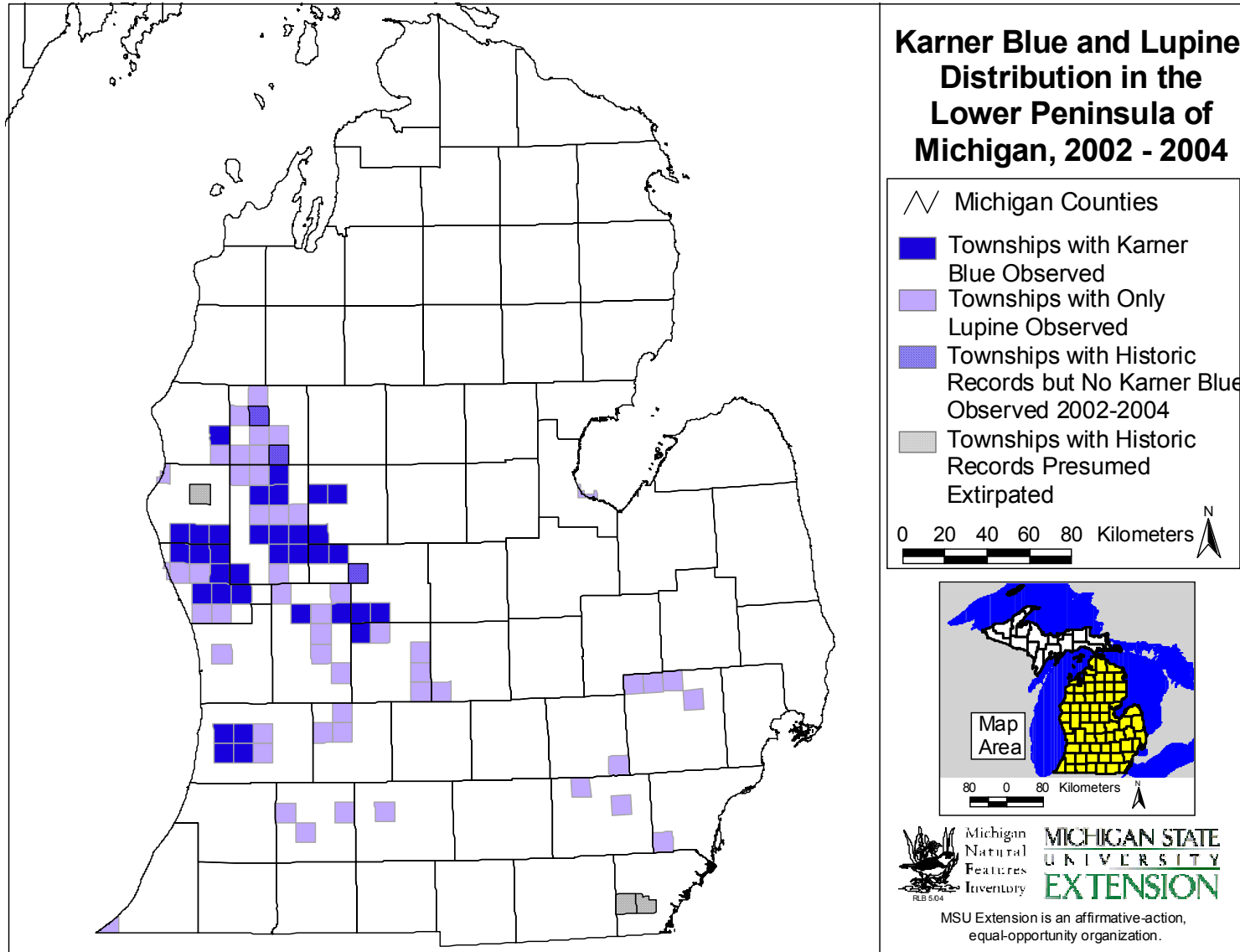


Figure 12. Known Karner blue distribution within Michigan townships after the final year of 2002-2004 MNFI surveys.

Table 9. Location and element occurrence (EO) status of rare species observed during 2004 Karner blue butterfly surveys.

Species	Township	County	EO status	EO#
Great Plains spittlebug (<i>Lepyronia gibbosa</i>)	20N 13W	Lake	New	44
	18N 12W	Lake	New	45
	17N 12W	Lake	Extension	42
	13N 11W	Newaygo	Extension	26
	12N 11W	Newaygo	Update	12
	10N 15W	Muskegon	New	46
	09N 16W	Muskegon	New	43
Dusted skipper (<i>Atrytonopsis hianna</i>)	11N 14W	Newaygo	New	36
	10N 16W	Muskegon	New	35
	10N 15W	Muskegon	New	36
Eastern box turtle (<i>Terrapene c. carolina</i>)	12N 15W	Muskegon	New	260
	10N 16W	Muskegon	Extension	151
Blanding's turtle (<i>Emys blandingii</i>)	03N 07E	Oakland	Extension	120
Spotted turtle (<i>Clemmys guttata</i>)	10N 11W	Kent	New	159

Meetings and Conferences

I attended several meetings during the 2004 fiscal year. I attended quarterly Karner blue working group meetings at John Ball Zoo and the Plainwell Field Office. Interested parties from the MNFI, MDNR, USFWS, Forest Service, TNC, Consumer's Energy, Howard Christensen Nature Center, Grand Valley State University and others were also in attendance. I presented summaries of MNFI surveys and project progress at each of the working group meetings. I attended a conference call with the Karner Blue Butterfly Recovery Team, adding insight into survey efforts, new findings, and data analysis taking place in Michigan. Attendees included individuals from MDNR and USFWS in East Lansing, and individuals from the Forest Service, Wisconsin DNR, Ohio DNR, Indiana DNR, New York State Department of Environmental Conservation, and TNC. I also participated in the southeast Michigan Prescribed Fire Council meeting in September 2004.

Inter-Agency Cooperation and Outreach Efforts

Results of Karner blue surveys were provided to a variety of interested parties. MDNR wildlife biologists received maps of

our predictive Karner blue habitat model and digitized Karner blue locations. Managers can use this visual representation of Karner blue distribution in the state and in managed areas in planning and management decision-making. MNFI continually provides comments on completed draft sections of the Karner blue Habitat Conservation Plan and the Michigan Recovery Implementation Plan as they become available. In addition, consultations with the HCP Coordinator on various aspects of surveys and planning are ongoing. Other inter-agency cooperation includes advice and field work assisting with an HCP created for the Michigan Energy Transmission Corporation (METC), advice and site leads for the MDNR Landowner Incentives Program (LIP), and providing photos, information on protocols, and tips for Karner blue identification tips to multiple parties including the MDNR LIP and Endangered Species Coordinator, Department of Defense at Fort Custer, METC, Detroit Zoo, and John Ball Zoo. Other outreach activities include distribution of Lupine Finder Cards, Karner blue brochures, and a presentation titled "Newaygo County's Rare and Unique Plants and Animals" at the Natural Newaygo Seminar Series hosted by the Land Conservancy of West Michigan. Finally,

consultations with several private landowners resulted in participation in conservation efforts on private lands and a

better understanding of the biology and conservation needs of Karner blue among the interested public.

DISCUSSION

Deductive Habitat Model

Models that predict the presence or absence of endangered species using habitat data are normally judged by the number of prediction errors. These may be of two types: commission (false positives) and omission (false negatives) errors. Factors that lead to prediction errors can be due to limitations imposed by the data-gathering process (Fielding and Bell 1997). Because we used a limited number of data layers in model creation, it is probable that other habitat predictors were not included in the model building process, thereby influencing prediction errors. Other layers exist that may have been useful in the model but were not used for various reasons (e.g. NRCS soils data not available for all counties). Additionally, time constraints limited the creation and use of derived variables (e.g. habitat connectivity, patch size). Data weighting may have also influenced prediction errors in this study. Because the model was deductive in nature, expert knowledge guided variable weighting. This has great potential to influence the model outcome.

Prediction errors may also be due to limitations imposed by or from the organism's ecology (Fielding and Bell 1997). The data layers were selected and variables were weighted according to the ecology of lupine rather than Karner blue. This becomes clear when prediction errors of habitat presence are compared to predictions of Karner blue presence. The model correctly identified areas with lupine more frequently than areas with Karner blue. This may be a result of Karner blue ecology and the fact that lupine is not the only factor in determining whether the species is present. Additionally, it suggests that there may be a missing variable for predicting

lupine presence (e.g. soil texture or depth of water table) because fewer sites were correctly classified as having lupine absent.

Robust measures of prediction success make use of independent data, i.e. data not used to develop the prediction model (Fielding and Bell 1997). In the case of our habitat model, known occurrences of lupine were not used to create the model, only knowledge about the habitat conditions typically present at sites of occurrence. In this way, our model can be perceived of as "robust". However, the deductive nature of our model presents other issues in the form of assumptions made during model creation, as described above. Further discussion of various habitat modeling processes can be found in Guisan and Zimmerman (2000).

Our habitat model led to the discovery of several new occupied sites and previously unknown sites with lupine present. The value of our model is apparent in this fact. It should be noted that the model presented here is just that – a model with limitations that should be taken into account when the model is being used. However, our model has been shown to be valuable in locating areas of potential Karner blue habitat, and limitations should not prohibit model use for locating new sites.

Population and Habitat Surveys

Lupine Surveys

Karner blue host plant presence is critical for survival of the species, making wild lupine presence a requirement for Karner blue occurrence. Lupine surveys were aimed at locating the plant across the broadest landscape possible in an effort to map the potential distribution of the butterfly throughout the central and southern Lower Peninsula. Roadside vegetation surveys can be useful in filling gaps in the knowledge of the distribution and abundance of plants that grow near roads.

This type of survey is cost-effective as it makes use of travel scheduled for other purposes and during trips between sites. It is rapid because surveys can cover a considerable distance for a continuous period of time. Lupine can often be found along roadsides where soils are suitable as a result of the disturbance and light regimes. Therefore, in order to locate lupine efficiently, roadside surveys were conducted across the state, mainly on rural roads and while traveling to survey sites.

A major limitation of the roadside survey method is that observations are limited to a short distance from the road edge, and this distance varies depending on presence of obstacles to the view. Lupine was observed generally within 10-15 m of the roadside edge. The distance lupine could be observed depended on the density of vegetation along the road, and presence of a hill or ditch. Lupine was most easily visible along highway rights-of-way, which are generally mowed and slightly raised. The plants were most difficult to observe along forested roads, where shading prevents or delays blooming and dense vegetation often obstructs the view of the ground. However, lupine was observed along such roads when there was limited traffic and the speed of surveys could be altered (e.g. along rural dirt roads).

Roadside surveys must be conducted by a trained observer that can recognize the species by its shape and color, which can vary by season and habitat. Lupine was easily identified from a distance when blooming due to its distinct purple spiked flower. Experienced surveyors were able to identify the plant by the unique color and shape of the leaflets in early spring as well. During this time, the leaflets take on a purplish-green hue and plants form rounded clumps, often standing out from surrounding vegetation. When lupine is identified in this way, a repeated visit when the plants are in bloom is suggested to verify the plant's identification.

Plants observed along a road may indicate presence elsewhere, away from the road. Lupine observations were made both

near larger openings containing lupine and where no other lupine was observed blooming or the surrounding environment was forested. The presence of lupine therefore did not necessarily indicate that additional habitat was nearby, but did indicate that soil conditions were suitable. This suggests that in cases where no additional lupine was observed, it may be possible to create a suitable environment and expand Karner blue habitat through management in nearby areas. Unfortunately, it was not possible to take detailed notes about the surrounding habitat while conducting roadside surveys and a simple map showing lupine points taken during roadside surveys may not be sufficient to locate openings suitable for Karner blue. If placed on a recent aerial photo or land use map, however, it may be possible to determine whether suitable habitat exists or management would be needed in the surrounding area. A GIS shapefile containing lupine points taken during roadside and site surveys is therefore available to interested managers for their use in management planning.

Lupine was observed throughout the known distribution of historic barrens and savanna in the west-central and southern Lower Peninsula. The distribution of lupine approximated the distribution predicted by the deductive habitat model, with the plant more locally abundant in the western part of the state and increasingly scattered in a belt across the southern counties. This distribution is influenced by the increased habitat fragmentation in the southern and eastern parts of the state. Because lupine surveys were mainly conducted along roadsides, the lupine distribution maps presented in this report serve to indicate lupine presence only, and do not suggest that lupine is absent outside the indicated townships.

Karner Blue Presence-Absence Surveys

Presence-absence surveys are the preferred survey method when determining butterfly distribution across a large area when the amount of time for surveys is

limited. The bivoltine nature of Karner blue flight periods limited our survey time to approximately three weeks in mid-May to early June and three or four weeks in mid-July to mid-August, 2004. Additionally, the target survey area included over 10 counties, making presence-absence surveys ideal for this study. We were able to visit multiple sites across a vast landscape in a short period of time using this survey method. The tradeoff for being able to accomplish this level of survey lies in the usefulness of the data for future population monitoring. Our surveys resulted in expanding the knowledge of where Karner blue exist in Michigan, but were of limited usefulness in determining the status of individual subpopulations. It is therefore suggest that subpopulations with habitat targeted for management under the HCP be re-visited to determine baseline butterfly numbers. This can be completed either concurrently with comprehensive surveys aimed at determining distribution or once those surveys are completed, but should be conducted prior to management under the HCP.

Public Lands Surveys

Most public lands surveys during 2004 occurred on state-owned lands where previous Karner blue surveys have not previously been observed. This distribution of survey efforts is a reflection of the goals of 2004 surveys – to find outlier sites and sites at the edge of metapopulations. However, some sites were known to have Karner blue present and were visited mainly during training of field staff. The fact that only one site on public lands had Karner blue observed (at previously known site) suggests that most Karner blue occupied sites on state-owned lands are currently known.

Several sites on public land had lupine present and may have had Karner blue present at some point in the past as well. Most state lands with lupine present but without Karner blue observed are found in landscapes with fragmented ownership that are dominated by agriculture and forest. In

many cases, the lupine stands on these state lands have benefited from management efforts aimed at keeping the areas open for wildlife habitat. Because this type of management is not compatible with some private land uses, the lupine is largely absent from the surrounding landscape. As West Michigan experiences increasing habitat fragmentation from urban and residential development, the role of state lands in conserving this species becomes more critical, and partnerships with conservation groups and private landowners become increasingly important.

Private Lands Surveys

Private properties surveyed included several owner types and presented some unique challenges. It was beneficial to create one contact person for each property to avoid confusion between visits. In some instances this may have resulted in missed opportunities to locate lupine or voucher specimens of rare species that were present. In some cases voucher photos were taken to substitute specimens, but identification of some species is not possible from a photo. Therefore, presence of these species may be underrepresented in those cases. Spring lupine surveys along power company rights-of-way were sometimes conducted while driving established access roads to conserve time. However, if lupine was found, surveys for Karner blue were conducted by foot following survey protocols.

All new Karner blue occurrences were found on private lands in 2004. While none represent true outlier populations, the discovery of five sites more than three miles from any known population does indicate that there are still discoveries to be made on private lands. It also indicates that private lands may play a critical role in conservation of Karner blue beyond a buffering capacity. Management and conservation of populations on private lands may significantly benefit the species.

Site-level Habitat Characteristics

The habitat data summary and preliminary analysis suggests that several

factors may influence Karner blue and lupine presence within a site. However, a model for Karner blue habitat suitability has not yet been completed and inferences regarding butterfly presence due to habitat features cannot be made at this time. Future analyses will look at habitat variables collected over the past three field seasons, habitat patch size, connectivity, and distribution across the landscape in an attempt to gain a better understanding of how these factors influence Karner blue presence. These analyses will be completed and summarized in a final report due to the MDNR in April, 2005. The following summarizes preliminary findings from 2004 data.

Lupine is essential to Karner blue populations, as it is the only host plant for Karner blue caterpillars. Lupine density appeared to be more important in determining Karner blue presence than lupine abundance during 2004 surveys. Karner blue were frequently observed in areas with dense lupine and less so in areas with scattered lupine. Likewise, Karner blue were often observed in areas where nearly all the lupine plants had blooms or had gone to seed. Similar results were found by Grundel et al. (1998b) who observed that larvae fed preferentially on lupine plants in dense patches

Other than lupine, the most influential habitat characteristics in Karner blue presence or absence appears to be the presence and diversity of flowering plant species. Butterfly weed, horsemint, and flowering spurge have all been listed in the literature as being preferred nectar species (Bidwell, 1994, Herms 1996, Grundel and Pavlovic 2000) and were frequently found in sites where Karner blue were observed in 2004. Several other species identified as nectar sources in the literature were also frequently found in sites with Karner blue. In particular, black-eyed susan, blazing star, evening primrose, sunflower, wild bergamot, and downy phlox all showed a statistically significant or marginally significant association in this and other studies (Packer 1987, Bleser 1992, Leach 1993, Papp 1993, Sferra et al. 1993, Bidwell

1994, Martin 1994, Maxwell and Givnish 1994, Grundel and Pavlovic 2000).

General characteristics at Karner blue sites suggest that many subpopulations are threatened by management and development. Both of these activities are legal in the absence of Karner blue. However, when the butterflies occupy areas that are managed or slated for development, it is important that interested parties apply for an incidental take permit (ITP). The State's efforts in acquiring an ITP through the HCP process is supported by 2004 data that show many areas threatened by these activities. Acquisition of an ITP will ensure that otherwise legal activities resume in a manner that will not be of detriment to Karner blue populations managed by the State.

Distribution and Abundance

Karner blue distribution is currently restricted to the counties in the West-central Lower Peninsula. Our deductive habitat model reveals the largest contiguous savanna remnants and restored savannas in the state remain in this region. Habitat loss, fragmentation, and degradation has caused the Karner blue distribution to shrink throughout its range (USFWS 2003), and continues to do so in Michigan as well. Current threats to the remaining Karner blue populations in Michigan are similar to those in other areas of the species range: incompatible land use (development and agriculture), succession to forest, incompatible recreation (off-road vehicle use), loss of biodiversity (lack of nectar plants), exotic species encroachment, and isolation of populations. The influence of these threats varies by ownership and location within the state, but one or more of these threats is likely to be present at all Karner blue sites to varying degrees. An in-depth discussion of threats will be included in the final report.

Opportunities for Translocation/Reintroduction

Surveys during 2004 revealed an additional area with potential for Karner

blue reintroduction or translocation, primarily on state-owned lands. In particular, the Musketawa Trail in Muskegon County contains large, dense areas of lupine along a Powerline right-of-way. Repeated visits to this site failed to turn up Karner blue, although several of the preferred nectar sources were available. It is recommended that an additional season of

surveys be conducted along this corridor, possibly by volunteers, to verify Karner blue absence. This site appears suitable and is within five miles of known occupies habitat. Introduction of Karner blue to this site would provide a unique educational opportunity, due to the close proximity to metropolitan Muskegon and the popularity of the trail for recreation.

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APPENDICES

Appendix 1. Karner blue butterfly survey protocol adapted from Wisconsin Habitat Conservation Plan.

KBB SURVEY PROTOCOL - PRESENCE/ABSENCE SURVEYS

(Adapted from Wisconsin HCP)

The following are *suggested minimum requirements* for conducting Karner blue butterfly (*Lycaeides melissa samuelis*) presence and/or absence surveys. For the purpose of this survey, *absence* means that KBBs were not detected at a particular site. It is not a 100% guarantee that KBBs do not exist at the site.

Purpose: First flight – To determine if lupine exists in a particular area and whether that area supports KBBs. Second Flight – Determine if KBBs occupy a particular habitat area (lupine and surrounding nectar species).

When To Survey:

- Surveys for the KBB can be conducted during both the first or second flight periods. The first flight normally begins in late May and ends in mid to late June while the second flight normally begins in mid-July and ends in mid to late August.
- Timing of flight periods can vary by as much as 2-3 weeks from year to year and from site to site, and the length of flight periods may vary from year to year (two weeks to five weeks in length).
- If resources do not allow you to conduct surveys during both flights, priority should be placed on conducting surveys during the main second flight (see "Determination of NO KBBs" listed below).
- Survey *three* times during the main second flight period. Only one survey is needed if KBBs are detected during the first survey. If you do not detect KBBs during the first survey, a second survey should be conducted. If KBBs are not detected during the second survey, a third survey should be conducted. Surveys should be spaced so that there is a 3-7 day interval between surveys.
- Conduct surveys during optimal time and weather conditions as listed below:
 - between 8:00 a.m. and 6:00 p.m.
 - when temperatures are above 60^oF
 - when temperatures are between 60^oF and 70^oF surveys should only be conducted under mostly sunny skies with calm to light wind
 - when temperatures are above 70^oF, no restrictions on cloud cover
 - when winds are less than 20 mph
 - do not survey under drizzly or rainy conditions

How To Survey: An individual who is knowledgeable in the identification of KBBs should conduct the surveys. It is recommended that individuals conducting surveys obtain training in identifying KBBs. Reference photos of KBBs may be obtained from Jennifer Fettingner at MNFI. An alternative to this is having Jennifer Fettingner or Dave Cuthrell positively identify a voucher photograph. Photo must capture underside of wing for positive identification.

- The KBB habitat area (lupine and associated nectar species) has been identified ahead of time and is indicated on a topographic map in each field folder.
- Each area separated by >100m of unsuitable habitat should be surveyed separately, each having its own field form.

- The surveyor(s) should walk the entire habitat area (being careful not to step on lupine plants) at a leisurely pace until all likely locations of KBB concentration areas are surveyed.
- The purpose of the survey is fulfilled when one KBB is observed (during either the first or second flight period). It would be advantageous to spend additional time at the site to record more observations.

Intensity Of Survey: Approximately 10 minutes of effort per survey are recommended for each acre of habitat (i.e. lupine patches and important nectar flowers within 100 meters of the lupine patch) to determine presence/absence and to map lupine. Surveying for a longer period of time is encouraged (but not mandatory) if KBBs are not found during the first 10 minutes of survey effort per acre of habitat.

Determination of No KBBs: The determination that no KBBs are present at a site can be made once the site has been surveyed (without documenting any KBBs) three times during the second flight period of one year. Surveys should be spaced so that there is a 3-7 day interval between surveys. The "KBB and LUPINE SURVEY FORM" should be filled out for the first visit to a site, and the "FOLLOW-UP KBB SURVEY FORM" should be completed on subsequent visits. Full instructions on filling out both field forms are located at P:/NFI/Zoology/Karner Blue/USFWS Grant Project/KBB Form Instructions.doc and /Follow-up Form Instructions.doc Note: Once one KBB is observed the purpose of the survey is fulfilled and additional surveys are not required *during that year*.

General Information:

- The "Determination of No KBBs" is based on surveys during the second flight since KBBs numbers are normally significantly greater during this flight period.
- KBB flight periods vary within year from site to site depending on the site's phenology (i.e. "fast" sites and "slow" sites). Flight periods normally occur first on sunny open sites and later on shady sites. Spacing of the surveys is necessary to ensure that at least one survey is conducted during the main flight. A 3-7 day range is used because the duration and amount of suitable survey weather varies among years.
- It would be advantageous for the HCP Team to develop/coordinate a cooperative method of determining the flight period phenology each year that accounts for variation by geography at a site ("fast" and "slow" sites).
- Time Period and Effectiveness of Results: The presence/absence survey has both a spatial and temporal component (i.e. absent here now but present here later). The question - How long does the absent status apply? - will need to be addressed.

For information on identification of KBBs, contact:

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Appendix 2. Survey form and instructions used in MNFI Karner blue butterfly surveys, 2004.

KBB and LUPINE SURVEY FORM				Page 1 of 2
Fill out this section after the survey has been completed				
1 KBB Present?: NO ___ Why? (see codes and circle all that apply) L N W S YES ___ Certainty of location: >95% (location gps'd) ___ 80 - 95% ___ 20 - 80% ___ 0 - 20% ___ UNKN ___				
SURVEYOR AND LOCATION INFORMATION				
Survey date: 2 ___ - ___ - ___		Time from: 3 to: ___		SITENAME: _____
Sourcecode: F _____ M I U S				
Surveyors (principal surveyor first, include first & last name): 4 _____				
5 TOWNSHIP: _____		RANGE: _____		SECTION: _____
OWNERSHIP: 6 _____		QUAD CODE: _____		
Weather (see codes page) 7 Begin Temp: _____ Begin Wind code: _____ Begin Sky code: _____				
End Temp: _____ End Wind code: _____ End Sky code: _____				
SITE CONDITION INFORMATION				
Use space provided on back to sketch the area surveyed.				
Type of opening (ROW, clearing, field, barrens, lawn): 8 _____			Size of opening: 9 _____	
Vegetation surrounding opening (wooded, agriculture, etc.): 10 _____				
Has the area been disturbed? (burn, cut, planted): 11 _____				
Other threats to the area? (ORV, Mechanical, Horses, etc.): 12 _____				
13 Light: open ___ partial ___ filtered ___ shade ___		14 Moisture: moist (mesic) ___ dry-mesic ___ dry (xeric) ___		
Ground cover description (Density, % bare soil, % grass/forb/fern): 15 _____				
WOODY VEGETATION ENCROACHMENT:				
Tree/shrub/stump species and form		Height	Density	Notes
16 _____	17 _____	18 _____	19 _____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
20 LOTIC ENCROACHMENT				
Species		Density	Notes	
_____	_____	_____	_____	
_____	_____	_____	_____	
_____	_____	_____	_____	
KARNER BLUE BUTTERFLY OCCURRENCE				
Mark occurrence on map using a * to indicate an occurrence				
21 Total number of KBB adults:		% of opening occupied	Survey effort: Time spent in opening	Notes, observations, etc.:
Male	Female	Unknown	22 _____	23 _____
_____	_____	_____	% of area surveyed	24 _____
*If the location(s) were gps'd, fill out this section, otherwise leave blank				
25 Type of unit: _____		Unit number: _____		
Waypoint name/# (when using Garmin) _____		File name (when using Trimble) _____		
OPTIONAL: Latitude _____		Longitude _____		
26 FEATURE INFORMATION (mandatory) Point : <12.5 m in both dimensions Line : >12.5 m in one dimension Polygon : >12.5m in both dimensions				
Source Feature (circle one): Single Source EO ___ Multi-Source EO ___ Conceptual Feature Type (circle one): Point ___ Line ___ Polygon				
LUPINE OCCURRENCE				
Map lupine distribution. Use a ● for scattered plants, an X for clumps, and circle (0) dense areas				
Overall distribution pattern (see codes): 27 _____				
28 Estimated % of area covered: ● _____ X _____ 0 _____				
Estimated % of lupine blooming or in seed: 29 _____		Ants present: 30 _____		Evidence of Browse: 31 _____
Comments: 32 _____				

NECTAR SPECIES PRESENT

List nectar species observed at this site. Note the number of plants and blooms where possible.

Species	Blooming?		Number Observed	Notes, observations, etc.
	Yes	No		
33		34	35	36

OTHER SPECIES PRESENT

List other species observed at this site. Note especially listed species and potential predators.

Species:	Number Observed	Notes, observations, etc.
37	38	39

Sketch the boundary of the area visited. Mark your survey route or area, KBB (*) and lupine (● X 0) occurrences and note other pertinent information.

40

KBB and LUPINE SURVEY FORM CODES

WIND CODES (Beaufort wind scale)

- 0 = Calm (< 1 mph) smoke rises vertically
- 1 = Light air (1-3 mph) smoke drifts, weather vane inactive
- 2 = Light breeze (4-7 mph) leaves rustle, can feel wind on face
- 3 = Gentle breeze (8-12 mph) leaves and twigs move, small flag extends
- 4 = Moderate breeze (13-18 mph) moves thin branches, twigs, and leaves, raises loose paper
- 5 = Strong breeze (19-24 mph) trees sway, branches move, dust blows
- 6 = Windy (> 24 mph)

SKY CODES

- 0 = Clear to few clouds
- 1 = Partly cloudy or variable sky
- 2 = Cloudy or overcast
- 3 = Fog or haze
- 4 = Drizzle or light rain
- 5 = Rain showers

KBB ABSENCE CODES

- L = No lupine
- N = No nectar sources
- W = Weather was poor, KBB may not be detectible
- S = Area >75% shaded

LUPINE DISTRIBUTION PATTERN CODES

- 0 = No lupine present
- 1 = Lupine scattered and sparsely distributed in the area
- 2 = Lupine scattered but common and distributed through much of the area
- 3 = Lupine scattered but abundant and distributed through most or all of the area
- 4 = Clumps of lupine sparsely distributed in the area
- 5 = Clumps of lupine common and distributed through much of the area
- 6 = Clumps of lupine abundant and distributed through most or all of the area
- 7 = Dense stands of lupine sparsely distributed in the area
- 8 = Dense stands of lupine common and distributed through much of the area
- 9 = Dense stands of lupine abundant and distributed through most or all of the area

“KBB and LUPINE SURVEY FORM” Instructions

1. Complete this box AFTER the survey has been completed. Check Yes or No if Karner blue butterflies were present or absent. If No, see the codes on page 3 and circle the appropriate letter. If none apply, write a reason next to the codes (eg. *Survey conducted outside KBB flight window*). If Yes, indicate the certainty with which the location(s) of KBB populations were placed on the accompanying topographic map.

SURVEYOR and LOCATION DATA

2. YYYY-MM-DD
3. Use military time or specify am or pm to indicate the duration of the survey
4. List surveyors by name rather than initials
5. List the appropriate Township/Range/Section and indicate the quarter section in which the survey was conducted
6. Describe the ownership (eg. State, Federal, or Private. If private, list landowners)
7. Describe the weather at the beginning and end of the survey by placing the appropriate codes in the blanks provided.

SITE CONDITION INFORMATION

Make a sketch of the area (as closely to scale as possible) on the bottom of page 2, noting major vegetative features

8. Describe the type of opening or area surveyed
9. Estimate, using the topographic map or visually, the size of the entire area
10. Describe the vegetation surrounding the survey area. This section should include potential barriers for butterfly dispersal or unsuitable habitat (eg. *planted pines to the north, dense hardwoods to the east and south, soybean field to west*)
11. List disturbances to the survey area, either evident or suspected (eg. *burned this growing season, evidence of past agriculture*)
12. List current or potential activities that would degrade the habitat and could potentially make the area unsuitable for KBB habitation now or in the future (eg. *Campfire in northwestern corner of opening in center of lupine stand, trash in southwestern ¼ also covering lupine*)
13. Check the category that best describes the majority of the survey area. Open = 75-100% sun, Partial = 50-75% sun, Filtered = 25-50% sun, Shade = 0-25% sun
14. Check the category that best describes the soil moisture at the site. (note: most sites with lupine will be dry/xeric)
15. Describe the ground cover in terms of % grass/forb/fern/bare for the site. (note: include lupine in your estimates of forb cover) If there is a section of the area that varies significantly from the rest, make a note, but include that type of cover in the overall area % (eg. If most of the area is covered in 100% forbs, but the northeast ¼ contains large areas covered with lichen with no other vegetation, indicate *75% forb and 25% lichen* and note *NE1/4 has large areas of lichen without other veg*. Likewise, if the area is a uniform mix of lichen and forbs with 3 times as much ground covered by forbs as lichen, indicate *75% forb and 25% lichen* and note *uniform mix throughout*).
16. List dominant species of woody vegetation within the area, including species entering the area from adjacent wooded areas and woody regeneration from past disturbances.
17. Indicate average height or range of heights at which the woody species are found inside the area
18. Describe the density of woody encroachment quantitatively in terms of the entire area and qualitatively in terms of the area covered by woody vegetation (eg. *10% scattered, 5% dense* would indicate that 10% of the area includes scattered stems of the species identified and another 5% is dominated by the species, for a total of 15% of the area including the species indicated. Qualitative descriptors from least dense to most may include sparse, scattered, patchy, abundant, and dense)
19. Make any notes to further describe the distribution and abundance of woody vegetation here
20. List species of exotic or invasive vegetation here. Common species encountered are Autumn olive (*Eleagnus umbellata*), spotted knapweed (*Centaurea biebersteinii*), and non-native hawkweeds (*Hieracium* spp.). Include woody and non-woody species. (note: some exotics are also used as nectar species, but do not include in that section if you include them here)

KARNER BLUE BUTTERFLY OCCURRENCE

Indicate KBBs on the drawing using a * for individuals or groups

21. Write the total number of male, female, and unknown KBBs under the appropriate category. If none were seen, draw a line through the spaces. See Jennifer Fettingler for identification tips and informational materials.
22. Indicate the % of the area surveyed that was occupied by KBBs. If the entire area (eg. Powerline ROW) was not surveyed, be sure to note this and indicate the area surveyed on the topo map and drawing.
23. Indicate the amount of time spent surveying the area and the amount of the area covered.
24. Note KBB behavior and important comments
25. If you have a GPS unit with you, take locations at the center of the KBB distribution(s) within the survey area
26. Fill out this section only if KBBs were present in the survey area, following procedures for the "Special Animal Form"

LUPINE OCCURRENCE (note: lupine may not be readily apparent during the second flight, and mapping may not be possible during that time)

Indicate where lupine is found in the area on the drawing using a ●, x, or o to indicate the density in a location

27. Describe how lupine is distributed in the area use the appropriate codes
28. Estimate the amount of the entire area covered by each lupine density type. (eg. if ½ of the area is covered by lupine, the sum of all three categories should not add up to >50%. Say that, of the area covered by lupine, half is scattered plants and half is in dense stands, ● = 25%, x = 0%, and o = 25%)
29. Indicate the % of all lupine in the survey area that is blooming and/or in seed
30. If active ant mounds are present in the survey area, write *yes*, otherwise write *no* or *none observed*.
31. If there is evidence of deer browse on the lupine (flower heads appear to have been cut off at the base), indicate the % of the lupine showing deer browse.
32. Write any notes on larval feeding evidence, lupine distribution here

NECTAR SPECIES PRESENT

33. List scientific or common names of dominant nectar species present on the site, either blooming or non-blooming (when possible)
34. Indicate whether the nectar species is blooming
35. Indicate the % of the area that contains the nectar species
36. Write notes on nectar species here. Include notes on barrens indicator species and rare species.

OTHER SPECIES PRESENT

37. List potential larvae or adult predators observed in the survey area (eg. dragonflies, robberflies, assassin bugs, praying mantids, parasitic wasps and flies, spiders, nesting songbirds, insectivorous songbirds, turkeys, rodents) along with other rare or notable species of plants and animals.
38. Indicate the number of each species or group of species. Where appropriate, use notation such as >25, >50, etc.
39. Write notes on predatory behavior and element occurrences here

40. Sketch the boundary of the area visited, prominent vegetative characteristics, mark your survey route, and indicate KBB and lupine within the area.

Appendix 3. Survey form and instructions used in MNFI Karner blue butterfly surveys, 2004.

FOLLOW-UP KBB SURVEY FORM

Page 1 of 2

1 This is the 2nd 3rd (circle one) survey of this site this year
 Fill out this section after the survey has been completed

KBB Present?: NO _____ Why? (see codes and circle all that apply) L N W S
 YES _____ Certainty of location: >95% (location gps'd*) _____ 80 – 95% _____ 20 – 80% _____ 0 – 20% _____ UNKN _____

SURVEYOR AND LOCATION INFORMATION

Survey date: **3** - - - Time from: **4** to: SITENAME: Sourcecode: F _____ M I U S
 Surveyors (principal surveyor first, include first & last name): **5**

6 TOWNSHIP: RANGE: SECTION: QUARTER SECTION:
 OWNERSHIP: **7** QUAD CODE:
 Weather (see codes page) **8** Begin Temp: _____ Begin Wind code: _____ Begin Sky code: _____
 End Temp: _____ End Wind code: _____ End Sky code: _____

KARNER BLUE BUTTERFLY OCCURRENCE

Mark occurrence on map using a * to indicate an occurrence

Total number of KBB adults:			% of opening occupied	Survey effort:	Notes, observations, etc.:
9 Male	Female	Unknown	10	Time spent in opening _____	
			% of area surveyed _____	11	

12

*If the location(s) were gps'd, fill out this section, otherwise leave blank

13 Type of unit: _____ Unit number: _____
 Waypoint name/# (when using Garmin) _____ File name (when using Trimble) _____
 OPTIONAL: Latitude _____ Longitude _____

14 FEATURE INFORMATION (mandatory) Point : <12.5 m in both dimensions Line : >12.5 m in one dimension Polygon : >12.5m in both dimensions
 Source Feature (circle one): Single Source EO _____ Multi-Source EO _____ Conceptual Feature Type (circle one): Point _____ Line _____ Polygon _____

NECTAR SPECIES PRESENT

List nectar species observed at this site. Note the number of plants and blooms where possible.

Species	Blooming?		Number Observed	Notes, observations, etc.
	Yes	No		
15	16	17	18	

OTHER SPECIES PRESENT

List other species observed at this site. Note especially listed species and potential predators.

Species:	Number Observed	Notes, observations, etc.
19	20	21

22 Sketch the boundary of the area visited on the back of this page. Mark your survey route or area, prominent vegetative characteristics, and KBB (*).

KBB and LUPINE SURVEY FORM CODES

WIND CODES (Beaufort wind scale)

- 0 = Calm (< 1 mph) smoke rises vertically
- 1 = Light air (1-3 mph) smoke drifts, weather vane inactive
- 2 = Light breeze (4-7 mph) leaves rustle, can feel wind on face
- 3 = Gentle breeze (8-12 mph) leaves and twigs move, small flag extends
- 4 = Moderate breeze (13-18 mph) moves thin branches, twigs, and leaves, raises loose paper
- 5 = Strong breeze (19-24 mph) trees sway, branches move, dust blows
- 6 = Windy (> 24 mph)

SKY CODES

- 0 = Clear to few clouds
- 1 = Partly cloudy or variable sky
- 2 = Cloudy or overcast
- 3 = Fog or haze
- 4 = Drizzle or light rain
- 5 = Rain showers

KBB ABSENCE CODES

- L = No lupine
- N = No nectar sources
- W = Weather was poor, KBB may not be detectible
- S = Area >75% shaded

“FOLLOW-UP SURVEY FORM” Instructions

1. Indicate whether this sheet represents the 2nd or 3rd survey of this site during this Year.
2. Complete this box AFTER the survey has been completed. Check Yes or No if Karner blue butterflies were present or absent. If No, see the codes on page 3 and circle the appropriate letter. If none apply, write a reason next to the codes (eg. *Survey conducted outside KBB flight window*). If Yes, indicate the certainty with which the location(s) of KBB populations were placed on the accompanying topographic map.

SURVEYOR and LOCATION DATA

3. YYYY-MM-DD
4. Use military time or specify am or pm to indicate the duration of the survey
5. List surveyors by name rather than initials
6. List the appropriate Township/Range/Section and indicate the quarter section in which the survey was conducted
7. Describe the ownership (eg. State, Federal, or Private. If private, list landowners)
8. Describe the weather at the beginning and end of the survey by placing the appropriate codes in the blanks provided.

KARNER BLUE BUTTERFLY OCCURRENCE

Indicate KBBs on the drawing using a * for individuals or groups

9. Write the total number of male, female, and unknown KBBs under the appropriate category. If none were seen, draw a line through the spaces. See Jennifer Fettingner for identification tips and informational materials.
10. Indicate the % of the area surveyed that was occupied by KBBs. If the entire area (eg. Powerline ROW) was not surveyed, be sure to note this and indicate the area surveyed on the topo map and drawing.
11. Indicate the amount of time spent surveying the area and the amount of the area covered.
12. Note KBB behavior and important comments
13. If you have a GPS unit with you, take locations at the center of the KBB distribution(s) within the survey area
14. Fill out this section only if KBBs were present in the survey area, following procedures for the “Special Animal Form”

NECTAR SPECIES PRESENT

15. List scientific or common names of dominant nectar species present on the site, either blooming or non-blooming (when possible)
16. Indicate whether the nectar species is blooming
17. Indicate the % of the area that contains the nectar species
18. Write notes on nectar species here. Include notes on barrens indicator species and rare species.

OTHER SPECIES PRESENT

19. List potential predators observed in the survey area (eg. dragonflies, robberflies, assassin bugs, praying mantids, parasitic wasps and flies, spiders, songbirds, turkeys, rodents) along with other rare or notable species of plants and animals. (Include big/little bluestem, witch grass, and prickly pear if present)
20. Indicate the number of each species or group of species. Where appropriate, use notation such as >25, >50, etc. If a plant is listed, note the distribution.
21. Write notes on predatory behavior and element occurrences here
22. On the back of the data sheet, sketch the boundary of the area visited, prominent vegetative characteristics, mark your survey route, and indicate KBB and lupine within the area.