FINAL

Karner Blue Butterfly
(Lycaeides melissa samuelis)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Ecological Services Field Office
New Franken, Wisconsin

2012

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Cover Page Photo Credit: Photo of male Karner blue butterfly courtesy of Paul Labus, The Nature Conservancy, Ohio.

5-YEAR REVIEW
Karner Blue Butterfly
(Lycaeides melissa samuelis)

1.0 GENERAL INFORMATION

1.1 Reviewers:

Lead Regional Office: Midwest Region
Contact: Carlita Payne, Endangered Species Division, 612-713-5339

Lead Field Office: Green Bay Ecological Services Field Office
Contact: Cathy Carnes, Endangered Species Coordinator, 920-866-1732

Cooperating Field Office: New York Ecological Services Field Office
Contact: Robyn Niver, Endangered Species Coordinator, 607-753-9334

Cooperating Regional Office: Northeast Region
Contact: Mary Parkin 617-417-3331

1.2 Methodology used to complete the review:

The U.S. Fish and Wildlife Service (USFWS) conducts status reviews of species on the List of Endangered and Threatened Wildlife and Plants (50 CFR 17.12) as required by section 4(c)(2)(A) of the Endangered Species Act (ESA) (16 U.S.C. 1531 *et seq*.). The USFWS provided notice of this status review via the Federal Register (74 FR 11600) on March 18, 2009, requesting new information on the Karner blue butterfly *(Lycaeides melissa samuelis)* that may have a bearing on its classification as endangered. Linda Filo and Jennifer Resch, University of Wisconsin-Green Bay students employed by the Green Bay, Wisconsin, Ecological Service Field Office (GBFO) through the USFWS Student Temporary Employment Program (STEP) gathered relevant information on the biology and habitat of the species as well as information on the recovery sites. USFWS Field Offices and state biologists assisted with information on recovery sites in their states. Cathy Carnes, Endangered Species Coordinator (GBFO), completed the status review. The USFWS did not carry out a formal peer review of the 5-year review because scientific uncertainty or controversy is not high.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review: 74 FR 11600, Wednesday, March 18, 2009 (USFWS 2009a).

1.3.2 Listing history:

Original Listing
FR notice: 57 FR 59236-59244
Date listed: (day) Monday, December 14, 1992
Entity listed: Subspecies
Classification: Endangered

1.3.3 Associated rulemakings: None.

1.3.4 Review History:

No previous USFWS 5-Year Reviews have been completed for the Karner blue butterfly.

1.3.5 Species' Recovery Priority Number at start of 5-year review: 9 C

(indicating a subspecies with a moderate degree of threat and high potential for recovery, and in conflict with construction or other development projects or other forms of economic activity).

1.3.6 Recovery Plan

Name of plan: Karner Blue Butterfly Recovery Plan (*Lycaeides melissa samuelis*)
Date issued: September 2003
Dates of previous revisions, if applicable: None

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate? *No*

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria? *Yes*

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat? *Yes*

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? *Yes*.

While some new threats to the KBB have been identified they have not substantially changed the nature of the threats or the manner in which the threat should be addressed and therefore do not require additional recovery criteria to address them. For example, pertaining to the threat posed by "*Present or threatened destruction, modification or curtailment of its habitat or range,"* mineral development on the Huron-Manistee National Forest has been identified as a new threat (refer section 2.3.2.1 below). This threat falls into the category of "commercial" development identified in the KBB recovery plan (USFWS 2003). The recovery criteria include a connectivity criterion to insure dispersal between subpopulations, especially important in habitats fragmented by commercial development. This threat is also addressed by the recovery criteria pertaining to the need for a management and monitoring plan which is to include "suitable buffering of the metapopulation against adverse disturbance and threats to survival."

2.2.3 **List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.**

The following is a review of the recovery and delisting criteria that appear in the KBB recovery plan (USFWS 2003) along with a discussion of how these criteria have been met. To facilitate ease of interpretation of acronyms in this document, refer to Appendix A.

Reclassification Criteria

Criterion 1:

Establish viable metapopulations (VPs) and large viable metapopulations (LPs) of KBBs in 13 recovery units (RUs) as specified in Table 4 and Table B1, reclassification column, of the KBB recovery plan (USFWS 2003).

The recovery sites in the KBB recovery plan (USFWS 2003) plus 6 additional potential recovery sites of note (since completion of the KBB recovery plan) are summarized in Appendix B, Table B1 (the 6 additional potential recovery sites are in bold, italics and shaded). For a review of the information on KBBs in the 7 states where the species currently occurs (including on recovery sites) refer to Appendix C.

For purposes of this review, the following recommended metapopulation goals were analyzed (refer to Appendix B, Table B1, "Notes"):

- For reclassification: 27 metapopulations (19 VPs and 8 LPs),
- For delisting: 32 metapopulations (21 VPs and 11 LPs)

Reclassification criterion 1 has not been met. As noted above a minimum of 19 VPs are recommended for reclassification. To date none of the 19 VP sites have met all the reclassification criteria. Of the 8 LPs recommended for reclassification, 3 LP sites in Wisconsin meet the reclassification criteria; those LP sites are Fort McCoy-North Post, Fort McCoy-South Post, and Necedah National Wildlife Refuge (NWR) (see below). In addition, the 3 LP sites occur in only 2 of the 13 RUs and none of the 13 RUs contain the recommended number of VPs and/or LPs recommended for reclassification (Appendix B, Table B1).

Criterion 2

Each <u>VP</u> shall have:

2.1. a management and monitoring plan, that is approved by the USFWS prior to the fifth consecutive year of monitoring, that will be implemented into the future and include:

a. suitable buffering of the metapopulation against adverse disturbance and threats to survival,
b. maintenance of a diverse and appropriate successional array of suitable KBB habitat and,
c. identification of appropriate responses to potential metapopulation declines, and (refer to 2.2)

Reclassification criterion 2.1 has not been met. However, 5 of the 19 VP sites recommended for reclassification have management plans that meet the above criterion. Those plans and VP sites are:

- *the management plan for the Albany Pine Bush Preserve (APBP) VP site in New York (APBP Commission 2010),*
- *the habitat management and monitoring plan for the Concord VP site in New Hampshire (Fuller et al. 2007),*
- *and the Huron-Manistee National Forest (HMNF) Land and Resource Management Plan for 3 VP sites (Otto, White River, and Bigelow) in the HMNF in Michigan (HMNF 2006).*

<u>Note:</u> Improvement of some of the plans noted above for VPs (and those noted below for LPs) may be needed to more explicitly address criterion 2.1. c. "identification of appropriate responses to potential metapopulation declines."

In addition, management plans that include maintaining and managing some barrens/savanna habitat for a limited period of time are in place for many of the recovery or potential recovery properties (Appendix B, Table B1) across the range (e.g., county forest plans in Wisconsin and state wildlife area management plans in Wisconsin and Michigan). Some of these plans also include monitoring for KBBs (refer to Appendix C).

2.2. a sufficient number of individuals in an appropriate metapopulation structure, maintained for at least 5 consecutive years. The number of individuals shall be at least 3,000 first or second brood adults in the final year of evaluation and in four of the five years overall. In all years, the number of adults shall be greater than 1,500 in one of either the first or second brood. In some circumstances the 3,000 level may be too high or too low [refer to APPENDIX E of the Kbb recovery plan (USFWS 2003)].

Reclassification criterion 2.2 has not been met. Currently no VP site has been documented as meeting the recommended 3,000 KBB criterion (as specified above) for 5 years. However, 7 of the 19 VP sites recommended for reclassification are within 1-4 years of meeting this criterion. This is based on annual second flight KBB population data documenting populations of 3,000 or more butterflies at the 7 VP sites (Appendix D, Table D1). Those 7 VP sites occur in the following 3 states: 1 in New York (Saratoga Sandplains), 3 in Michigan (Otto, Bigelow and Hayes Road), and 3 in Wisconsin [Sandhill State Wildlife Area (SWA), Whitewater SWA, and a Private Landowner (Marquette County)] (refer to Table 1 below).

2.3. connectivity between subpopulations so that the average nearest-neighbor distance between subpopulations is no more than 1 kilometer (0.62 miles), and the maximum distance between subpopulations is no greater than 2 kilometers (1.24 miles). In some cases the 1 kilometer dispersal distance may be too far [refer to APPENDIX G, INCREASING THE COLONIZATION RATE OF SUBPOPULATIONS WITHIN A METAPOPULATION in the KBB recovery plan (USFWS 2003)].

Reclassification criterion 2.3 has not been met at 19 VP sites. However progress has been made as the 5 sites with management plans noted in reclassification criterion 2.1 meet or will meet this criterion as their metapopulations are restored. Some additional VP sites may have met this criterion as well, however more information is needed to assess this.

Each LP shall have a management and monitoring plan that includes the same information as the management and monitoring plans recommended for VPs in Criterion 2.1 above.

Of the 8 LP sites recommended for reclassification, 3 have management and monitoring plans; those are Necedah NWR, Fort McCoy-North Post, Fort McCoy South Post (all in Wisconsin) (refer to Appendix C, Recovery Units, Wisconsin).

Each LP shall have in addition to Criterion 2.1:

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

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

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

Reclassification criterion 2.4 has not been met at 8 LP sites. As noted under criterion 1 above, for purposes of this analysis, to reclassify the KBB from endangered to threatened, recovery of 8 LPs is recommended. However, 3 LP sites in Wisconsin meet this reclassification criterion; those LP sites are Fort McCoy-North Post, Fort McCoy-South Post, and Necedah National Wildlife Refuge (NWR). A fourth site, Jackson County Forest (a potential recovery site) may meet this criterion as well, however additional information is needed to fully assess this.

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

a. connectivity between subpopulations so that the average nearest neighbor distance between subpopulations is no more than 1 kilometer (0.62 miles), and the maximum distance between subpopulations is no greater than 2 kilometers (1.24 miles). In some cases the 1 kilometer (0.62 miles) dispersal distance may be too far. For subpopulations greater than 2 kilometers from their nearest-neighbor, validation that dispersal is occurring is needed prior to including that subpopulation into the LP.

Reclassification criterion 2.5.a. has not been met. However, 3 out of the 8 recommended LPs meet this criterion, those LPs are in Wisconsin and are Fort McCoy-North Post, Fort McCoy-South Post, and Necedah NWR (Wisconsin). Jackson County forest (a potential recovery site) may meet

this criterion as well, however additional information is needed to fully assess this.

b. at least 6,000 adult butterflies maintained for at least 5 consecutive years. At least 6,000 first or second brood adults shall be present in the final year of evaluation and in 4 of the 5 years overall;

Reclassification criterion 2.5.b. has not been met for 8 LPs. However the criterion has been met for 3 of the 8 LPs, Fort McCoy-North Post, Fort McCoy-South Post, and Necedah NWR (Wisconsin). In addition, 2 LP sites, the Welch/Emmons/Hartman Complex and Crex Meadows/Fish Lake WAs are within 2 and 4 years respectively, of meeting this criterion (Table 1 below). This is based on annual second flight KBB population data (Appendix D, Table D1). Note: It is likely that the LP criterion has been met at Crex Meadows/Fish Lake WAs in some additional years as well (Table 1 below, footnote 5).

2.6. reduced monitoring and management requirements compared to those required for a VP.

Reclassification criterion 2.6 has been met at 2 of the 8 recommended LP sites. Both Necedah NWR and Fort McCoy derive their KBB population estimates by determining KBB densities from a representative subset of habitats and use those calculations to extrapolate the annual population size. This results in a reduced survey effort.

Delisting Criteria:

Criterion 1

Establish VPs and LPs of KBBs in 13 RUs as specified in Appendix B, Table B1 (refer to "Delisting" column and sites that are not in bold, italics and shaded).

Delisting criterion 1 has not been met. For purposes of this review (as noted above under reclassification criterion 1 above) to delist the KBB, 32 KBB metapopulations (21 VPs and 11 LPs) are recommended to be recovered in 13 RUs across the species range (Appendix B, Table B1). No VP site meets the recovery criteria for delisting. However of the 11 LPs needed for delisting, 3 LPs in Wisconsin meet the delisting criteria; those are Fort McCoy-North Post, Fort McCoy-South Post, and Necedah NWR (Table 1 and Appendix D, Table D1). Of the 13 RUs range-wide, recovery has only been partially achieved in 2 RUs in Wisconsin, the Glacial Lake Wisconsin RU (Necedah NWR) and West Central Driftless RU (Fort McCoy North Post and South Post). Therefore, none of the 13 RUs contain the recommended number of VPs and/or LPs for delisting.

Criterion 2

Same as Criterion 2 above for reclassification with the addition that each VP shall be demonstrably self-reproducing, shall be maintained at or above minimum allowable population sizes, and shall be managed and monitored under the specified management and monitoring plans for at least 10 consecutive years. Each LP, after the initial 5 years of monitoring for reclassification purposes, shall be monitored sufficiently to demonstrate that the LP is being maintained.

Delisting criterion 2 has not been met. Of the 21 VPs recommended for delisting, no VP site has met this delisting criterion. However 3 out of the 11 LP sites recommended for delisting have met this delisting criterion. Those sites are Fort McCoy-North Post, Fort McCoy-South Post, and Necedah NWR (Wisconsin); all three of these sites are managed and monitored, and have maintained 6,000 or greater KBBs for at least 10 years (refer to Table 1 below and Appendix D, Table D1).

Criteria as they relate to the 5-listing factors:

Primarily the recovery criteria are expressed using demographic criteria (VP and LP KBB population sizes) and also include desired habitat size (LP), subpopulation connectivity and the need for management and monitoring plans at recovery sites. These criteria directly and/or indirectly address the following 5-listing factors:

1. Present or threatened destruction, modification or curtailment of its habitat or range: All of the criteria for reclassification and delisting are relevant to this listing factor.

2. Overutilization for commercial, recreational, scientific, or educational purposes: All of the criteria for reclassification and delisting are relevant to this listing factor. Especially pertinent is Criterion 2 (under "reclassification" criteria) which includes development of a management and monitoring plan that will be implemented into the future and includes:
    a. suitable buffering of the metapopulation against adverse disturbance and threats to survival,
    b. maintenance of a diverse and appropriate successional array of suitable Karner blue habitat, and
    c. identification of appropriate responses to potential metapopulation declines.

3. Disease or predation: Same as No. 2 above.

Table 1. Karner blue butterfly recovery sites meeting or nearing reclassification/delisting criteria as of 2011.

State	Recovery Site	[1]Reclass. Population Criterion	Reclass. Population Criterion met?	Years Reclass. Population Criterion Met	Years of Population Data Needed to Meet Reclass. Criterion
NY	Saratoga Sandplains	VP	No	2	3
MI	Otto	VP	No	3	2
	Bigelow	VP	No	2	3
	[2]Hayes Road	VP	No	3	2
WI	Welch/Hartman/Emmons Complex	LP	No	[3] 3	2
	Sandhill SWA	VP	No	4	1
	White River Marsh	VP or LP	No	1	4
	[2] Private Landowner – Marquette Co.	VP	No	2	3
	Fort McCoy– North Post	LP	[4]Yes	5	0
	Fort McCoy- South Post	LP	[4]Yes	5	0
	Necedah NWR	LP	[4]Yes	5	0
	[5]Crex Meadows and Fish Lake WAs	LP	No	1	4

1 Reclassification Population Criterion: VP (viable population) = 3,000 KBBs, or LP (large viable population) = 6,000 KBBs for 4 out of 5 years and in the 5th year.

2 New *potential* recovery sites since listing; refer to Appendix B, Table B1 and Appendix C, Wisconsin, Morainal Sands RU.

3 There were 5,850 KBBs recorded from the Welch/Hartman/Emmons Complex in 2008, as not all KBB sites were monitored in this complex, it is likely that 6,000 or more KBBs were present, therefore the reclassification criterion of 6,000 KBBs will be considered met in 2008 for purposes of this review, making the total numbers of years the criterion has been met 3 years.

4 Delisting population criterion also met (6,000 KBBs for 10 years).

5 It is likely that the 6,000 KBB annual population criterion has been met at Crex Meadows in some past years as this is a large property managed as barrens with anecdotal information of good KBB numbers in the past (refer to Appendix C, Wisconsin, Superior Outwash RU).

4. Inadequacy of existing regulatory mechanisms: This is addressed under Criterion 2 (of "reclassification" criteria) which includes development of a management and monitoring that will be implemented into the future and includes the elements (a-c) identified in No. 2 above for "*Overutilization for commercial, recreational, scientific, or educational purposes."*

5. Other natural or manmade factors affecting its continued existence. Same as No. 2 above.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

Summarized below is information on the KBB's biology and life history gleaned from articles and reports published since 2001. Information on the KBB published or available prior to 2001 can be found in the KBB recovery plan (USFWS 2003).

KBB Eggs

While it is known that eggs of the KBB are textured, Nickles et al. (2002) further describes the outer casings of the eggs as having interwoven ridges and depressions, while the inner vitelline membrane is described as fairly flat. The micropyle is particularly rich in calcium, and in unhatched eggs the micropyle is also rich in phosphorous (Nickles et al. 2002). Recent research also shows that that KBBs overwinter (within the egg) as first instar larvae (USGS 2011).

Larval and Pupal Growth

As noted above under "KBB Eggs," research has shown that KBBs overwinter (within the egg) as first instar larvae (USGS 2011). Laboratory and field observations indicate that larvae do not usually pupate until they averaged 10-15 millimeters in length. Larval feeding studies (using leaves from open, partial and closed subhabitats) found that subhabitat did not have a significant effect on pupal survival. It was also found that KBBs placed on lupine plants as pupae had consistently higher survival rates than those placed as larvae (Lane and Andow 2003).

Larval Behavior

Swengel (1995) observed that larvae may drop off of lupine plants in response to disturbance. A 4.5 mm larva tended by 25 ants was observed dropping off a plant upon human approach and burrowing underground into sandy soil

completely out of view. A 2.5 mm larva was also observed 17 mm below the soil surface in the space around the lupine stem and root.

Oviposition Behavior and Patterns

Pickens and Root (2008a) are the first to describe circling behavior in late first brood ovipositing (egg laying) females at Kitty Todd Nature Preserve in Ohio. The circling behavior observed was described as females landing on leaves of host-plants and moving in tight circles, while batting their antennae against the leaves. Following this display, the females were then observed to either crawl down the stem and oviposit, or move to another host-plant. In contrast, circling behavior was rare in second brood KBBs. Circling behavior did not appear to be positively correlated with heat. This was evidenced by the fact that while temperatures were consistently higher in the second brood, the circling behavior was observed to be more common late in the first brood.

In addition to observing the circling behavior Pickens and Root (2008a) documented that first brood KBBs only oviposited on lupine stems while second brood KBBs oviposited on grasses (16.7%), dewberry (*Rubus villosus*) (1.2%), early golden rod (*Solidago juncea*) (1.2%), and the ground (1.2%), in addition to lupine (79.8%).

Other findings were that first brood KBBs tended to oviposit singly on host-plants (1.06 eggs per location), while the second brood tended to oviposit in clumps (2.94 eggs per location). This change in strategy may be due to environmental conditions and/or differences in survivorship between broods. Second brood KBBs deposited their eggs at a greater height ($\leq$ 13 cm) compared to the first brood ($\leq$ 10 cm). Fecundity did not differ between the two broods, and the number of eggs produced in the field (139.6 eggs per female for first brood and 136 eggs per female for second brood) was similar to the number of eggs produced by females brought into captivity (usually around 100 eggs per female with a maximum of 200) (Pickens and Root 2008a).

Lane and Andow (2003) also examined oviposition patterns in Wisconsin (Sawyer and Emmons Creek State Fishery Area properties) and Minnesota (Whitewater Wildlife Management Area) over the course of 3 years. Oviposition (egg laying) was evidenced by larval locations. Larvae were most often located on lupine leaves (82%); however larvae were occasionally observed on stems (7%), petioles (8%) and also on reproductive parts (2% on buds, flowers and seed pods), with the latter being a rare occurrence. Of the larvae found on leaves, 86% were located on the lower leaf surface. While larvae did move from leaf to leaf, most remained on one lupine stem (Lane and Andow 2003).

Effect of Habitat Management on Oviposition

The influence of habitat management on oviposition behavior at 4 sites in the Kitty Todd Nature Preserve (Ohio) was examined by Pickens and Root (2009). Management of these sites consists of burning one-third, mowing one-third, and leaving one-third unmanaged (not burned or mowed) each year. Treatments are rotated annually within each site such that the interval between identical treatments is usually 3 years. At the time of this study the unmanaged units had not been burned for about 4-7 years. Female KBBs oviposited significantly less in unmanaged areas (only 5 of 127 ovipositions, with all five occurring at South Piels) than in burned or mowed areas. This change in oviposition preference was likely due to habitat degradation in the unmanaged areas and the availability of early successional habitat in the managed areas (Pickens and Root 2009).

Ovipositioning Rates of Wild and Captive Bred KBBs

Pickens and Root (2007) also quantified oviposition and foraging rates of reintroduced and wild female KBBs in the field. The field study indicated very low oviposition rates of captive-bred and released adults compared to wild-born adults. In addition, modeling indicated that even at low larval survival rates (6%) releasing larvae was a more efficient method than releasing adults (Pickens and Root 2007). However, a more rigorous study is needed to more fully address this research topic and assess the preliminary findings (Peter Tolson, Toledo Zoo, in litt. 2008).

Effect of Subhabitat on Adult Production

Subhabitats, created by variations in canopy cover, effect adult production by influencing the number of host and nectar plants present, egg-laying patterns, and immature survivorship. Research by Lane and Andow (2003) in Wisconsin found that the largest number of eggs tended to occur in open subhabitats (0-15% canopy cover) at the Sawyer site (16,460-665,860 eggs over five sampling periods). At the Emmons Creek SFA, the greatest number of eggs (61,470-173,430), also occurred in open subhabitats during the second flight in two out of five sampling periods. However, in some years and/or broods, partial subhabitats (16-75% canopy cover) supported the greatest number of eggs (24,850-88,160 eggs). The fewest eggs (20-12,740) were laid in closed subhabitat (76-100% canopy cover) but larval survival rates were highest in these closed subhabitats. This suggests that the healthiest KBB populations are produced in habitats with large areas of partial canopy subhabitat favoring high rates of oviposition and larval survival, especially during the second generation. However, these results do not incorporate variations in habitat or environmental conditions between broods or among years, so one could conclude that all subhabitat types may be necessary for long-term KBB persistence (Lane and Andow 2003).

Wild Lupine (Host Plant)

Lupine Leaf Nitrogen

Pavlovic and Grundel (2008) found that KBB larval growth at Indiana Dunes National Lakeshore (IDNL) was positively correlated with lupine leaf nitrogen content, possibly producing strong selective pressure for KBBs to choose lupine based on quality.

Pickens and Root (2008b) found that there was no significant difference in leaf nitrogen content between burned, mowed, and unmanaged treatments at Kitty Todd Preserve (Ohio) for the first brood larval stage. During the second brood, increased herbaceous vegetation density and canopy cover, in addition to flat/north aspects were associated with higher quality host-plants (Pickens and Root 2008b).

Pickens (2006) also found that herbaceous vegetation density alone at the Kitty Todd Preserve (Ohio) explained 37% of the variance in nutritional quality of lupine (leaf nitrogen content for first brood, and nitrogen and water content for the second brood), while canopy cover contributed a relatively minor portion of the variance (8%). Herbaceous vegetation appears to play a pivotal role in lupine quality by providing a source of shade for the lupine plants, thus preventing early senescence or drying out.

Lupine Patch Colonization

Several factors have been identified that influence lupine patch use by KBBs, some of which varied by location of study site. Grundel and Pavlovic (2007) examined characteristics of colonized lupine patches in Wisconsin and Indiana. Colonized lupine patches at Fort McCoy (Wisconsin) were characterized by the following: (1) the patch size was significantly larger, (2) they were more northward facing and (3) found on less significant slopes, (4) exposed to higher levels of potential incident radiation (higher heat load), (5) located at a lower elevation, (6) more likely to have medium to high lupine density than low lupine density, (7) surrounded by a relatively low percentage of unoccupied lupine patches, (8) had a lower percentage of woody cover (at a density less than $37m^2$ of woody vegetation/ha within 200 meters of the patch), and (9) a higher percentage of area within 200 meters of the patch had trees removed during the ten years prior.

The colonized lupine patches at IDNL had the following characteristics: (1) the patches were significantly larger than and (2) more southward facing than the unoccupied patches, and (3) occupied patches were surrounded by a relatively low percentage of unoccupied patches. Patch area was an especially strong positive predictor of patch occupancy, but was a much less strong predictor of KBB feeding damage within a patch (viable patch size will vary with patch size

distributions within a site, therefore there is no rule of thumb for patch size across the KBB range). There were various other characteristics pertaining to feeding damage in the patches observed at this site, which were that feeding damage increased as: (1) patch area increased, (2) as the ratio of unoccupied to occupied lupine patches in the surrounding matrix decreased, (3) as potential incident solar radiation (derived from the patch's slope, aspect, and latitude) decreased, and (4) as canopy cover decreased (Grundel and Pavlovic 2007).

At both the Fort McCoy and IDNL sites, the area of host-plant (lupine) patches was a significant predictor of host-plant patch occupancy and feeding damage. As the host-plant patch size increased, the probability of patch occupancy and larval feeding activity increased. Grundel and Pavlovic (2007) also found that the probability of patch occupancy and rates of larval feeding damage within a patch both decreased as the percentage of unoccupied patches surrounding the occupied patch increased. The strong effect of patch connectivity on the two aforementioned factors may be associated with habitat quality in determining patch use. For example, a high connectivity ratio (calculated from the number of unoccupied patches divided by occupied patches) could indicate a local concentration of poor habitat conditions for patch occupancy that could broaden to the focal patch, or it could signify a lack of potential migrants from the surrounding matrix to the focal patch (Grundel and Pavlovic 2007).

Resource availability (patch area and lupine density or cover), microclimate, and matrix quality were similarly important in determining patch use by KBBs at both locations, but these three sets of predictors did not account for most of the variation in patch use. The majority of the variation was attributed to spatial trends and connectivity of habitat patches. The authors recommend that, in addition to abundance of lupine, managers consider the quality of the surrounding matrix and microclimate, connectivity of surrounding occupied patches, and management of the thermal environment (Grundel and Pavlovic 2007).

Lupine Viability, Soil, Litter, Canopy, and Vegetation Cover

Recent investigations have been conducted on factors that influence lupine plant viability including soil pH, organic matter, leaf litter, canopy cover and other vegetation cover. Dunn (2008) found no significant difference in soil pH or organic content within or outside of large, well-established lupine patches in the Muskegon Recovery Unit (Michigan). The mean soil pH within and outside lupine patches was found to be 5.05 and 5.0, respectively. Soil organic content was low for all sites (Dunn 2008). An additional study that examined soil pH (from 4.6-5.5) and organic matter content within lupine patches in Ohio (Oak Openings Metroparks, Kitty Todd Nature Preserve, and Lou Campbell State Nature Preserve) found no effects on lupine seedling survival, establishment, or size (Plenzler 2008). Clark and Francis (2008) found that soil organic matter and bulk density did not influence lupine establishment at Alderville, Ontario, and modeling suggests that lupine is associated with moderate soil sodium levels

(mean = 3.9 mg/kg), high soil magnesium (mean = 11.6 mg/kg), and high potassium levels (mean = 16.6 mg\kg).

Evidence suggests that lupine performs better when leaf litter cover is low. Pickens (2006) found that lupine plants at Kitty Todd Preserve (Ohio) were smaller in areas of high leaf litter (depth >3.5 cm). Pavlovic and Grundel (2008) also report that low litter cover is favorable for lupine reintroduction in Indiana. While Clark and Francis (2008) did not directly measure litter depth in Alderville, Ontario, they found that lupine survival and establishment were limited to areas with 10 percent or less exposed bare ground, along with a soil minimum water holding capacity of 35 grams of water per 100 grams of soil. Previous studies have indicated that litter levels affect soil moisture (Ontario Ministry of Natural Resources 2001, Caitling, Caitling, and McKay-Kuja 1992). Modeling of lupine survival by Plenzler for three sites in Ohio (2008) indicated that soil moisture increased the chance of seedling survival to July 1, but was not an important predictor of over-wintering survival.

Canopy cover also affects lupine establishment. A study conducted by Pavlovic and Grundel (2008) at IDNL found that lupine seedlings (from winter planted lupine seeds) had a higher emergence in openings than in dense shade over the course of the first growing season, and that seedlings emerged earlier under open or partial canopy cover. It was also observed that seedling survival was four times greater in openings and partial shade than in dense shade. Similarly, Clark and Francis (2008) discerned that a minimum of 10 percent tree cover was needed for lupine establishment. The best lupine performance occurred when canopy cover exceeded 20 percent; lupine did not establish when canopy cover surpassed 60 percent.

Moderate vegetation cover also appears to favor lupine establishment at IDNL (Pavlovic and Grundel 2008). Plenzler (2008) modeled lupine survival for native established populations in Ohio and determined that moss cover and ferns increased the chances of seedling survival to July 1. Additionally, increased exposure to light (measured at the seedling level in full sun) decreased the probability of seedling survival to July 1, however light exposure was not an important predictor of over-wintering survival (Plenzler 2008). Numbers of adult lupines, non-lupine forbs, grass stems, oak leaves, fine leaf material, matted grass, bare sand, and lichen ground cover categories displayed no correlations with lupine seedling survival, establishment, and size (Plenzler 2008).

Studies conducted at IDNL by Pavlovic and Grundel (2008) suggest that in sand-mined areas, supplemental watering, the addition of moderate litter cover, the incorporation of organic matter into the sand, or establishment of shade plants will benefit wild lupine seedling survival in reintroduction areas such as those at IDNL.

Pavlovic and Grundel (2008) suggest that reducing canopy cover and leaf litter will benefit lupine reintroduction efforts, while reducing vegetation cover in openings may hinder lupine restoration; this varies with other habitat variables, however. The authors advise that uniform restoration treatments applied across a mosaic of canopy cover could be problematic due to the fact that there are significant interactions between litter cover, canopy cover, and herbaceous vegetation cover. Therefore, it is suggested that lupine be planted across combinations of site conditions. Pavlovic and Grundel (2008) consider treatments in openings unnecessary to increase lupine establishment. In partially shaded areas, herbaceous vegetative cover should be reduced and the litter should remain intact. In dense shade, litter removal and/or vegetative cover reduction would promote lupine establishment (Pavlovic and Grundel 2008).

Lupine Seedling Performance and Lupine Plugs

Lupine seedling survival is influenced by many factors including soil temperature, inbreeding, light intensity, management and seed source. Pavlovic and Grundel (2008) studied factors affecting lupine seedling survival at IDNL by planting one-hundred single lupine seeds (collected from Inland Marsh) in plots with varying canopy cover, litter depth, and herbaceous vegetation cover during late November and early December. They found that seedlings emerged earlier when soil temperatures were warmer, and that seedling survival increased 14% with the addition of each new leaf. In Ohio, Plenzler (2008) found that larger initial lupine size increases the chances of seedling survival to July 1. Clark and Francis (2008) monitored lupine reintroduction in Ontario, and found that overall transplant success of lupine plugs was low (38-58% survival); seedling mortality was attributed to drought, transplant shock, and the excavating of newly planted seedlings by skunks.

Studies conducted by Dr. Helen Michaels and colleagues suggest that inbreeding can decrease lupine seedling performance. Even in seemingly large populations, lupines are susceptible to considerable fitness declines through both inbreeding load and drift load, via genetic erosion and fixation of deleterious alleles between populations. The expression of inbreeding depression in lupine depends on the environment, and inbreeding depression can be masked when conditions are favorable. This suggests that offspring from field collected plants (that experience inbreeding depression) propagated under favorable conditions of captivity/greenhouse environments may perform poorly, or die when transplanted to the field. Significant genetic structuring can occur among lupine populations in a relatively small geographic range. This study suggests that lupine restoration programs should avoid using non-local lupine seeds, and instead collect seeds from multiple populations within a region (H.J. Michaels, pers. comm., 2008).

During their reintroduction experiment in Ontario, Clark and Francis (2008) observed that approximately 40% of the lupines did not flower, and many of the non-flowering plants were juvenile and likely the product of sexual reproduction.

Reduced floral production occurred when lupine plants were located in either deep shade or intense light. Herbivory by deer and early abscission (cause of early abscission not known) of flowers also appeared to affect lupine flowering. Of the blossoming lupine plants monitored at a single site (Alderville), an average of 25 flowers were found per plant; pod set was on average 6.5 pods per plant with an average of 3.8 seeds per pod. Similar to other members of the genus, *Lupinus perennis* has poor pod set relative to floral production. Regarding the seeds, 58.7% were fully developed at the time of dehiscence (bursting open). Clark and Francis (2008) estimate that one-in-twenty seeds from the established lupine population germinate in the fall within study plots. Plenzler (2008) found that a substantial number of lupine seedlings planted by April are able to emerge in the fall and establish before winter.

Plenzler (2008) also examined the effects of various management strategies on natural lupine seedling recruitment and establishment in Oak Openings Metroparks, Kitty Todd Nature Preserve, and Lou Campbell State Park (all located in Ohio) by using logistic modeling of variables. He found that litter depth decreased with increased management events and increased prescribed burns. Oak sapling numbers rose with increased prescribed fires as well. Lupine establishment varied among sites; Cactus Hill, Sweet Fern, and Wahl had comparable levels of seedling survival (28-50%), however establishment was less than 20% in all other sites. Lupine plants that senesced earlier were not different in size from other seedlings. The size of burned seedlings was not different from unburned seedlings, but their leaves were smaller after re-sprouting (burn occurred in spring 2008, and measurements were taken mid-May) (Plenzler 2008).

Studies in Ontario begun in the spring of 2002 with the planting of lupine seedlings to monitor lupine establishment at a potential reintroduction site found that lupine showed strong co-occurrences and plant associations with New Jersey tea (*Ceanothus americanus*), woodland sunflower (*Helianthus divarticus*), showy-tick trefoil (*Desmodium canadense*), heath aster (*Aster ericoides*), and bracken fern (*Pteridum aquilinum*). Lupine benefited from high intensity early spring burns that removed "weedy" competitors. In years when fire swept through monitored savannas, lupine growth increased markedly including higher floral production and seed pod set (Clark and Francis 2008).

Results of a study by Kleintjes et al. (2003) found that hand seeding lupine and nectar species in the fall led to establishment of a successful dry sand prairie; transplanting lupine plugs in June resulted in low survival, and that early April or September/October (after lupine has senesced) are recommended times for transplanting lupine plugs. Kleintjes et al. (2003) recommends that when restoring dry sand prairie, disturbance to topography and topsoil should be minimized to promote proper drainage and reduce seed loss and that new habitat sites should include variations in elevation and texture to avoid loss of seeds from wind and rain.

Seed Sources for Lupine Propagation

It is recommended that local seed sources be used when propagating lupine. Research by Newhouse et al. (2010) to evaluate commercially and locally collected lupine (*Lupinus perennis)* seed sources for use at New York KBB recovery sites found that the seed source influenced first-year over-wintering survival and subsequent height and growth of surviving plants. The lupine sources more closely related genetically to native New York lupine populations survived better and exhibited more robust growth in the field in the areas targeted for restoration. Newhouse et al. (2010) recommend that using reputable providers that are known to collect and propagate native *L. perennis*, such as Prairie Nursery and Prairie Moon Nursery in the Midwest is much more preferable than planting seeds of unknown genetic heritage. However, based on this research it has also been recommended that lupine seeds from the Midwest not be planted in New York, but rather that seeds be collected locally (Gabriela Bidart-Bouzat, Bowling Green State University, pers. comm., 2010). Using local seeds addresses the following genetic and evolutionary considerations: 1) plants and animals are usually adapted to local environmental conditions that differ from one region to another, and, 2) there are co-evolutionary relationships between species that closely interact and therefore introducing a new genetic variant could completely alter the associations due to the fact that plants from different regions can differ in chemical and nutritional components (Gabriela Bidart-Bouzat, pers. comm., 2010).

Nectar Plants and Adult Foraging Behavior

Savanick (2005) examined the floral preference of KBBs based on butterfly visitation and floral abundance during the summer flight at sites near Fort McCoy and Waupaca, Wisconsin. Summer nectar plants used by KBBs are listed in Table 2. Summer nectar plants identified in the KBB recovery plan (2003) that were not used by KBB are listed in Table 3.

Helianthus occidentalis (western sunflower) was highly preferred by males, while *Monarda punctata* (horsemint) also had high male visitation rates. Overall, male visitation was almost double female visitation, possibly suggesting males require more nectar (Savanick 2005).

Savanick (2005) also examined nectar feeding behavior of male KBBs during the spring flight at Fort McCoy, Wisconsin and in Cuthrell Valley at Whitewater Wildlife Management Area (WMA), Minnesota. Table 4 lists the spring nectar plants listed in the recovery plan (all uncommon except for *P. pilosa*) but not used by males. Table 5 lists the spring nectar plants listed in the recovery plan and used by KBB males.

Three species, *Arabis lyrata* (sand-cress), *Hieracium aurantiacum* (orange hawkweed), and *Potentilla simplex* (common cincquefoil), seem to be preferred

by males, but a clear preference could not be determined (Savanick 2005). *Arabis lyrata* (sand cress) appears to be an important resource because it is abundant and widespread. Male KBBs land on lupine flowers, but it is not clear if they feed; it has been suggested that they may be searching for a mate or regulating body temperature. Dr. Thomas Givnish (UW-Madison, pers. comm., 2004) believes that KBBs do not feed on lupine. It has been observed that 3 species listed in the recovery plan, *Lithospermum caroliniense* (hairy puccoon), *Lithospermum canescens* (hoary puccoon), and *Phlox pilosa* (downy phlox), may not be used by KBBs due to the presence of long corolla tubes. Due to the fact that KBBs visit numerous nectar species and preference is likely to change depending on species availability, the variation in floral array between site visits increases the variation in KBB plant visitation rates. In other words, when a nectar species is more

Table 2. Summer nectar plants listed in the KBB recovery plan (USFWS 2003) and visited by adults at 4 sites at Fort McCoy and 2 sites at Waupaca in Wisconsin (Savanick 2005).

Scientific Name	Common Name
[1] *Amorpha canescens*	lead plant
[1] *Asclepias tuberosa*	butterfly -weed
[1] *Helianthus occidentalis*	western sunflower
[2] *Monarda punctata*	horsemint
[3] *Coreopsis palmata*	stiff tickseed
[3] *Helianthus divaricatus*	woodland sunflower
[4] *Asclepias verticillata*	whorled milkweed
[5] *Chrysanthemum leucanthmum*	ox-eye daisy
[5] *Ceanothus americanus*	New Jersey tea
[5] *Euphorbia podperae*	leafy spurge
Erigeron annuus	daisy fleabane
Euphorbia corollata	flowering spurge
Melilotus alba	white sweet clover
Berteroa incana	hoary alyssum
Rudbeckia hirta	black-eyed susan

1 Nectar plants preferred by male and female KBBs at both locations
2 Nectar plants preferred by male KBBs at both locations
3 Nectar plants preferred by female KBBs at both locations
4 Nectar plants preferred by both sexes at Waupaca, but not at Fort McCoy
5 Nectar plants preferred by female KBBs at Fort McCoy, but not at Waupaca

Table 3. Summer nectar plants listed in KBB recovery plan (2003) present but not used by adults at 4 sites at Fort McCoy and 2 sites at Waupaca in Wisconsin (Savanick 2005).	
Scientific Name	**Common Name**
Achillea millefolium	common yarrow
Hedyotis longifolia	long-leaved houstonia
Hypericum perforatum	common St. John's wort
Linaria vulgaris	butter-and-eggs
Lithospermum caroliniense	hairy puccoon
Lithospermum canescens	hoary puccoon
Monarda fistulosa	wild bergamot

Table 4. Spring nectar plants listed in the KBB recovery Plan (USFWS 2003) present, but not used by males at 3 sites at Fort McCoy, Wisconsin and 1 site at Cuthrell Valley in the Whitewater WMA, Minnesota (Savanick 2005).	
Scientific Name	**Common Name**
Fragaria virginiana	strawberry
Hedyotis longifolia	long-leaved houstonia
Lithospermum canescens	hoary puccoon
Lithospermum caroliniense	hairy puccoon
Phlox pilosa	downy phlox

Table 5. Spring nectar plants listed in the KBB recovery plan (USFWS 2003) and used by males at 3 sites at Fort McCoy, Wisconsin and 1 site in Cuthrell Valley at Whitewater WMA, Minnesota (Savanick 2005).	
Scientific Name	**Common Name**
Arabis lyrata	sand-cress
Euphorbia corollata	flowering spurge
Gaylassacia baccata	huckleberry
Potentilla simplex	common cincquefoil
Hieracium aurantiacum	orange hawkweed

abundant than other species at a site, the plant will have a higher visitation rate simply because it is more readily available (Savanick 2005).

Pickens (2006) observed first and second brood female foraging behavior at 4 sites at the Kitty Todd Nature Preserve in Ohio. Percent foraging times for nectar species are listed in Table 6 and are based on the abundance of nectar species and the number of KBBs at each site.

When host plant nutrition (water and nitrogen) was lower during the second brood larval stage, second brood KBB adults compensated by spending significantly more time foraging. Pickens suggests that second brood nectar species are very significant because they could provide essential nutrients that are needed due to the lower nitrogen and water content in lupine during the second brood. Foraging rates were similar for burned, mowed, and unmanaged habitat (Pickens 2006).

Table 6. Percent of total foraging time spent on nectar species by female KBBs at Kitty Todd Nature Preserve, Ohio (Pickens 2006).

Brood	Scientific Name	Common Name	*Percent Total Foraging Time
1st	*Potentilla simplex*	common cinquefoil	41%
1st	*Rubus flagellaris*	northern dewberry	18%
1st	*Fragaria virginiana*	strawberry	11.5%
2nd	*Achillea millefolium*	common yarrow	22.7%
2nd	*Monarda punctata*	horsemint	16.6%
2nd	*Baptisia tinctoria*	horsefly-weed	14.6%
2nd	*Rudbeckia hirta*	black-eyed susan	12.1%

*Percent "Total Foraging Times" are listed for the nectar species on which female KBBs spent 10% or greater of their time. Remaining foraging times (females spent <10% of their time) and nectar species can be found in the original report by Pickens (2006).

Habitat Characteristics Considered for Reintroductions in Ontario

Using data from potential founder population sites (Table 7) in the United States, Chan and Packer (2006) identified the minimum standards for KBB reintroduction in Ontario. These were: 1) 1.50 lupine stems/m^2; 2) 47.25 nectar plant stems/m^2 first flight and 47.85 nectar plant stems/m^2second flight; 3) at least five tending ant species; and 4) a standard deviation of integrated light intensity of at least 16.82%. No potential reintroduction sites in Ontario currently meet these criteria (Chan and Packer 2006).

Table 7. Habitat characteristics of potential founder population sites in the United States (Chan 2006).

Site	Lupine Density (stems/m2)	Nectar Plant Density (stems/m2) 1st Brood	Nectar Plant Density (stems/m2) 2nd Brood	Number of Tending Ant Species	Standard Deviation of Integrated Light Intensity % (Habitat Heterogeneity)
SCA	7.47 ±1.69	100.85 ± 9.69	72.00 ± 9.92	5	18.68 ± 1.44
MNF	14.27 ± 2.85	67.22 ± 4.35	75.80 ± 8.30	12	23.46 ± 1.92
IDNL	15.97 ± 3.18	52.50 ± 3.71	53.17 ± 4.08	10	18.79 ± 1.46

SCA = Saratoga County Airport, NY MNF = Manistee NF
IDNL = Indiana Dunes National Lakeshore

Dispersal

Studies continue to find that KBB dispersal distances are influenced by habitat composition and degree of fragmentation. In studies conducted by Dunn (2008), at sites in the KBB Muskegon Recovery Unit (RU) of the Huron-Manistee National Forest (HMNF) in Michigan, dispersal of the butterfly was monitored during both the first and second flights in 2005 and 2006. The findings from the study suggest that: (1) closed canopy forest was not a barrier to KBB dispersal, (2) high landscape connectivity occurred within a complex forested matrix, (3) corridors among patches were not necessary for re-colonization, (4) greater than 90% of the flights between patches were greater than 200 meters, and (5) the median flight distance measured was 370 meters. Based on the study, Dunn (2008) found that 10.6% of butterflies left one patch for another patch (between patch dispersal) and that the population appeared to behave as a true metapopulation. This is especially significant because the landscape in the Muskegon RU is heavily forested, and in most cases of dispersal KBBs likely flew through mature oak forest or red pine plantation (Dunn 2008).

In the Morainal Sands RU in Wisconsin, KBBs are believed to move within a two mile radius of a prairie restoration. KBBs moved at least 0.8 miles between sites (Shillinglaw and Shillinglaw 2008). Shillinglaw (2008) suggests the creation of dispersal corridors may not be important in this portion of the Morainal Sands RU due to the proximity of the sites to each other, and evidence indicating that KBBs can travel up to 0.76 miles. The terrain is gently rolling, and the prairie restorations (predominantly on Plainfield sands) occupy a variety of habitats from extremely dry to wet prairie, and include two rivers and six wetlands (Shillinglaw and Shillinglaw 2008). As noted in the KBB recovery plan (2003) the Morainal Sands RU has the most fragmented KBB populations of the 5 Wisconsin RUs.

In New York, Fuller (2008) conducted a mark-release-recapture study in the Albany Pine Bush (APB) to determine the effects of habitat fragmentation on KBB dispersal. He found that habitat fragmentation contributes to Allee processes (events that contribute to unsuccessful mating resulting from extremely low population numbers) and can pose a serious threat to the viability of the population. Emigration and immigration displayed a relationship with variations in population density and sex ratio, and both these rates of movement were highest in the habitat patches that maintained a low population density. Males emigrated more frequently from habitats with low densities of KBBs to areas containing more favorable sex ratios, while females were less likely to disperse from the low density habitat. The sex ratios of females to males did not affect the frequency of female migration from low density plots to high density plots. When KBBs emigrated from high density plots, they often navigated back to their points of origin. This dispersal behavior could have detrimental effects on the ability to colonize low density patches, due to the fact that males tend to immigrate to high density habitats, thus decreasing the probability of the females present in the low density areas to mate and produce offspring.

Fuller (2008) also observed that frequency of emigration and immigration appeared to be correlated with the presence of pavement and roads. Null dispersal, the movement to non-habitat, exhibited an association with plots that were adjacent to pavement, and migration to low density plots increased when the proportion of paved habitat boundary increased and nectar availability decreased. Areas next to roads appear to be habitat sinks, which are defined as areas of low quality habitat that are not able to support a population on its own. Migrations were more frequent within contiguous blocks of habitat than among blocks that were separated by roads, and KBBs that migrated from low density habitats were more likely to cross roads in pursuit of a more favorable habitat. Fuller (2008) suggests that local translocations to existing or created habitats at the interior of preserve areas may be necessary to maintain metapopulations that are currently concentrated along roads, and recommended that preserves have a closed-canopy barrier greater than 50 meters between the preserve interior and all bordering areas. Fuller (2008) also recommends that preserves should contain habitat blocks that are large enough to minimize the road-crossing behavior exhibited by KBBs.

KBB – a Flagship Species

Due to the fact that the KBB is an endangered species which receives significant attention and public support, Guiney and Oberhauser (2008) find that it can serve as a flagship species and aid in the conservation of other pine barrens and oak savanna species. Recovery programs should (or continue to) use this strategy to help support recovery of the KBB.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Lifespan

A captive reared male KBB has been found to have had a 29 day life span (Savanick 2005). The male emerged on July 10th, was released in Whitewater WMA (MN) on July 15th, and was observed feeding and flying on August 8th (29 day lifespan). It is not clear how this relates to native KBBs that are not captive reared. Prior to this report, the maximum time between mark-release-recapture dates for an adult male KBB in the field was recorded as fourteen days (Bidwell 1995). This information updates the information in the KBB recovery plan (USFWS 2003) which reported that the mean lifespan estimated by mark-recapture-release data was four days with some researchers believing individuals could live two to three weeks.

KBB Metapopulation Dynamics and Population Growth Rates

A study conducted by Guiney et al. (2010) found that the KBB population at Fort McCoy (Wisconsin) likely exhibits a patchy metapopulation structure. The study determined KBB abundance for 11 subpopulations. Seven of the 11 subpopulations showed a decline from the summer 1997 flight to the 1999 spring flight, and an increase from the summer 1999 flight to the spring 2003 flight (Savanick 2005). Savanick (2005) proposes that this many indicate a long term population cycle of high to low, then low to high abundance over 10 generations. The data essentially shows a U-shaped pattern, indicating a long term population trend with a half-period length of approximately 2½ years (full-period of 5 years). Four sites did not display a long-term population trend, those populations tended to oscillate around a constant population index. It was determined that the KBB metapopulation at Fort McCoy can be described as a patchy population and not as a classic metapopulation. If the KBBs existed as a classic metapopulation historically, it has been transformed to a patchy population structure through human intervention and landscape management. The eleven populations of butterflies studied at this site did not fluctuate asynchronously (at different times) which is the phenomena observed in a classic metapopulation. Managing core-satellite or patchy populations could reduce monitoring costs, simplify reserve design, and create more robust populations (Guiney et al. 2010).

The data from the 11 sites also showed a generational pattern that corresponds to observations of larger summer flights than spring flights (Savanick 2005). There was evidence of density-dependent growth in both the summer and over-winter generations. Negative density-dependent growth (there is an increase in the death rate or decrease in the birth rate as a population increases) was consistently observed during the summer and found only sporadically during the over-wintering period. Savanick (2005) did not pinpoint the exact reason for density dependence in KBBs, but offered some hypotheses including: 1) high KBB densities in the summer may lead to an insufficient number of high quality oviposition sites; 2) more eggs occur on low quality lupine reducing larval survival, 3) competition for nectar and, 4) limited numbers of tending ants, could also cause larvae survival to be reduced at high KBB densities (Savanick 2005).

A significant positive relationship between net population growth rate and early summer rainfall was also found during the summer (Guiney et al. 2010), thus implying that increased precipitation from spring to summer appears to result in increased larvae survival at Fort McCoy due to an increase in lupine quality (Savanick 2005). A significant positive relationship was found between net population growth rate and the number of days with cold temperatures during over-wintering periods [less than -12° C (10.4 °F) and less than -12° C (10.4 °F) without snow cover], which suggests that increased exposure to cold temperatures may increase egg survival (Guiney et al. 2010).

Brood Size, Brood Number and Growth Rates

KBB brood size and growth rates vary with season as well as habitat characteristics. Data from Swengel and Swengel (2005a) who monitored KBB populations in Wisconsin from 1990-2004 found that brood size varied more in consecutive springs than consecutive summers, and spring totals usually reached half to 100% of summer totals. As the geographic scale of an index increased, the variability in the brood size decreased.

Pickens (2007) calculated two separate growth rates, summer (first to second brood) and winter (second to first brood of the next year), for each annual KBB cycle at two sites in New York for multiple years. At Saratoga Airport, the mean summer growth rate was 3.7 ± 0.54 and the mean winter growth rate was 0.47 ± 0.11. At Edee Sandpit, the mean summer growth rate was 2.2 ± 0.47 and the mean winter growth rate was 0.62 ± 0.05. The effects of density dependence and weather on growth rates were modeled for both sites. Large population declines occurred in the winter and were a result of the previous year's dry summer and cool spring weather. Density dependence was the only factor that explained summer growth rates at both sites (growth rates were unaffected by weather) and likely reflect the carrying capacity of a site. Pickens (2007) believes that poor host plant condition and senescence due to low amounts of precipitation during the summer may not result in direct mortality of second brood larvae, but rather suggests that the nutritional conditions of second flight adults at emergence result in a lag effect (lower number of KBBs). Pickens (2007) recommends that recovery criteria include a second brood carrying capacity, a mean winter growth rate and multiple subpopulations.

Modeling by Fuller (2008) found the intrinsic growth rate of KBBs was less than 1 in 52.9% of trials, indicating that populations are capable of crashing due to natural dynamics. Local extirpations should be expected, and isolated populations are not likely to be viable. The model provides theoretical evidence that it is beneficial for females to lay eggs early instead of late, signifying that early ovipositing is a key strategy for depressed populations (see also "Minimum Viability Population Analyses" below). Quality nectar sources are required for females to oviposit early in both flights. KBB populations are highly sensitive to over-wintering egg survival (whose fate is highly uncertain) and summer egg survival. Summer disturbance (i.e., burning or mowing) can be catastrophic to eggs and over-wintering egg survival could be exacerbated by increased exposure to spring or fall temperature variations. Fuller (2008) recommends that habitat management/disturbances that have the potential to affect the survival of eggs should be avoided in June. Larvae mortality also poses a moderate risk to KBB populations. Management efforts that improve larval survival to adulthood, which in turn enhances the contribution to fecundity, could be effective in increasing larval numbers and survival.

KBBs are normally bivoltine (have 2 broods per year). Several people have reported early first brood KBB adults and/or third brood adults. Swengel (2009) suspected that a fresh KBB male observed on September 6, 1994 in Wisconsin was part of a third brood. Other observations made by Scott and Ann Swengel (pers. comm., 2011) in Wisconsin include butterfly flights averaging 15 days early in 2010, with spring and summer sightings being the earliest to date. They also report that KBBs had a partial third brood in late July to approximately mid-August (Scott Swengel, pers. comm., 2011). Others observing third broods in Wisconsin include Tim Wilder (Fort McCoy, pers. comm., 2010), Robert Hess and Gregor Schuurman (WDNR, pers. comm., 2010). Third broods have also been reported from New York (Kathy O'Brien, NYSDEC, pers. comm., 2010) (Neil Gifford, APBPC, pers. comm., 2010) and Indiana (John Drake, TNC, pers. comm., 2010), (Ralph Grundel, USGS, pers. comm., 2010). Climate change research being conducted in Indiana (in 2010) revealed third brood (third flight) KBBs. For captive reared females, nearly 90% of total fertile eggs hatched, this was lower for wild caught females, only 10% of their eggs hatched (Grundel 2011). It is possible that third flights may occasionally occur in nature during warmer years, particularly when timing of KBB first flight is earlier than average (as was the case in 2010 in Indiana and likely other states).

Population Synchrony and Spatial Trends

Studies indicate that there is relatively high synchrony among local KBB populations in Wisconsin. Swengel and Swengel (2005b) examined geographic patterns of KBB population fluctuations in Wood, Jackson, and Burnett counties, Wisconsin. At the onset of the study, both spring and summer broods were monitored in Jackson and Wood counties, but only summer broods exclusively were being monitored in Burnett County (Scott Swengel, pers. comm., 2010). The three counties fall within different KBB recovery units (USFWS 2003), and all sites within a county are nearer to each other (<25 km apart) than to any site in another county. Significant population synchrony (fluctuations in size of KBB populations located close to one another that occur simultaneously) occurred at short distances, <3 kilometers, throughout all three counties. The strongest spatial autocorrelation (the correlation between population numbers and distances) was among sites <3 kilometers apart, which infers that there is relatively high synchrony among local sites over regional sites. This relationship gradually leveled off at greater distances. Regional spatial autocorrelation (across 264 km) suggests that environmental factors such as weather may induce some synchronization of KBB populations. Much higher local synchrony is consistent with the species' short dispersal distance. Spatial autocorrelation can increase the likelihood of correlated local extinctions during low fluctuation broods, especially when these coincide with unfavorable weather or adverse habitat events (Swengel and Swengel 2005b).

Allee Dynamics

Allee dynamics (any of a suite of possible demographic phenomena that may decrease population growth rate with decreasing population size) has been shown to influence KBB survival, migration and sex ratio. Data from Fuller (2008) indicates that the extirpation of the Concord, New Hampshire, KBBs resulted from a first brood bottleneck which reduced second brood egg and larval yields. Data showed that female fertility was depressed prior to extirpation (Fuller 2008). In the Albany Pine Bush Preserve (APBP), Karner, New York, Allee effects were found to influence KBB dispersal and sex ratio (refer to Dispersal section above).

Minimum Viable Population (MVP) Analysis

Research by Fuller (2008) suggests that a minimal viable population of KBBs should be a first and second brood average of 7,641-12,960 adults, or 11,217-19,025 second brood adults, maintained on average over five or more years and the average KBB number should fall within these ranges every year. Fuller (2008) recommends using the brood average because the first brood is usually smaller than the second brood and can represent a bottleneck. More clarification is needed relative to Fuller's (2008) recommended minimal viable population numbers e.g., for how long would these population numbers need to be maintained to preclude extinction, and what is the extinction risk associated with these numbers? It would also be helpful to know the extinction risk associated with the KBB recovery criteria in the KBB recovery plan (USFWS 2003). Note: The recommended annual KBB population criteria in the KBB recovery plan (USFWS 2003) are 3,000 (VP) or 6,000 (LP) KBBs. The recovery plan also recommends maintaining population levels 4-5 times greater than these levels. This is because KBB population levels can fluctuate 4-5 times in size from year to year and maintaining higher population levels helps insure that the population will remain at or above the 3,000 and 6,000 population criteria.

Fuller (2008) also recommends that metapopulations have high connectivity, be buffered against a fragmented matrix, have a minimum of 5-9 subpopulations, and that asynchronous populations should have higher MVP numbers. Modeling other requirements for a sustainable KBB MVP such as the number of lupine stems and carrying capacity (the number of eggs oviposited on each stem) it was found that in order to sustain the MVP, **7**-9 well connected subpopulations buffered from fragmentation are needed, with each supporting at least 128,130 lupine stems during the first brood. This stem requirement is based on a site average of 0.5 eggs per stem during the second brood; if the egg density is lower, more stems are needed (Fuller 2008).

Modeling indicated that the greatest risk of population extinction in the first brood occurred when overwintering egg survival was decreased, while in the second brood the greatest risk of extinction was the mortality of latent females (adult females present in the early part of a brood). Fuller (2008) provides two reasons why latent females are vital to avoiding population decline: 1) mortality of latent

females hinders reproduction in later reproductive stages and 2) mortality of peak and senescent females increase the value of the contribution made by their latent peers. A stochastic population explosion or population augmentation may be necessary in order for KBBs to become established in an uncolonized habitat or a newly created habitat. In some cases, habitat management without population augmentation may not be enough to mitigate the risk of extinction (Fuller 2008).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

KBB Genetics

Genetic research has found that KBBs are a single taxonomic group. Gompert et al. (2008) examined KBBs east and west of Lake Michigan and compared them to Melissa blues to determine whether any genetic differences existed between the two KBB populations. Twenty-five KBB populations were sampled for mtDNA (mitochondrial DNA) variation in Wisconsin, Indiana, and New York. Melissa blues *(Lycaeides melissa melissa)* were sampled from sites in South Dakota and California. Two distinctly different mtDNA haplotypes were discovered in KBBs. East of Lake Michigan, all populations possess a unique group of mitochondrial haplotypes that are not found in any other *Lycaeides*. West of Lake Michigan, populations possess a single mitochondrial haplotype also found in Melissa blue populations. This suggests gene exchange between Melissa blues and the western KBBs (Nice et al. 2005). However, applied fragment length polymorphism (AFLP) nuclear DNA data provides no evidence for a genetic boundary at Lake Michigan. This suggests all KBBs are a single taxonomic group, with mtDNA introgression in western populations (Gompert et al. 2006). The Melissa blue mtDNA haplotype is introgressed in western KBBs, and all western KBBs with endoparasitic bacteria *(Wolbachia)* were found to have the introgressed haplotype (Gompert et al. 2008) (refer to discussion on *Wolbachia* below).

Lucas et al. (2008) studied male genetalic variation in the American *Lycaenidae* populations to assess whether or not the current species and subspecies designations for the group were accurate. Across North America, 868 individuals from 61 populations were examined. Male KBB genetalic morphology was found to be similar, but not identical to that of *L. melissa*, and there is no significant difference between eastern and western male KBBs (Lucas et al. 2008).

Wolbachia and the KBB

Nice et al. (2009) conducted other studies concerning the nature of *Wolbachia* in KBB populations which support the findings of Gompert et al. (2006) that there appears to be a split between western and eastern KBB populations. Nice et al. (2009) tested 13 populations (212 KBBs) for *Wolbachia* infection; 8 from Wisconsin, 2 from New York (Albany Pine Bush and Saratoga), 1 from New

Hampshire (Concord), 1 from Michigan (Allegan), and 1 from Indiana (IDNL) (the Indiana site is considered east of Lake Michigan). *Wolbachia* infections were detected in all 121 KBB specimens tested west of Lake Michigan while only one KBB from Saratoga Springs, New York, tested positive for Wolbachia east of Lake Michigan. Using multi-locus sequence typing, Nice et al. (2009) found that the *Wolbachia* infection in KBBs west of Lake Michigan is attributable to a single strain of *Wolbachia* and is perfectly correlated with the presence of Melissa blue (*L. m. melissa)* mitochondrial haplotypes; the *Wolbachia* infection at Saratoga Springs is a different *Wolbachia* strain.

Nice et al. (2009) also simulated KBB population growth by utilizing models to assess the effects of *Wolbachia* at high, intermediate, and low carrying capacities. Permutation tests revealed that single population model simulations carried out with the presence of *Wolbachia* had significantly lower adult population sizes through time than those model simulations without *Wolbachia* infection at all carrying capacities tested. More simply stated, *Wolbachia* introduction poses several threats to uninfected host populations including reduction of population size (and therefore increased probability of extinction) and reduction in genetic variation (Chris Nice, University of Texas –San Marcos, pers. comm., 2009). *Wolbachia* may exhibit the following phenotypes: 1) parthenogenesis in the host (asexual reproduction in females resulting in production of only females), 2) feminization of genetic males, 3) death of infected males (male mortality happens early in life either as embryos or as larvae that die early), and 4) cytoplasmic incompatibility i.e. the inability of *Wolbachia* infected males to successfully reproduce with uninfected females or females infected with another *Wolbachia* strain; both individuals must be infected to mate successfully and produce young.

Cytoplasmic incompatibility (only infected KBB males and females reproduce successfully) is most likely to occur in infected KBBs because: 1) all the other phenotypes create a sex ratio distortion (female bias) that has never been reported in KBB populations, 2) it is the most frequently reported phenotype in insects, and 3) it is the most likely phenotype to be associated with a mitochondrial sweep (invasion) (Chris Nice, pers. comm., 2009). KBB populations already infected with *Wolbachia* are not considered at risk from the bacteria (no reduction in effective KBB population size anticipated). *Wolbachia*, therefore, poses the greatest threat to uninfected KBB populations because it lowers population size and genetic variability (as noted above). Nice et al. (2009) advise that screening for the presence of *Wolbachia* (along with other endosymbionts) is vital, particularly in the case where reintroduction or population augmentation is taking place. This is especially important with reintroductions east of Lake Michigan where KBB populations may not yet be infected. West of Lake Michigan where it appears all KBBs are infected with *Wolbachia*, this is not an issue because, as noted above, if both sexes are infected mating and production of adults is successful.

Studies examining *Wolbachia* infection in other species found contradictory results regarding the use of the antibiotic tetracycline as an anti-*Wolbachia* treatment. Sakamota et al. (2007) found that after adult Asian corn-borer moth (*Ostrinia furnacalis*) females were treated with tetracycline and cured of *Wolbachia,* their progeny were killed during various stages of larval development. The timing of male killing varied in the infected and untreated line, but was observed most often immediately before or shortly after hatching (Sakamota et al. 2007). However, studies conducted on the common yellow butterfly (*Eurema hecabe*) by Narita et al. (2007) found that the female-biased sex ratio resulting from *Wolbachia* infection was reversed after treatment with tetracycline. Results of these and future studies on *Wolbachia* may play an important role in developing potential methods to treat and/or prevent the spread of the bacteria in KBB populations.

2.3.1.4 Taxonomic classification or changes in nomenclature:

There have been no changes by the USFWS in KBB taxonomic classification or nomenclature.

Full Species Status

Forister et al. (2010) examined the relationship between the KBB (*Lycaeides melissa samuelis), L. melissa* and *L. idas* using a large population-genomic dataset and a model of population divergence with migration. Gene flow between the KBB and *L. melissa* is low and is comparable to gene flow between *L. melissa* and *L. idas*. Based on this evidence, the authors concluded that KBBs should be considered a full species, *Lycaeides samuelis*.

Other Scientific Names

Plebejus melissa samuelis. The Integrated Taxonomic Information System (ITIS) identifies the valid taxonomic name of the KBB as *Plebejus melissa samuelis* and states that *Lycaeides melissa samuelis* is still used in the Checklist of North American Butterflies, 2nd Edition (2009) (ITIS, 2011).

Plebejus samuelis. In his Catalogue of the Butterflies of the United States and Canada, Pelham (2011) considers *Lycaeides* a synonym or subgenus of *Plebejus*, and refers to the KBB as both *Plebejus samuelis* and *Lycaeides melissa samuelis*.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

Overview of Species Distribution

The historical range of the KBB in the United States has not changed although changes in the distribution of the KBB within its historic range have occurred since listing. The historic KBB range in the Oak Openings of northwest Ohio and southeast Michigan are now occupied by small KBB populations as a result of on-going reintroductions **(**refer to Table 8 and Appendix C, Potential Recovery Units). KBBs occurred in the province of Ontario, Canada until about 1991 when they were likely extirpated (USFWS 2003). Within the last year there has been renewed interest in starting a recovery program for the butterfly in the province of Ontario, Canada (Elaine Williams, Wildlife Preservation Canada, pers. comm., 2011).

The overall rangewide number of KBB populations or sites has remained generally the same since listing. Based on available information there were 114 and 116 KBB populations or sites in 1992 and 2011, respectively (refer to Table 8). Note: The number of KBB populations used to calculate these totals for Wisconsin and Michigan were based on 4 km separation distances between metapopulations (refer to Wisconsin and Michigan discussions below). The rangewide totals do not represent the number of metapopulations present rangewide, that would be a lesser number as many of the sites/subpopulations in New York, Indiana, and likely Ohio represent 1 to only a few metapopulations**.**

There have been some changes to the spatial distribution of the KBB in the U.S. since listing (1992). Of the eight states with KBBs in 1992 (Illinois, New Hampshire, New York, Indiana, Ohio, Michigan, Wisconsin and Minnesota) (USFWS 1992), KBBs remain present in all of the states except Illinois and possibly Minnesota. Very low numbers of KBBs were documented in Illinois only twice (1992 and 2001) at one site, Illinois State Beach Park (Kris Lah, USFWS, pers. comm., 2010) (refer to Table 8). In 2011, no KBBs were found at Whitewater WMA in Minnesota (the only KBB site in that state), however further surveys are needed to document whether KBBs are still present at the site.

The distribution of KBBs in each of the states has generally remained the same, except for Michigan and Wisconsin where the range of the butterfly has expanded. In Michigan, the number of counties with KBBs rose from 6 to 11 between 1992 and 2011. More importantly in Wisconsin and Michigan, the number of element occurrence (EO) clusters rose between 1992 and 2011 (see discussion below for each state). Wisconsin lost KBBs in one county, Outagamie County, but as this county supported only one small site, the loss was not significant (refer to Table 8). In addition, KBBs exist in very low numbers at

Greenwood WA, a Wisconsin recovery property (refer to Appendix C, Wisconsin, Morainal Sands RU) and therefore may not prove to be a suitable recovery site (Bob Hess, WDNR, pers. comm., 2012).

Spatial distribution at the metapopulation level has improved at some KBB recovery sites as a result of habitat restoration and management activities, however habitat degradation and loss from vegetational succession and the presence of invasive plants remain primary threats to the species at all recovery sites (refer to section 2.3.2).

A more detailed discussion on the distribution of KBBs is provided for several states below.

New Hampshire:

While several new areas are occupied by KBBs in the Concord Barrens, no significant change in the butterfly's distribution has occurred in New Hampshire; KBBs still occur only in Concord where a reintroduction is on-going (refer to Table 8 and Appendix C, New Hampshire).

New York:

Distribution of the KBB has not changed significantly in New York although it has contracted somewhat within the counties that are occupied as small outlying populations mapped in 1989 disappeared. This is especially true in Warren County where the NYSDEC is attempting to restore the Queensbury Sandplains KBB metapopulation, a state recovery site (Kathy O'Brien, NYSDEC, pers. comm., 2011). There is one less county (Schenectady County) with KBBs in 2011 compared to 1992, however this resulted in the loss of only one small site (refer to Table 8).

Ohio:

No KBBs were present in Ohio at the time of listing. Due to a reintroduction program begun in 1998, KBBs have now been restored to 4 sites in Ohio [refer to Table 8 and Appendix C, Potential Recovery Units, Oak Opening PRU (Ohio)].

Indiana:

The KBB distribution in Indiana has not changed significantly. In 1992, the West Gary metapopulation had three occupied sites: Ivanhoe Dune and Swale NP, Tolleston Ridges NP, and Gibson Woods NP. Ivanhoe Dune and Swale NP and Gibson Woods NP went through a series of extirpations and repopulation events, with Gibson Woods NP remaining permanently extirpated. The populations at Dupont Natural Area and Tolleston Ridges NP may likely have also been extirpated if it were not for the last series of KBB augmentations. As of 2011

there are three known occupied sites in the West Gary metapopulation: Ivanhoe Dune and Swale NP, Dupont Natural Area and Tolleston Ridges NP, all of which are located within 4 km (about 2.5 miles) of each other (John Drake, TNC, pers. comm., 2011). The number of sites at the IDNL rose from 6 in 1992 to 8 at present (2011) (refer to Table 8 and Appendix C, Indiana).

Wisconsin

Wisconsin still supports the largest and most widespread KBB populations range wide. In 2007 the KBB high potential range (HPR) in Wisconsin (which includes extant and potential range) was adjusted based on a KBB probability model. The KBB HPR was reduced from about 1.9 million to about 1 million acres (Sickley et al. 2007). The most current KBB HPR map for Wisconsin can be found on the WDNR's webpage for the Wisconsin Statewide KBB Habitat Conservation Plan (HCP): http://dnr.wi.gov/forestry/karner/. The reduction of the KBB HPR range is due to a reduction in areas considered high potential habitat for the species.

Currently 14 counties are known to support the KBB; those are Adams, Burnett, Clark, Eau Claire, Green Lake, Jackson, Juneau, Marquette, Menominee, Monroe, Portage, Waushara, Waupaca, and Wood. Another 3 counties, Chippewa, Oconto and Shawano counties are on the USFWS's Midwest Region's Section 7 County List (http://www.fws.gov/midwest/Endangered/section7/sppranges/index.html) as small portions of these counties occur within the KBB HPR (Terrell Hyde, WDNR, pers. comm., 2011) (Refer to Table 8).

To make a rough comparison of the number of KBB metapopulations present at the time of listing (1992) and currently (2011), the KBB element occurrence (EO) data in WDNR's Natural Heritage Database were analyzed. (Note: An EO can be one KBB site or a group of KBB sites). For purposes of this analysis, the KBB EOs were clustered based on two different separation distances, 4 km and 8 km (refer to Appendix E). The Nature Serve EO specs developed by Dale Schweitzer for KBBs recommended a 4 km separation distance for unsuitable habitat and an 8 km separation distance for suitable habitat (Nature Serve 2011). This means if there is 4 km or less of unsuitable habitat between two subpopulations, those subpopulations would be part of the same metapopulation. If there is 8 km or less of suitable habitat between two subpopulations those subpopulations would be part of the same metapopulation. (Note*:* The 2 km separation distance was also mapped but not included in this analysis).

To determine the number of EO clusters present at the time of listing all EOs observed in 1992 or before 1992 were determined and mapped. To determine the number of KBB EO cluster present in 2011, the number of EO clusters with a last observed date greater than or equal to 1998 were identified and mapped. This was considered a reasonable approach because KBB habitat can be lost due to vegetational succession in 10-15 years if not managed. The 1998-2011 EO data set provides a 14 year data set that falls within this 15 year window; the

assumption is being made that the KBB EOs observed in 1998 are likely still present in 2011. Historic (greater than 25 year from last observed date) and extirpated EO were not used in this analysis. Note: This is an imperfect analysis as data are not available to determine actual presence of KBBs at all the EOs used in this analysis and not all KBB sites in Wisconsin have been identified and mapped. However, based on this available data, the number of EO clusters present in or before 1992 and in 2011 (in or before 1998) are as follows:

Wisconsin EO Clusters:

Dates:	Total No. EOs	No. EO Clusters – 4 km	No. EO Clusters-8 km
≤1992	109	39	23
≥1998 (present)	134	63	31

Figure E1 (Appendix E) shows EO clusters present from 1998 to present (>1997) in red; blue indicates EOs present on or before 1992 (<1993). The additional EO clusters in 2011 compared to 1992 (for the 4 km and 8 km separation distances) shows an increase in the area supporting KBBs in Wisconsin since listing. The additional EO clusters fill in gaps between the 1992 EO clusters, add some new clusters and/or expand some existing EO clusters. When looking at the 8 km separation distance, it appears a couple of the 1992 EO clusters have likely been lost in Marquette and Waushara Counties.

There has not been a significant change in the geographic distribution of KBBs in Wisconsin since listing as can be noted in Table 8. All counties that had KBBs in 1992 had KBBs in 2011 except for Outagamie County. And since there was only 1 EO present in Outagamie County the loss of this county does not represent a significant change in distribution of KBBs in the state. KBBs exist in low numbers at one of the Wisconsin recovery sites, Greenwood WA in the Morainal Sands RU (refer to Appendix C, Recovery Units, Wisconsin, Morainal Sands RU) and the habitat may not be suitable for recovery at this site (Bob Hess, WDNR, pers. comm., 2011).

Several of the KBB sites have been found by partners to the Wisconsin Statewide KBB HCP since about 1994. Between 1998 and 2009, HCP partners conducted 3,170 lupine surveys and 1,866 KBB surveys on their lands. KBBs were found in about 39 percent of the surveyed sites. These surveys have contributed to our understanding of the KBB range in Wisconsin. In addition, the new sites have provided opportunities for conserving the KBB on partner lands through implementation of the HCP's conservation program (Dave Lentz, WDNR, pers. comm., 2009).

Multiple KBB sites occur on 7 of the 13 larger industrial and county forested landscapes managed by HCP partners (Burnett, Clark, Eau Claire, Jackson, Juneau, and Wood county forests, and Plum Creek Timber Company) as well as

on the BRSF. These larger forested landscapes offer more secure habitat than private lands due to their size and shifting habitat mosaic management regime. However, a better understanding is needed of the metapopulation structure and dynamic on these forests to assess the ability for viable KBB metapopulations to persist for the long term on these landscapes. The number and locations of secure, dedicated barrens areas (that can act as metapopulation core areas) appears key to insuring viable metapopulations though the long term. Threats related to these forest lands that may eliminate KBB habitat include sale of KBB occupied land and conversion of that land to other uses, planting of red pine in a manner that eliminates understory vegetation (lupine and nectar plants), and reduced timber sales due to a slowing economy (refer to Appendix C, Wisconsin, Other Larger Forested Landscapes with KBBs in Wisconsin).

Michigan:

The KBB range has expanded in Michigan since listing. The number of occupied counties in the state rose from 6 to 11 between 1992 and 2011 (refer to Table 8). The presence of KBBs in Monroe County in southeast corner of the state is the result of a reintroduction program begun in 2008 at Petersburg State Game Area (refer to Appendix C, Potential Recovery Units and Table C1). It appears that one KBB recovery site has been extirpated, the Brohman metapopulation (Newaygo County) in the HMNF (refer to Appendix C, Recovery Units, Newaygo RU and Table C1).

To make a rough determination of the number of KBB metapopulations present at the time of listing (1992) compared to present (2011), the KBB element occurrence (EO) data in the Michigan Natural Features Inventory were analyzed (Rebecca Rogers, MDNR, pers. comm., 2011). (Note: An EO can be one KBB site or a group of KBB sites.) For purposes of this analysis, the KBB EOs were clustered based on two different separation distances, 4 km and 8 km as a rough measure of the number of KBB metapopulations present based on these two separation distances, in the same way as described for Wisconsin (see above). Based on this available data, the following number of EO clusters present in or before 1992 and in 2011 (in or before 1998) were as follows:

Michigan EO Clusters:

Dates	Total No. EOs	No. EO Clusters – 4 km	No. EO Clusters-8 km
≤1992	46	8	8
≥1998 (present)	115	11	8

Figure E2 (Appendix E) is a map of the KBB EO clusters in Michigan and indicates that KBB sites have expanded in the state from 1992 to present [red indicates EOs present from 1998 to present (>= 1998); blue indicates EOs present on or before 1992 (<=1992)]. Compared to 1992 (time of listing), KBBs are

currently present in all counties that had KBBs at the time of listing plus 5 additional counties, Ionia, Kent, Mason, Mecosta, and Monroe (refer to Table 8). It appears that 2 EOs have been lost, one in Lake and one in Montcalm counties as they do not show up in the >= 1998 data set (Appendix E, Figure E2, blue EOs without red outlines). Also as noted above, the Brohman KBB population is likely extirpated.

KBB sites on the HMNF (Newaygo and Muskegon RUs) have generally been declining. KBB presence/absence data collected since 1997 by the HMNF at 55 sites shows that the percentage of occupied sites declined between 1997 and 2009, and then increased in 2010 (Keough 2010). The increase in the number of KBBs from 2009 to 2010 is suspected to be the consequence of a year with optimal weather conditions and only occurred in the Otto and White River metapopulations and the Hayes population. Monitoring over the coming years will help to determine if the population increase continues in the future (Keough 2010).

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Habitats that support the KBBs are early successional habitats composed mainly of remnant oak savannas and pine barrens, and also include prairies and human altered habitats such as roads, utility rights-of ways and larger forested landscapes. The amount, distribution, and suitability of KBB habitat varies across the butterfly's range and is dependent to a great extent on management that inhibits vegetational succession. Vegetational succession increases canopy cover and decreases lupine and nectar plants resulting in the loss of suitable habitat within about 15 years. It is especially important to maintain and restore habitat for the butterfly at recovery sites across the species 7 state range. Recovery sites are located within 13 recovery units (Appendix B, Table B1) and are reviewed in detail in Appendix C. The amount of habitat and subpopulations associated with the recovery sites and larger commercial and industrial forest in Wisconsin are summarized in Appendix C, Table C1. Potential recovery sites include the 2 sites where reintroductions are on-going, the Ohio Oak Openings PRUs and Michigan Oak Openings PRU (refer to Appendix C, Potential Recovery Units).

Several studies and modeling efforts have been done since 2001 that provide insights on habitat or ecosystem conditions/parameters important to the KBB; those studies are briefly reviewed below. Studies on the effects of different management treatments are also reviewed below as management is critical to maintaining suitable KBB habitat.

<u>Habitat and Landscape Variables Important to the KBB</u>

While the KBB recovery plan (USFWS 2003) still provides good guidance for designing viable metapopulations, TNC has developed specific guidance that they

are using to restore viable KBB metapopulations in New York. Appendix F includes a summary of the KBB viability assessment criteria for the APBP (Gifford et al. 2011). These criteria are being used to assess all of the KBB metapopulations in the Glacial Lake Albany RU (New York). The criteria were derived using an assessment tool developed by Parrish et al. (2003).

Ratings for various parameters (e.g., number of subpopulations, lupine stem density, etc.) were drawn from the Federal KBB recovery plan (USFWS 2003) and/or the draft NYSDEC KBB recovery plan. The goal is to move a subpopulation's rating from its current condition to at least a "Good" rating. This rating represents the "minimum viable" or "conserved" status for subpopulations in the Glacial Lake Albany RU. Appendix F also includes a KBB conceptual ecological model that has been incorporated into planning documents related to TNC's Northern Glacial Lake Albany Conservation Area Plan (Rebecca Shirer, TNC, pers. comm., 2012).

The relative importance of certain habitat and landscape variables in determining the presence and relative abundance of KBBs in the HMNF (Michigan) was modeled by Brosofske and Cleland (2010) using field data from 2006-2009. The study found that the most predictive variables of KBB occurrence or abundance varied by year, but elevation, percent cover of lupine, and canopy cover consistently emerged as relatively important variables in many of the models. Other variables found to be important, or that possessed the potential to be, related to nectar plants and spring and winter temperatures. Land cover, soil available water storage, and cover of bare ground were also important predictors or surrogates in some of the models. Other variables of potential importance were lupine density and dispersal, spring temperatures, and distance to the nearest lake. Variables that did not contribute to any of the final models included dispersal, density, and observed frequency of blooming nectar plants. Variables of low importance included soil depth, drainage, and texture (Brosofske and Cleland 2010) (Kimberly Brosofske, pers., comm., 2010).

Effects of Management Treatments on KBBs and Herbacious Plant Species

Burn and Mow Treatments

The effects of burning and mowing on KBB habitat use at sites within the Kitty Todd Nature Preserve in Ohio was studied by Pickens (2006) and Pickens and Root (2008b). Study sites were divided into thirds, each third being burned, mowed, or unmanaged in yearly rotations. The studies found that burned sites within 120 meters of occupied unburned sites were quickly recolonized and there was not a clear selection by KBBs for burned treatments versus mowed treatment. No significant differences in KBB male or female abundance was found during the first brood at the burned, mowed, and untreated sites (Pickens 2006). During the second brood significantly more females were found in burned areas

Table 8. Numbers of KBB populations or sites by state and counties of occurrence in 1992 and 2011.							
	1992			2011			
State	Counties w/ KBBs		No. of Pops. or Sites	Counties w/ KBBs		No. of Pops. or Sites	Comments
	No.	Names		No.	Names		
NH	1	Merrimack	1	1	Merrimack	1	Native KBBs likely extinct at site in 2001, KBB reintroduction program ongoing from 2001 to present (2011).
NY	4	Albany, Saratoga, Schnectady, Warren [1]	50 sites (10 site clusters) [1]	3	Albany, Saratoga, Warren [1]	29 subpops. [2,3]	The KBB site in Schenectady Co. was likely lost in 1998; this was a small isolated site (Kathy O'Brien, NYSDEC, pers. comm., 2011).
OH	0	NA	0	1	Lucas	3	In 1998 KBBs were reintroduced to Kitty Todd Preserve; currently KBBs are present at 4 sites, Kitty Todd NP, Meilke Wildlife Area, Campbell Prairie and Cactus Hill Prairie Management Unit .
IN	2	Lake, Porter	10 sites (in 2 populations) [1]	2	Lake, Porter	11 subpops. [4,5]	There were 3 sites in the West Gary metapopulation in both 1992 and 2011. Two sites had KBBs in both years, Ivanhoe Dune and Swale NP and Tolleston Ridges. In addition in 1992 KBBs occurred at Gibson Woods and in 2011 at Dupont Natural Area (John Drake, TNC, pers. comm., 2011). Currently, there are 8 sites at IDNL (Randy Knutson, NPS, pers. comm., 2010) (Appendix C, Indiana). In 1992, 6 sites were present at IDNL and 4 sites at other locations (USFWS 1992).
MI [6]	6	Allegan, Lake, Montcalm, Muskegon, Newaygo, Oceana	46 EOs (8 EO clusters for both 4km and 8 km separation distances)	11	Same plus: Ionia, Kent, Mason, Mecosta, and Monroe	115 EOs (8 or 11 EO clusters for 4 km and 8 km separation distances respectively)	Monroe County in southeast MI was added in 2008 with the start of a reintroduction program at Petersburg SGA (refer to Appendix C, Potential Recovery Units).
IL	1	Lake	1	0	NA	0	KBBs have been documented in very low numbers at Illinois State Beach Park twice, in 1992 and 2001 (Kris Lah, USFWS, pers. comm., 2010).
WI [7]	15	Adams, Burnett, Clark, Eau Claire, Green Lake, Jackson, Juneau, Marquette, Menominee, Monroe, Outagamie, Portage, Waupaca, Waushara, Wood	109 EOs (**39** or 23 EO clusters for 4 km and 8 km separation distances respectively)	14	Same as 1992 minus Outagamie County	134 EOs (**63** or 31 EO clusters for 4 km and 8 km separation distances respectively)	Outagamie County had only one KBB EO record from 1993 which is no longer considered present. While KBBs are not considered present in Chippewa, Oconto, and Shawano Counties (and are therefore are not included on this table), these three counties are on the USFWS Midwest Region's Section 7 County List as small portions of these counties occur within the KBB High Potential Range.
MN	1	Winona	5 sites [1]	1	Winona	1?	Kbbs were historically present in Turkey, Cuthrell, Historic, and Lupine Valleys within the Whitewater Wildlife Management Area (WMA). In the past several years the KBB has only been found in Cuthrell Valley at 1 site. In 2011, no KBBs were recorded from Cuthrell Valley; more surveys are needed to determine whether the butterfly still occurs here.
TOTAL Sites/ Pops. [8]			**114 [8]**			**116 [8]**	

[1]USFWS. 1992.

[2] Kathy O'Brien, NYDEC, pers. comm., 2011.

[3] Neil Gifford, APBPC, pers. comm., 2010.

[4] Randy Knutson, NPS-IDNL, pers. comm., 2010.

[5] U.S. Fish and Wildlife Service 2006b (in Appendix C), Indiana KBB Safe Harbor.

[6] Rebecca Rogers, MI DNR, MI Natural Features Inventory, pers. comm., 2011 (Email dated 5/4/2011); Michigan DNR 1992 (Wilsmann Report).

[7] Terrell Hyde, WDNR, pers. comm., 2011 (Email dated 5/5/2011); Bleser 1992.

[8] Total Site/Pops. For Wisconsin and Michigan the number of EO clusters with a 4 km separation distance were used to calculate the total number of range-wide KBB sites/populations. The number of EO clusters with a 4km separation distance in Wisconsin in 1992 and 2011, were 39 and 63 EO clusters respectively. Michigan had 8 EO clusters with a 4 km separation distance in both 1992 and 2011.

The rangewide totals do not represent the number of metapopulations, that would be a lesser number as many of the sites/subpopulations in New York, Indiana, and likely Ohio represent 1 to only a few metapopulations.

Note: MI and WI EO cluster data - The numbers of EO (element occurrence) clusters for 1992 and 2011 are based on 4 km and 8 km separation distances between EOs with a last observed date on or before 1992, and a last observed date on or after 1998; historic and extirpated EOs were not used in this analysis. Because KBB sites can be lost due to succession in 10-15 years, the >=1998 EO data set was used to derive the number of EO clusters likely present in 2011, this assumes that sites present in 1998 would still be present in 2011 (a 14 year time span). Refer to 2.3.1.5., Spatial distribution, trends in spatial distribution, Wisconsin and Michigan for additional information and Appendix E, Figures E1 and E2.

Pops. = Populations

compared to mowed and unmanaged sites, and significantly more males were found in burned and mowed areas compared to unmanaged areas (Pickens 2006).

The effect of mowing and burning on the KBB and herbaceous plant cover was studied at 15 sites at Necedah NWR in Wisconsin by King (2003). Results of the July burn versus the control showed that KBB density increased on the burned sites in the year immediately following the burns while it decreased on the control sites. No significant differences in KBB abundance were found between the summer burn and control sites. The effects on herbaceous plant cover varied; *Potentilla simplex* (common cinquefoil) and *Rubus spp.* (bramble) increased, and *Pteridium aquilinum* (western bracken fern) decreased on burn sites. The November burn versus the control yielded no significant difference in KBB density between the burned and control sites. The effect on herbaceous plants included a significant increase in *Aster azureus* (sky blue aster), *Rosa Carolina* (Carolina rose), and *Rubus spp.* (bramble) in burned areas, while there was a significant decrease in *Comptonia peregrine* (sweet fern) on the burned sites. Results of the final experiment comparing a July burn, an August mow, and a control revealed that KBB density increased on the burned and mowed sites in the year immediately following the fire, while density decreased on the control sites. The differences found were not significant, however. No significant treatment-related changes in KBB densities were detected, lupine was unaffected by the treatments, and most of the affected herbaceous plants were not KBB nectar sources. This study suggests that burns conducted in late fall and during the second flight do not affect use of these areas by KBBs at Necedah NWR. Spring burns and spring/summer mows were not evaluated, and their effect is unknown (King 2003).

King (2002) also studied the effects of single burns on degraded (closed canopy) oak savannas. The sites were located in the Necedah Wildlife Management Area in Wisconsin (Juneau, Jackson, Monroe, and Wood counties), and had not been burned in the twenty-five years prior to the experiment. The study found that jack pine tree density increased on the control sites (unburned) and decreased on spring and fall burn sites. Shrubs and species richness increased on the control and fall burn sites (64% and 21%, respectively) but decreased on the spring burn site (66%), and herbaceous plant species richness increased on both the fall and spring burn sites (12% and 15%, respectively), but increased significantly more on the control sites (28%). Bird and tree species richness were unaffected by the different treatments (King 2000).

The effects of summer burns on KBB adult mortality at Necedah NWR (King 2002) found that at least some KBBs survive fire. In the summer of 1994, mark-recapture surveys were conducted immediately before and after prescribed burns at two sites. Each of the two study sites were adjacent to unburned plots of equal or greater size than the burned sites and served as sources of recolonizers for the burned plots. No unmarked butterflies were captured after the burn at either site, dead or partially burned butterflies were not found, and KBBs were not observed

leaving the site prior to the burn. At Site A, immediately behind flames, 4 marked males were recaptured, resulting in a recapture rate of 2.9 percent. On Site B, 5 marked males and 1 marked female were recaptured, resulting in a recapture rate of 6.7 percent. Based on these findings, King (2002) concludes that the KBBs seen after the fire were not recolonizers from adjacent sites. The study also demonstrated that not all adult KBBs are killed by summer burns. More research is required to assess the level of KBB mortality due to fire (King 2002). It should be noted that the study did not include the potential mortality of KBB eggs and larvae resulting from burns.

Mowing and Herbicide Treatments

A primary management goal for the APB is to reduce the scrub oak density by about half, to 30-35%. This is anticipated to restore open barrens where grasses and forbs essential to the KBB and many other shrubland species are codominant with scrub oak and other native shrubs. Mowing and prescribed fire treatments during the dormant season did not produce the desired results due to immediate regeneration of the scrub oak. In 2008, a growing-season mow along with an herbicide treatment was applied to four scrub oak patches. Mowing occurred between July 2 and August 6; all vegetation was cut to 20-25 cm in height with a Hydro-Ax, and the debris left on-site. Herbicide application (using ultra-low volume back pack pump sprayers) was made between September 2 and 23 in a pattern that sprayed 2 scrub oak crowns then skipped one crown. The herbicide mixture included Krenite "S" (active ingredient fosamine), which is selective for woody species and inhibits the next year's growth, and Arsenal (active ingredient imazapyr), which is nonselective. In 2009 (first year after treatment) scrub oak cover density was reduced overall to 5%–16%, well below the 30%–35% target at two sites that had pre-treatment data. It is anticipated that three years after treatment scrub oak density will approximate the desired 30%–35%. If this management method proves effective, the APB will use herbicides after mowing, but only in initiating the shrubland stage, and not to maintain it. Frequent low-intensity prescribed fire will be the primary management tool to maintain scrub oak density at or below the 30-35% mark and less than 2 meters in height (Bried and Gifford 2010).

The effects of several vegetation clearing methods on lupine populations and associated communities of nectar species for KBBs along a power line corridor were studied by Forrester et al (2005) in the Hudson Valley Sand Belt of New York. Eighteen of 35 extant or recently extirpated KBB populations within the Hudson Valley Sand Belt occur in power line corridors. Clearing methods differed in intensity (annual, four, or eight year intervals) and type [high and low volume herbicide and/or mechanical (mowing to brushing) treatments]. The study found that lupine and plant community responses did not significantly differ among the treatment types, but lupine cover, clump size, and density of stems per clump increased following the application of each treatment in general. The number and cover of nectar species, total herbaceous cover, and species richness

also responded positively to each treatment overall. After the establishment of sites and treatment applications KBBs were observed at two sites where they previously had not been observed (Forrester et al. 2005).

Military Activities

Habitat disturbance activities associated with military training activities at Fort McCoy, Wisconsin, were positively correlated with lupine abundance and the proportion of lupine stems with signs of KBB larval feeding. Habitat disturbance activities at the Fort include those associated with the movement of tracked vehicles around the base and fires caused by military munitions, suggesting that maintenance of lupine habitat can be achieved in concert with military training activities at Fort McCoy (Smith et al. 2002).

Selective Thinning

A study by Kleintjes et al. (2003) related to the development of a KBB mitigation site for a wastewater treatment facility near Fairchild, Wisconsin found that selective thinning of pine in the conservation and management area was important in sustaining KBB numbers in other areas.

Herbicide Treatment

LaBar and Schultz (2011 unpublished) conducted a field study to examine the short-term effects of the grass specific herbicide sethoxydim on butterflies and their habitat using the Puget blue (*Icaricia icarioides blackmorei*) as a model. The forelegs of all female butterflies have a combination of spines and olfactory hairs used to puncture and taste leaves to choose suitable host plants prior to oviposition (Scott 1986). The study tested for possible avoidance of lupine sprayed with sethoxydim. Results indicated that sethoxydim had little to no effect on flower density, lupine cover, larval performance (based on leaf damage from feeding), and oviposition (similar number of eggs were laid in control and treated plots). Adult butterflies did not avoid sethoxydim treated plots but did spend significantly less time in treated plots than in control plots suggesting that sethoxydim does alter adult butterfly behavior. (LaBar and Schultz 2011 unpublished). It should be noted that sublethal effects to butterflies were not studied in the field. In a laboratory study however, Russell and Schultz (2010) found that sethoxydim and fluazifop-p-butyl both reduced development time of Puget blues from the date of treatment to eclosure, and also reduced the survival, pupal weight, and wing size of cabbage white butterflies. The effect of this herbicide on tending ant species is unknown. Also unknown are the long-term and large-scale effects of herbicide use on butterflies (C.C. LaBar, *pers. comm.*, 2009).

Note: Stanley et al. (2011) evaluated combinations of mowing, burning, and herbicide treatments over three years in prairies in the Pacific Northwest. They

found that spring application of sethoxydim, followed by a fall burn and a post-fire glyphosate treatment, resulted in the best control of invasive grasses and forbs without reducing native species abundance.

LeBar and Schultz (2011 unpublished) provide the following recommendations to reduce adverse effects of herbicide use on butterflies:

- In small areas containing few invasive plants, spot spray or hand pull.
- When spraying large areas, and in the absence of data on demographic effects, assume 100% mortality of butterflies in sprayed areas.
- Limit herbicide application so that individuals from unsprayed areas can easily recolonize sprayed areas e.g., treat only one-third of the site to allow adult butterflies the option of moving between untreated and treated habitat patches.
- Management programs should consider the cumulative effects of restoration practices (chemical, mowing, mechanical) over multiple years, factoring in spatial considerations of how to leave adequate refugia when recolonization from untreated areas is critical to maintenance of a rare population. A plan that rotates impact areas allows some areas to receive intense treatment and others to serve as refugia.

The above recommendations are consistent with conservation guidelines being implemented for the KBB.

Biocide: Gypchek Treatment

Gypchek (a gypsy moth specific virus used to control the gypsy moth) is used in Wisconsin and other states that support KBBs to control the gypsy moth. Raffa and Yanek (2008) examined Gypchek and its carrier (Carrier 038-A) on the KBB in response to concerns over the possible adverse effects of these products on the butterfly. The analysis was conducted using KBB larvae that were collected from the central sands region of Wisconsin. Laboratory treatments consisted of a control (water), Carrier 038-A alone, and Carrier 038-A with low, medium, and high concentrations of Gypchek. The data from the study did not provide clear evidence of KBB mortality from Gypchek applied under field conditions. In laboratory conditions, the carrier, which is sticky, did demonstrate a possible adverse effect on KBB larvae. In order to properly assess the effects of Carrier 038-A on KBBs, studies conducted under field conditions are needed. Prior to any confirmed detrimental effects under field conditions, Raffa and Yanek (2008) recommend that Gypchek continue to be viewed as a preferable gypsy moth control in comparison to *Bacillus thuringiensis kurstaki*, (Btk) which is a Lepidopteran-specific virus shown to cause KBB larval mortality.

Recreational management

Research by Bennett (2010) at IDNL found that KBB breeding success can be adversely impacted by disturbance caused by recreational trail use. Significantly fewer eggs were laid by females within habitat extending 10 - 15 m from the trail. In this area and up to 20 m from the trail, eggs were not uniformly laid across the available habitat and oviposition events were concentrated to host plants furthest from the trail. The research suggests that habitat patches in proximity to trails and other public rights of way should extend a minimum of 25 m from that trail.

2.3.1.7 Other information on the KBB:

Information on the KBB (including the Recovery Plan, Captive Propagation Handbook for the KBB, Guide to use of distance sampling methods, threats table, etc.) is available on the USFWS's Midwest Ecological Services, Endangered Species website at:
http://www.fws.gov/midwest/endangered/insects/kbb/index.html

Detailed information on the distribution of the KBB in Wisconsin and on the Wisconsin Statewide KBB HCP can be found at the WDNR's website at:
http://dnr.wi.gov/forestry/karner/

Information on the KBB in Michigan including the Statewide KBB HCP can be found at:
http://www.michigan.gov/dnr/0,1607,7-153-10370_12145_12204-33007--,00.html

For information on the KBB in other states (New York, New Hampshire, Ohio, Indiana and Minnesota) go to the USFWS Ecological Services Field Office website and/or the state's natural resource agency's website for that state.

2.3.2. Five-Factor analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

The major threats identified in the KBB recovery plan (USFWS 2003) were loss and alteration of KBB habitat (from residential, commercial, industrial, agricultural and some silvicultural activities) as well as incompatible management related to pesticide use, mowing, prescribed fire and deer and grouse management. The destruction, modification or curtailment of habitat due to commercial, industrial, and residential development remains a threat especially in New York, New Hampshire, and Indiana where recovery sites are limited in size and KBB population numbers are generally low (refer to Appendix C, Table C1 and Appendix D, Table D1).

While development remains a threat, it has been reduced and it is anticipated that this threat will be further reduced over time through a variety of tools. All of the states in the KBB range have been working proactively to protect, restore and manage habitat for the KBB with many of these efforts supported by various grants [e.g. USFWS Endangered Species Act (ESA) Section 6 grants, state wildlife grants, and Environmental Protection Agency Great Lakes Restoration Initiative grants]. One of the more significant restoration efforts has been done at the Saratoga Sandplains in New York where about 120 acres were restored to KBB habitat resulting in a significant increase in the butterfly population at that site in 2010 (refer to Appendix D, Table D1). As noted above, all states are proactively restoring and managing habitat for KBBs at recovery sites and at the reintroduction sites in New Hampshire, Ohio and Michigan.

In addition to those efforts, we expect additional habitat restoration through the implementation of Safe Harbor Programs by TNC, and by habitat conservation plans (HCPs) in both New York and Indiana. In New York, TNC is working on its first cooperative agreement (under their Safe Harbor Program) with a private landowner (Neil Gifford, APBPC, pers. comm., 2011). In Indiana, TNC plans to work with private landowners (per their Safe Harbor Program) to help restore the West Gary KBB metapopulation (TNC 2006). In New York a draft HCP has been developed by National Grid which will help support recovery efforts at the APB and in Queensbury (a NYSDEC KBB recovery site) (ChazenChazen Engineering, Land Surveying and Landscape Architecture Co., P.C 2011). In Indiana, a HCP is being implemented by the Northern Indiana Public Service Company and Indiana-American Water Company; the HCP involves vegetation management of utility line rights-of-way to help maintain KBB populations, active habitat restoration efforts, and restoration of a mitigation site for the KBB (Kortum B. 2005).

Threats are being addressed in Michigan and Wisconsin through implementation of HCPs for the KBB in these states which help conserve the butterfly on non-federal lands. The Wisconsin Statewide KBB HCP has 42 partners including the Wisconsin Department of Natural Resources (WDNR), industrial and county forests, utility companies, county and town highway departments, Unimin Corporation (a frac sand mining company) and the Wisconsin Departments of Transportation and Agriculture. The HCP's conservation program is being implemented on about 241,141 acres of partner lands which includes potential as well as extant KBB sites (Lentz 2010); in addition, Unimin Corporation has recently added 1,195 acres to the HCP (Unimin Corp. in litt. 2012). HCP partners implement the HCP's conservation measures designed to avoid, minimize and mitigate take of KBB when conducting land management activities in occupied habitat. As part of their HCP commitments, the WDNR is also helping to recover viable KBB populations on 9 state properties. USFWS's incidental take permit for implementation of the HCP was renewed on July 12, 2010, for 10 years. Information on the Wisconsin HCP can be found at: http://dnr.wi.gov/forestry/karner/.

The Wisconsin Statewide KBB HCP's strategy to encourage voluntary KBB conservation on non-HCP partner private lands (without regulatory oversight or permit needs) has been successful in promoting conservation of the butterfly on additional private lands in Wisconsin (WDNR 2010, USFWS 2010). The USFWS's Partners for Fish and Wildlife Program (Partners Program) in Wisconsin is implementing wildlife conservation agreements with about 380 landowners that are voluntarily restoring habitat for the KBB on about 3500 acres of land (Greg Hamilton, USFWS, pers. comm., 2011). While this is helping to promote the conservation of KBBs in Wisconsin, it unknown how many of these properties actually support the butterfly. The term of the conservation agreements is generally10-25 years which would put these sites at risk of loss after that time period. Similarly, the National Resources Conservation Service (NRCS) is helping private landowners restore KBB habitat on their property through the State Acres for Wildlife Enhancement (SAFE) program.

The Michigan Department of Natural Resources (MIDNR) completed a statewide KBB HCP in 2010 that was modeled after Wisconsin's HCP. Activities conducted in areas occupied by the KBB will be conducted per conditions that minimize and mitigate adverse effects to the butterfly. Types of activities covered in the HCP include habitat management, utility and transportation right-of-way maintenance, and development. There are 25 stakeholders interested in participating with the MIDNR in the HCP; these include three utility companies, the Michigan Department of Transportation, TNC, and others (MIDNR 2009). As of 2011, MI DNR remains the only HCP member.

In Wisconsin, some of the forested landscapes that support KBBs (Plum Creek Timber Company, and Wausau Paper Corporation, both HCP partners) are selling lands which could result in the loss of KBB sites as well as habitat fragmentation. Other threats that may reduce the amount of extant or potential KBB habitat include less tree harvesting due to depressed timber prices and regrowth of forests previously infected with jack pine budworm (Dave Lentz, WDNR, pers. comm., 2011). Planting of red pine in KBB extant or potential habitat areas at a density that excludes understory vegetation is also a threat.

Habitat loss due to mineral development is a newer and increasing threat in the HMNF in Michigan. Currently mineral development is occurring in the northern portion of the Newaygo RU. In addition, the majority of the Bigelow metapopulation area is in private landownership with habitat loss increasing on these lands due to development and planting of conifers for Christmas tree plantations (Heather Keough, HMNF, pers. comm., 2009).

A new threat in Wisconsin is frac sand mining. Frac sand is used to fracture rock (by pumping the sand into crevices) in order to extract oil and gas. High quality frac sand areas occur throughout the entire KBB high potential range in Wisconsin (Brown 2011) and can impact hundreds of acres of land. Wisconsin has about 60 mining operations of various sizes involved in frac sand mining and

about 32 processing facilities operating or under construction (WDNR Frac Sand Issue Brief dated December 1, 2011). The impact of frac sand mining on the Wisconsin KBB recovery program has yet to be assessed. This activity may assist with recovery if frac sand companies become partners to the Wisconsin KBB HCP and their mitigation plans (for take of KBBs) are designed to promote recovery of the species on recovery sites. Unimin Corp. a frac sand mining company is the newest partner to the Wisconsin HCP and is interesting in conserving KBBs on its property (Dave Lentz, WDNR, pers. comm., 2012). Negative impacts could result from the unmitigated loss of KBB sites due to companies unaware of regulations protecting the KBB. Frac sand mining may also be a threat in the Glacial Lake Albany RU (New York) as this area also contains high quality frac sands (Brown 2011).

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Extensive collection of KBBs in areas of the range where only a few small populations remain was identified as a threat in the KBB recovery plan (USFWS 2003). Collection of KBBs does not appear to be a significant threat as the USFWS is not aware of any such collection activities. Currently vehicles, especially off-road-vehicles (ORV) and dispersed camping are threats at some locations on the HMNF (Heather Keough, HMNF, pers. comm., 2009). In Ohio, off road vehicle (ORV) use has degraded habitat at one KBB site (Toledo Zoo, in litt. 2011). ORV use is also a threat in Wisconsin and New York, especially along road and powerline rights-of-ways that may support KBBs.

2.3.2.3 Disease or predation:

The KBB recovery plan (USFWS 2003) identified insect predators, parasitoids and pathogens as threats to the KBB as well as birds, mammalian browsing of lupine, and lupine plant diseases (e.g., powdery mildew). These remain as continuing threats. In addition to the mammalian threats noted in the KBB recovery plan (e.g., birds, deer, rabbit and woodchuck) turkey browsing on lupine may also adversely affect the butterfly (Paul Samerdyke, WDNR, pers. comm., 2008). Threats due to deer browse appear to be increasing in the HMNF (Heather Keough, HMNF, pers. comm., 2009). Approximately 80% of wild lupine plants planted in 2 restoration plots at the Concord reintroduction site had their flower stalks removed by grazing during 2004 (NHFG, unpublished data).

Insect herbivores are a threat to KBBs at some sites. Thrips (*Odontothrips loti*) found at some New York sites may reduce the amount of nutrients (in lupine leaves) available to KBB larvae and affect seed production (Kathy O'Brien, NYSDEC, pers. comm., 2008). Caution is advised when propagating lupine and/or nectar plants in greenhouses as thrips (on these plants) may be transported to KBB habitat areas via plantings and spread to other sites on their own or via

management and/or monitoring activities (Kathy O'Brien, NYSDEC, pers. comm., 2011).

The blister beetle, *Lytta sayi* found at some Wisconsin sites can obliterate lupine flowering and seed production for a season. Findings also suggest that female KBBs may choose shaded lupine more frequently for ovipositioning to avoid lupine occupied by *L. sayi* (Swanson and Kleintjes-Neff 2007).

KBB sites, especially those near agricultural fields, are at risk from predation by the seven spotted ladybird beetle *(Coccinella septempunctata)* (Shellhorn et al. 2005). The beetle co-occurs spatially and temporally with KBB eggs and larvae. Shellhorn et al. (2005) observed one beetle consuming two second instar KBB larvae. Modeling suggests that a predator density of 0.074 beetles per plant would cause about 6.0% KBB larval mortality, and an increased predator density of 0.37 beetles per plant would cause 27% larvae mortality.

In 2010, an aphid infestation at some New York KBB sites, combined with late spring frosts and an unusually hot, dry summer, affected flower production and caused many plants to drop leaves (Kathy O'Brien, NYSDEC, pers. comm., 2010). Other lupine herbivores include the painted lady larvae *(Vanessa cardui).*

Sang and Teder (2011) found that predation of butterflies by dragonflies can play a significant role in butterfly conservation efforts. They found that predation levels should be considered one of the most important factors when selecting habitat areas to restore for butterflies (Sang and Teder 2011). Several KBB sites are located near wetlands, e.g. the Indiana sites are located in a ridge and swale complex on the southern end of Lake Michigan, and sites at Necedah NWR, and Crex Meadows and Fish Lake SWAs in Wisconsin occur in a landscape mosaic of upland and wetland, exposing KBBs to predation by dragonflies.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

Lack of state legislation to protect and manage KBB habitat was identified as a threat in the KBB recovery plan (USFWS 2003). This threat was reduced in 2010 when the NYSDEC implemented new incidental take regulations that help conserve KBBs in occupied habitat (Kathy O'Brien, NYSDEC, pers. comm., 2012). The KBB recovery plan (USFWS 2003) also recommended development of more flexible regulatory mechanisms to ensure a habitat base for the species. This threat has been addressed in part through development of programmatic HCP and Safe Harbor programs (refer to section 2.3.2.1 above) that provide regulatory flexibility and permit streamlining to private landowners. Lack of enforcement of local regulations prohibiting ORV use in KBB habitat areas is a newer concern; several recovery partners have identified ORV use as a threat (refer to section 2.3.2.2 above).

2.3.2.5 Other natural or manmade factors affecting its continued existence:

The KBB recovery plan identified stochastic events such as unusual weather, large-scale wildfires, and aggressive exotic (non-native) plants as threats to the species as well as global warming. All of these threats remain. Additional threats include natural succession, pesticide use, hybridization, and genetic fitness at some sites with low population numbers. These threats are discussed more thoroughly below.

One of the most significant threats to the KBB is loss of habitat from natural succession. Early successional habitats required by the KBB (oak savanna, pitch pine and jack pine barrens and other habitats) can be degraded or lost due to natural succession generally within 15 years. Habitat management and restoration is crucial to maintaining suitable habitat for the KBB over the long term. There is a lack of base funding available for many recovery partners to maintain and restore sufficient habitat needed to support viable KBB populations; recovery partners are dependent on grants to support much of their habitat work. Savannas and barrens are considered globally imperiled ecosystems and providing habitat not only for the KBB but for numerous additional rare species (USFWS 2003) making restoration and protection of these habitats especially important.

Non-native invasive plant species are an increasing a threat at many KBB sites; some more recent invasive species of concern include spotted knapweed (*Centaurea maculosa*), St. John's wort (*Hypericum perforatum*), crown vetch (*Coronilla varia*), cow vetch (*Vicia cracca*) (USFWS 2009b) and sassafras (Toledo Zoo, in litt., 2011). In New York, black locust is a major concern at some sites.

Increased use of pesticides to control invasive species, if not designed to avoid or minimize harm to the KBB could adversely affect butterfly populations. Use of biocides is also a concern. The pollen of maize genetically engineered to contain the insecticidal endotoxin proteins from *Bacillus thuringiensis* (Bt) is a possible, (but likely more minor) threat to KBBs (Peterson et al. 2006). Modeling has shown some potential exposure of larvae to maize pollen, however maize pollen dispersal is most likely to occur after the majority of larval feeding on lupine. In addition, in most of the sites studied lupine was sufficiently separated from the treated agricultural field that high rates of larval mortality were anticipated to be low. Studies have shown that the levels of pollen outside the 7 meter area are not enough to cause high rates of mortality in other *Lepidoptera* (Peterson et al. 2006). A small number of potential or existing KBB sites are located near maize fields, including sites in Burnett County, Wisconsin.

Hybridization between *L. melissa melissa* (Melissa blue) found in western Wisconsin (near Hudson) with KBBs has the potential to threaten the genetic distinctness (as a taxon) of the KBB at some locations in western Wisconsin. Movement of *L. m. melissa* may be facilitated by the presence of crown vetch

(Coronilla varia), one of their larval host plants which is found along many roadsides in Wisconsin (Dane and Lane 2005).

Other genetic concerns include the low numbers of KBBs at the Whitewater WMA recovery site in Minnesota. The persistently low numbers may indicate lack of genetic fitness and decrease in the ability for recovery of this population (Jaime Edwards, MNDNR, pers. comm., 2010). No KBBs were found at Whitewater WMA during the 2011 surveys indicating a likely further decline of this species at the only site it is known from in Minnesota.

Variable weather conditions continue to impact KBB subpopulations in the HMNF and other KBB sites across the range. Frosts (that nip wild lupine blooms), cold, wet springs, significant rains during peak flight, and drought during second flight may lead to early senescence of wild lupine and nectar plants which would affects KBB survivorship and reproductive success**.**
Global warming is an emerging threat. Global warming is predicted to result in a hotter longer growing season reducing KBB habitat quality in some areas and increasing threats from larval predators and insect herbivores (USFWS 2009b). Preliminary climate change projections suggest that global warming may render many current KBB sites in the U.S. uninhabitable in coming decades and that much of the suitable habitat will then be found in Ontario, Canada (Jason Dzurisin, University of Notre Dame, pers. comm., 2011).

A recent vulnerability assessment conducted by Olivia LeDee for the KBB found that climate change could cause increases in KBB larval as well as adult mortality (WICCI 2011, Wildlife Working Group Report). Adult KBBs exhibit heat stress at 96-98°F (Lane 1999), thus reducing foraging activity. In 2010, high heat [greater than 100 degrees F (37.8° C) for at least 2 days] resulted in the mortality of 600 captive reared KBB pupae that were nearing eclosure (in the field) and planned for released in the APBP (Neil Gifford, APBPC, pers. comm., 2010). By the end of the century, the Crex Meadows population in northwestern Wisconsin may experience an additional 2-9 days of temperatures greater than100°F (37.8° C) and populations in central Wisconsin may see 2-13 days of temperature greater than 100°F (37.8° C). Because KBBs are poor dispersers and occur in a fragmented landscape a population shift in climate niche is not anticipated but rather declines are likely under future climate conditions (WICCI 2011, Wildlife Working Group Report). A conceptual model of climate impacts on the KBB developed by Olivia LeDee (WICCI 2011) identifies primary and secondary factors that contribute to the effect of climate change on the KBB (refer to Appendix G).

Climate projections show that annual average temperature in Wisconsin is likely to warm by 4-9 ° F by 2055 with northern Wisconsin warming the most. Wisconsin's winters are projected to warm by 5-11° F by 2055 with the warmest temperatures projected for northwest Wisconsin (WICCI 2011). This warming trend may have been the cause of a recent (prior to 2010) decline in the KBB

population at Crex Meadows and Fish Lake Wildlife Areas (one of larger KBB metapopulations in the state) in northwest Wisconsin. The KBB decline has generally been attributed to a long-term drying trend occurring in northwest Wisconsin over the past 50 years, and a much more pronounced acceleration of spring onset than seen in the rest of the state (Hess 2010). This drying trend is projected to continue. In addition, less precipitation as snow in the winter and more freezing rain is likely to occur. Snow depth and the extent of snow cover are expected to decrease significantly by 2055 (WICCI 2011).

Preliminary results from climate change work in Indiana suggest that exposure of KBB eggs to low temperatures may threaten egg survival (Grundel 2011). Research to assess the super cooling point of KBB eggs found that eggs froze in the lab at around -27°C to -30°C (-17°F to -22°F) demonstrating that KBBs practice freeze avoidance. The research indicates that if eggs are totally exposed on nights when temperatures are below the super cooling temperatures (-17°F to –22°F), they would die. In addition, low temperatures above the super cooling temperatures would likely be lethal to a part of the KBB population as might repeat exposure of eggs to lower temperatures (above the super cooling temperature). Cold temperatures that could kill KBB eggs (e.g., - 20° F) still occur, especially in the northern part of the KBB range; these low temperatures will likely become less frequent over time (Ralph Grundel, USGS, pers. comm., 2011).

Based on the above, egg exposure due to loss of snow cover could be a significant threat to KBB overwintering survival. Preliminary research has found that snow cover provides considerable insulation for overwintering eggs. Mean temperature under the snow increases as snow depth deepens. With 10 inches of snow, temperature under the snow is nearly constant (27 to 33° F) (-2.8 to 0.6° C); temperatures vary more when snow cover is less than 10 inches. The research also found that the duff layer provides an insulation effect; the range of temperatures under litter was about 12-40° F (-11.1 to 4.4° C) compared to -1 to 62° F (-18.3 to 16.7° C) without any litter cover (Ralph Grundel, USGS, pers. comm., 2011). This suggests that as the climate changes and there is less snow cover, fall burns in KBB occupied areas should be avoided to allow the duff to provide insulation for overwintering eggs.

Preliminary research also indicates that increasing temperatures can result in an increased number of adult broods. Generally, KBBs are bivoltine, producing 2 adult broods per year. However, voltinism patterns are determined primarily by temperature (Aardema et al. 2011) with less time spent as larvae or pupae as the temperature increases. Diapause is often triggered by cues such as day length (Aardema et al. 2011). Research findings show that an increase of 3.6° F (2° C) above current temperatures can result in a third adult brood. An increase of 10.8° F (6° C) produces a fourth adult flight, the pupae of which do not mature. Findings also show that the second and third broods of KBB adults are smaller in size than adults of the first brood which may affect fitness and fecundity (Jason

Dzurisin, Notre Dame University, pers. comm., 2011). Because many lupine plants senesce by mid-summer, larvae from third brood adults may lack sufficient lupine for optimal development. Several recovery partners across the KBB range have reported third brood KBB adults in recent years (refer to section 2.3.1.2, Brood Size, Brood Number and Growth Rates, above). A third brood of adults noted in New York in 2010 may have contributed to lower KBB numbers seen in that state in 2011 (Kathy O'Brien, NYSDEC, pers. comm., 2011).

Future KBB reintroductions should consider the potential effect of climate on the KBB. Populations that occur at different latitudes may exhibit significant differences in diapause induction, which could make introductions and translocations more challenging (Aardema et al. 2011).

Preliminary climate change research also indicates that while KBB larvae have a relative high upper thermal limit, 47-49° C (116.6-120.2 °F) compared to other Lepidoptera, they may have a reduced ability to physiologically adjust to higher temperatures. However more research is needed to assess the lack of differences in treatments and assess associated factors such as sex, and heredity. Determining whether metabolic differences exist as a result of rearing temperatures is an important part of the research that has not yet been funded (Ralph Grundel, USGS, pers. comm., 2011).

An important aspect of the climate change research not yet completed is niche modeling to determine the potential for local adaptation as the climate warms and to generate management recommendations for habitat features that would help conserve the KBB for the near future at the subpopulation level.

A study conducted by Enrique Gomezdelcampo indicates that climatic factors may have contributed to the extinction of KBBs in the Oak Openings of Ohio and in the Pinery in Ontario. The study assessed the climatic characteristics at these 2 sites and at 3 sites where KBBs populations are present (Allegan, Michigan; Fort McCoy, Wisconsin; and Saratoga, New York). Results of the study may indicate that high precipitation is a restricting factor for the persistence of KBBs; in areas with lower precipitation extinction may occur more readily. Extreme high temperatures and low rainfall intensity may have had a combined effect at the Ohio and Ontario sites in 1988 resulting in KBB extinctions at these sites. The number of frost days throughout the time periods studied decreased significantly for all the sites except for Fort McCoy; the number of extreme cold days dropped significantly for all sites, but decreased most dramatically at the Ohio and Ontario sites (Enrique Gomezdelcampo, Bowling Green State University, Ohio, pers. comm., 2008).

Global climate change may highly impact barrens and savanna communities upon which KBBs depend through phenological changes related to pollination, community disaggregation (formation of "novel" communities), invasive species/diseases/pests, fragmentation/isolation, and fire seasonality; herbivory is likely to increase as well (WICCI 2011).

To help reduce the threats due to the KBB from varying seasonal weather conditions and to the more long term threats associated with climate change, KBB habitats should be designed to be heterogeneous. It should include a variety of subhabitats from open to more closed canopy sites and with varying moisture regimes, slopes and aspects, to provide suitable habitat for the KBB especially important during times of drought. Adequate nectar and lupine plants should be available. Such measures will help enhance KBB occupancy and survival.

2.4 Synthesis

The biological principles that allow us to evaluate the range wide population status of the KBB relative to its long-term conservation are representation, redundancy, and resiliency. These principles are discussed below.

At the time of listing in 1992, KBBs were present in 7 states. Since 1992, the overall state range of the KBB has contracted slightly, from 7 states in 1992, to 6 states in 2011. This is due to the likely extirpation of KBBs from Illinois (Illinois State Beach Park) and possibly Minnesota (Whitewater WA) and the addition of Ohio to the species range (refer to section 2.3.1.5, Overview of Species Distribution, and Table 8). A program to reintroduce KBBs to Ohio began in 1998 [Appendix C, PRUs, Oak Opening PRU (Ohio)].

The range of KBBs in each of the states that had populations at the time of listing in 1992, has generally remained the same except in Michigan where the butterfly's range expanded by 5 counties (from 6 to 11 counties). In Wisconsin and New York, the ranges contracted by one county, from 15 to 14 counties, and 4 to 3 counties respectively (refer to section 2.3.1.5 and Table 8).

The distribution of KBBs within each of the states has generally remained the same since listing except for Michigan and Wisconsin. In both states the known distribution of the KBB within the range present in 1992 expanded (refer to section 2.3.1.5, Table 8 and Appendix E).

The overall rangewide number of KBB populations/sites has remained generally the same since listing. Based on available information, there were 114 and 116 KBB populations/sites in 1992 and 2011, respectively. These rangewide totals do not represent the number of metapopulations present rangewide, that number would be a lesser number. This is because many of the sites/subpopulations in New York, Indiana, and Ohio represent only 1-3 metapopulations (Table 8).

Progress has been made on meeting the recovery criteria for reclassification and delisting as recommended in the KBB recovery plan (USFWS 2003) (section 2.2.3). Currently none of the 19 and 21 VP sites recommended for reclassification or delisting respectively, are known to have met the reclassification or delisting criteria. However 7 of the VP sites are within 1-4 years of meeting the KBB VP population criterion (3,000 KBBs for 4 out of 5 years and in the fifth year) for reclassification. Three out of the 8 and 11 LP

sites, recommended for reclassification and delisting respectively, have met both the reclassification and delisting criteria**.** The 3 LP sites are in Wisconsin and are: Fort McCoy-North Post, Fort McCoy-South Post and Necedah NWR. In addition, 1 LP site (Crex Meadows/Fish Lake WAs) has met the reclassification population criterion (6,000 KBBs for 4 out of 5 years and in the fifth year) for at least 1 year and possibly additional years (refer to section 2.2.3, Table 1 and Appendix D, Table D1).

While progress has been made on meeting recovery criteria an insufficient number of viable KBB metapopulations have been recovered range wide to ensure the species will not go extinct. The KBB recovery strategy recommends restoring a total minimum number of 27 VPs and LPs for reclassification and a total number of 29 VPs and LPs for delisting (Appendix B, Table B1, "Notes"). The VPs and LPs should be distributed in 13 RUs across the species range to preserve possible geographically associated genetic variation and to buffer against large-scale stochastic variation by providing an adequate number of widely dispersed metapopulations in a wide range of habitat types (USFWS 2003). The 3 KBB metapopulations that meet reclassification and delisting criteria (Table 1) are located within only 2 of the 13 range-wide RUs (Glacial Lake Wisconsin RU and West Central Driftless RU) (Appendix B, Table B1). None of the 13 RUs contain the recommended number of VPs and/or LPs recommended for reclassification (refer to section 2.2.3).

Restoring viable KBB populations in each RU will ensure maintenance of the species throughout its range present at the time of listing thus providing adequate representation of the species (i.e., occupancy of representative KBB habitats across the species range). This approach also provides for redundancy (i.e., the distribution of KBB populations in a pattern that offsets unforeseen losses across a portion of the KBBs range), guarding against possible management failures or other threats (e.g., stochastic events). While all the recovery properties noted in the KBB recovery plan (USFWS 2003) (refer to Appendix B, Table B1) are owned in part or whole, by states, TNC, counties, or Federal agencies (and/or include state natural areas being managed for KBBs and barrens), and contain the broad goal of maintaining at least some barrens/savanna habitat, only 8 sites (5 VP and 3 LP sites) have management plans that include recovery criteria that are the same or exceed the recovery criteria recommended in the KBB recovery plan (refer to section 2.2.3, VP Criterion 2.1 and LP Criterion 2.1, and Appendix C).

The KBB has not proven to be more resilient than previously understood. The butterfly's mobility is generally the same as previously known (dispersal distance is low). Habitat remains restricted to those habitats identified in the KBB recovery plan i.e. remnant native savanna and barrens habitats and other contemporary habitats (e.g., utility and road rights-of-ways, airport safeways, military bases, young forest stands, forest openings and along forest roads and trails).

Major threats identified in the KBB recovery plan (USFWS 2003) included loss and alteration of habitat, incompatible management, lupine plant diseases (e.g., powdery mildew), predation (e.g., by birds and deer browsing on lupine), lack of habitat protection (e.g., via land purchases, conservation agreements, and management agreements),

stochastic events (e.g., unusual weather), aggressive exotic (non-native) plants, and potentially global warming; for more details on these threats refer to the KBB recovery plan (USFWS 2003).

Numerous conservation and recovery actions have been implemented since 1992 by local, State and Federal agencies, TNC, and private landowners to address threats to the species. Of special note are the statewide HCPs in Michigan and Wisconsin and the Safe Harbor programs in New York and Indiana. The Wisconsin Statewide HCP currently has 42 partners. The Michigan HCP and Safe Harbor programs are just beginning to build their partnerships. Protection and expansion of KBB sites on recovery partner lands has been accomplished in some states through State and Federal grants. Several research and recovery actions specified in the KBB recovery plan (USFWS 2003) and spotlight species action plan (USFWS 2009b) have been completed or are on-going. Private landowners are involved in habitat restoration projects for the KBB in Wisconsin as well through USFWS's Partners and NRCS's SAFE programs (refer to section 2.3.2.1 above).

Although progress has been made on addressing threats, one or more threats identified in the KBB recovery plan (USFWS 2003) as noted above are still present at all KBB sites throughout the species range. Loss of habitat due to vegetation succession continues as a major threat. Managers of State and Federal recovery sites frequently lack sufficient funding to conduct needed management work to maintain KBB habitat and depend on grants to help support this work. Funds to expand habitat at small sites are frequently lacking as well. Non-native invasive plant species (e.g., spotted knapweed, crown vetch, and black locust) are a continuing threat at many recovery sites. Invasive species displace lupine and preferred nectar species degrading habitat for the butterfly. In addition, use of pesticides to manage these areas can be a threat if application plans are not designed to avoid or minimize harm to the butterfly. Commercial, industrial and residential developments continue as significant threats to recovery especially at sites in New Hampshire, New York, and Indiana (refer to section 2.3.2.1 above).

While Michigan and Wisconsin support more numerous KBB sites (EOs) (refer to section 2. 3.1.5 and Appendix E), many of the individual KBB EOs on private lands are small, isolated, and/or lack permanent long term protection and are therefore at risk of loss due to succession or other threats. Early successional KBB habitat (oak savannas and pine barrens) if not managed succeeds to forest in about 15 years, shading out lupine and resulting in the loss of habitat and the butterfly. In addition to the loss of KBBs, numerous other species dependent on barrens and savanna ecosystems (which are globally imperiled) are adversely affected as these early successional habitats are lost or degraded (USFWS 2003).

Larger forested landscapes in Wisconsin that support a number of KBB sites (refer to Appendix C, Wisconsin, Other Larger Forested Landscapes with KBBs in Wisconsin, Appendix C Table C1, and section 2.3.1.5, Wisconsin) provide more secure habitat for the KBB, however the ability for these landscapes to support viable KBB populations for the long term needs assessment. More permanently protected core habitat areas are likely

needed within these shifting habitat mosaics to insure the long term survival of viable KBB populations on these larger landscapes.

Other threats include small KBB population sizes (less than 3000 KBBs second flight where population size known) e.g., at Concord (New Hampshire), APBP and Saratoga Airport (New York), West Gary (Indiana), Whitewater WMA (Minnesota), and Meadow Valley WA, Hardwood Range, and Greenwood WA (Wisconsin) (Appendix D, Table D1). One or more of the recovery sites in 6 of the 7 states currently supporting KBBs are geographically small (New Hampshire is the exception) with less than 200 acres of habitat present; more land is likely needed to ensure recovery of viable populations at these sites (Appendix C and Table C.1). Population trend data at some recovery sites shows long term population declines e.g., IDNL (IN) and sites in the HMNF (Michigan) (Appendix C).

Global climate change is a growing threat. Climate projections show that annual average temperature in Wisconsin is likely to warm by 4-9 ° F by 2055 with northern Wisconsin warming the most (WICC 2011). A recent vulnerability assessment conducted by Olivia LeDee found that climate change could cause increases in KBB larval as well as adult mortality (WICCI 2011). Preliminary research indicates that increasing temperatures are likely to result in production of third and possibly fourth broods of KBB adults (third brood adults were observed in several states in 2010). Due to reduced quantity and quality of lupine resources for larval development, these third and fourth broods will likely be less fit leading to reduced reproduction and overall population numbers (Jason Dzurisin, University of Notre Dame, pers. comm., 2011). Adverse effects to the KBB associated with global climate change will likely be exacerbated by loss of snow cover which provides insulation for overwintering eggs (refer to section 2.3.2.5). Preliminary climate change projections suggest that global warming may render many current KBB sites in the U.S. uninhabitable in coming decades and that much of the suitable habitat will then be found in Ontario, Canada (Jason Dzurisin, University of Notre Dame, pers. comm., 2011) (refer to section 2.3.2.5).

The KBB should continue to remain listed as endangered because the populations at some recovery areas (in New York, Indiana, Michigan and Minnesota) have remained low or are demonstrating a decline. In addition, major threats have not been ameliorated and the criteria for downlisting to threatened has not been met. Declining populations and loss of habitat in Minnesota, Indiana, and New York are not compensated for by the more numerous populations in Wisconsin and Michigan. Threats persist for the KBB in all states including loss of habitat due to natural succession, lack of management, invasive species and commercial, industrial and residential development. Threats related to global climate change appear to already be occurring with the presence of third brood KBBs noted in most states in 2010, and more severe threats will likely be realized in the coming decades. In sum, our current understanding of the KBB's status leads us to conclude that this species continues to face a probability of extinction throughout all or a significant portion its range, thereby meeting the definition of endangered under the Endangered Species Act.

3.0 RESULTS

3.1 Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_x__ No change is needed

3.2 New Recovery Priority Number: *No change*

3.3 Listing and Reclassification Priority Number: *No change*

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Recommended future actions are noted below.

Management, Monitoring and Protection

Because habitat loss due to vegetative succession continues to be a major threat, work to manage and restore habitat for the KBB remains a priority action rangewide. Habitat management is identified as a Priority 1 Action in the KBB recovery plan (USFWS 2003) for recovery sites in New Hampshire (Action 1.21), Minnesota (Action 1.22) and New York (Action 1.23), and as a Priority 2 Action for recovery sites in Michigan (Action 1.24), Indiana (Action 1.25), and Wisconsin (Action 1.26). The Spotlight Species Action Plan for the KBB (USFWS 2009b) also identifies habitat management in all of the states noted above plus Ohio, as priority tasks under the "Manage KBB Recovery Sites" strategic action.

KBB habitats should be designed to be heterogeneous to help reduce threats associated with seasonal weather conditions and to the more long term threats associated with climate change. Recovery sites should include a variety of subhabitats from open to more closed canopy sites and with varying moisture regimes, slopes and aspects, to provide suitable habitat for the KBB especially important during times of drought. Adequate nectar and lupine plants should be available; such measures will help enhance KBB occupancy and survival.

Continued KBB population and habitat monitoring is needed at all recovery properties. Population data is needed to assess progress in meeting recovery criteria. Population monitoring at Whitewater WMA (Minnesota) should continue in order to determine if KBBs are still present at this site. To promote the recovery of the KBB, habitat monitoring should be conducted, especially at recovery sites where KBB numbers are low to assess what actions may be taken to improve habitats (and subhabitats) (e.g., mowing, burning, herbicide work and/or planting of lupine and nectar plants). Population and habitat monitoring are identified as Priority 1 Actions in the KBB

recovery plan (USFWS 2003) for New Hampshire (Actions 1.11), Minnesota (Action 1.12 re: KBB monitoring), and Michigan (Action 1.13 re: KBB monitoring), and as Priority 2 Actions in New York (Action 1.14), Indiana (Action 1.15) and Wisconsin (Action 1.16). The Spotlight Species Action Plan for the KBB (USFWS 2009b) also identifies "Monitoring KBBs at Recovery Sites" as a strategic (recovery) action.

Work is needed to secure long term habitat protection and management for the KBB. Therefore it is important to develop long term protection and management plans (recovery implementation plans) for recovery sites lacking such plans. Plans should adopt the recovery criteria in the KBB recovery plan (USFWS 2003) and be flexible enough to incorporate any future changes to the recovery criteria based on new information and/or research. Development of protection and management plans is identified as a Priority 1, 2, or 3 Task (depending on the state) in the KBB recovery plan (USFWS 2003) (refer to Actions 1.311, 1.312, 1.313, 1.314, 1.315, 1.316 for Minnesota, New York, Indiana, Michigan, Wisconsin, and New Hampshire respectively). The Spotlight Species Action Plan for the KBB (USFWS 2009b) identifies development of KBB recovery implementation plans for Wisconsin recovery sites as a recovery task (under the "Protect KBB Recovery Sites" strategic action).

Research

It is important to continue research on the effects of climate change on the KBB. Information from these studies should be used to inform management decisions (e.g., what subhabitat features would more likely help conserve the KBB during times of droughts). Recovery partners should continue to collect information on third brood KBBs, e.g., year and place of occurrence. It would also be helpful to document KBB emergence timing, lupine/nectar plant availability, and weather-linked changes in KBB activity (Olivia LeDee, UW-Madison, pers. comm., 2011). Climate change is identified as a threat in the KBB recovery plan (USFWS 2003). Research on climate change is identified as a recovery task in the Spotlight Species Action Plan for the KBB (under the "Conduct Research" strategic action) (USFWS 2009b).

It is also important to work with forest entities interested in helping to recover the KBB especially those that are or have the potential to serve as recovery sites for the species (e.g., Clark, Eau Claire, Jackson and possibly Burnett County Forests as well as the BRSF). Assist the forest in assessing whether forestry practices can support viable KBB metapopulations for the long term. Information that would be helpful for this assessment includes locations of KBB sites, KBB population sizes in dedicated barrens areas, and an understanding of how the shifting habitat mosaic created by forest activities contributes to the metapopulation dynamic and/or how it could be modified to better support a viable population. The number and locations of dedicated barrens areas (that can act as metapopulation core areas) appears key to insuring viable metapopulations though the long term. These areas provide refugia for KBBs, help maintain the population and provide colonizers of early successional habitats resulting from forestry activities. Forest management research has been identified as a Priority 2 recovery action (Action 5.25) in the KBB recovery plan (USFWS 2003). Assessing whether forests can support viable

KBB populations is also identified as a recovery task in the Spotlight Species Action Plan for the KBB (under the "Conduct Research" strategic action) (USFWS 2009b).

Research is needed to assess whether hybridization between *L. m. melissa* (Melissa blue*)* found in western Wisconsin (near Hudson) with KBBs has the potential to threaten the genetic distinctness of the KBB in western Wisconsin. Movement of *L. m. melissa* may be facilitated by the presence of crown vetch *(Coronilla varia)*, one of their larval host plants which is found along many roadsides in Wisconsin (Dane and Lane 2005). This has been identified as a recovery task ((under the "Conduct Research" strategic action) in the Spotlight Species Action Plan for the KBB (USFWS 2009b).

Further assessment of the minimum viable population size necessary to recover the KBB for the long term would be helpful. Research by Fuller (2008) suggests that a minimal viable population (MVP) of KBBs should be a first and second brood average of 7,641-12,960 adults, or 11,217-19,025 second brood adults, maintained on average over five or more years and the average KBB number should fall within these ranges every year. More clarification is needed relative to Fuller's (2008) recommended MVP numbers e.g., for how long should these population numbers be maintained to preclude extinction, and what is the extinction risk associated with these numbers? Also, clarify the extinction risk associated with the VP and LP recovery criteria (3000 and 6000 KBBs respectively) recommended in the KBB recovery plan (USFWS 2003). Consider the results of the on-going KBB genetics research (which should identify KBB effective population size for several recovery sites across the species range) to help inform this task.

Other

The taxonomic name of KBB should be revised to *Lycaeides samuelis* if such a change continues to be supported by peer–reviewed literature. The taxonomic name revision would also direct a change in the recovery priority number to reflect the full species (rather than subspecies) status of the KBB.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of the
Karner blue butterfly (*Lycaeides melissa samuelis*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: N/A

Review Conducted By: Cathy Carnes, Green Bay, Wisconsin, Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field ~~Supervisor,~~ Fish and Wildlife Service

Approve Peter J. Fasbender Date 6 September 2012

Peter J. Fasbender

REGIONAL OFFICE APPROVAL:

Lead Assistant Regional Director, Midwest Region, Fish and Wildlife Service

Approve Lynn M. Lewis Date 9/17/12

~~Assistant~~
Cooperating Regional Director, Northeast Region, Fish and Wildlife Service

X Concur ____ Do Not Concur

Signature Paul R. Pg Date 9/18/12

APPENDIX A

KEY TO ACRONYMS AND ABBREVIATIONS

KEY TO ACRONYMS AND ABBREVIATIONS

Agencies and Organizations:

APB:	Albany Pine Bush
APBP:	Albany Pine Bush Preserve
APBPC:	Albany Pine Bush Preserve Commission
CMA:	Concord Municipal Airport
DOD:	Department of Defense
DZS:	Detroit Zoological Society
MI DNR**:**	Michigan Department of Natural Resources
MN DNR:	Minnesota Department of Natural Resources
NHF&GD:	New Hampshire Fish and Game Department
NPS:	National Park Service
NRCS:	National Resource Conservation Service
NYSDEC:	New York State Department of Environmental Conservation
OH DNR:	Ohio Department of Natural Resources
SCA**:**	Saratoga County Airport
TNC:	The Nature Conservancy
USDA:	U.S. Department of Agriculture
USFWS:	U.S. Fish and Wildlife Service
USGS:	U.S. Geological Survey
WDNR:	Wisconsin Department of Natural Resources
WIANG:	Wisconsin Air National Guard
WWPP:	Wilton Wildlife Preserve and Park

Other:

AFLP:	Applied Fragment Length Polymorphism
APB:	Albany Pine Bush (NY)
BRSF:	Black River State Forest
Btk	*Bacillus thuringiensis kurstaki*
C:	Celsius
DPS:	Distinct Population Segment
EMU:	Ecological Management Unit
EO:	Element Occurrence
ESA:	Endangered Species Act
F:	Fahrenheit
FR:	Federal Register
HCP:	Habitat Conservation Plan
HMNF:	Huron-Manistee National Forest
HPR:	High Potential Range
IDNL:	Indiana Dunes National Lakeshore
KBB:	Karner blue butterfly
LP:	Large viable metapopulation
MNF:	Manistee National Forest
mtDNA:	Mitochondrial DNA
MVP:	Minimum Viable Population
NF:	National Forest
NP:	Nature Preserve
NWR:	National Wildlife Refuge

ORV:	Off-road vehicle
PRU:	Potential Recovery Unit
RU:	Recovery Unit
SAFE	State Acres for Wildlife Enhancement Program (NRCS)
SFA	State Fisheries Area
SGA:	State Game Area
SHA:	Safe Harbor Agreement
SNA:	State Natural Area
SWA:	State Wildlife Area
VP:	(Minimum) viable population
WA:	Wildlife Area
WMA:	Wildlife Management Area

APPENDIX B

LOCATIONS OF RECOVERY SITES BY RECOVERY UNIT

Table B1. Locations of recovery sites by recovery unit [includes sites in Table B1 of KBB recovery plan (USFWS 2003) and additional potential recovery sites].

Recovery Unit *(RU unless otherwise noted)*	State	* Recovery Goals		Potential Locations
		Reclassification	Delisting	
Merrimack/Nashua River System	NH	VP	VP	Concord (includes Great Bay NWR) (reintroduction)
Glacial Lake Albany	NY	VP VP VP -	VP VP VP -	Albany Pine Bush Saratoga Sandplains Saratoga West ***Queensbury (NY Recovery Area)***
Oak Openings PRU	***OH***	-	-	***NW Ohio Oak Openings (reintroduction)***
Ionia	MI	2VP or 1 LP	2VP or 1LP	Flat River SGA
Allegan	MI	VP VP	VP LP	Allegan SGA/private lands – Sand Plains Allegan SGA/private lands - Pine Plains
Newaygo	MI	2VP	VP + LP	HMNF/private lands – Bigelow and Brohman ***HMNF - Hayes Road***
Muskegon	MI	2VP -	2LP -	HMNF/private lands (White River and Otto) ***Muskegon South (Muskegan SGA/ private lands)***
Oak Opening PRU	***MI***	-	-	***Petersburg SGA (reintroduction)***
Indiana Dunes	IN	2VP VP	2VP VP	IDNL West Gary on TNC and other private lands
Morainal Sands	WI	(1LP)	LP VP or LP VP or LP -	Hartman/Emmons/Welch Complex White River Marsh WA Greenwood WA ***Private Landowner (Marquette Co.)***
Glacial Lake Wisconsin	WI	LP LP (2VP)	LP LP VP VP VP east of Wis. River	Necedah NWR Meadow Valley WA Sandhill WA Hardwood Range – Air National Guard Quincy Bluff (TNC)
West Central Driftless	WI	VP 2LP LP	VP 2LP LP	Black River State Forest Fort McCoy **(**North Post and South Post) Jackson County Forest (possibly)
Wisconsin Escarpment and Sandstone Plateau	WI	VP	LP	Eau Claire and Clark County Forests (possibly)
Superior Outwash	WI	2VP	2VP or 1LP	Glacial Lakes Grantsburg (Crex Meadows and Fish Lake State WAs)
Paleozoic Plateau	MN	2VP or 1LP	2VP or 1LP	Whitewater WMA

Notes*:*

*Summary of Goals:	VPs	LPs	Minimum No. of VPs and LPs	Total Minimum No. of VPs and LPs
Reclassification:	19-23	6-8	19 VPs and 8 LPs (27) or 23 VPs and 6 LPs (29)	27
Delisting:	13-21	11-16	13 VPs and 16 LPs (29) or 21 VPs and 11 LPs (32)	29

( ) = location of metapopulation not designated to a specific site, can occur at any location

Some additional clarifying site names (e.g., North Post and South Post for Fort McCoy, and White River and Otto for HMNF/private lands), have been added; these site names were not in the original Table B1 of the KBB recovery plan (USFWS 2003).

Gray shaded italics (bold) = One existing site (Queensbury), 3 newer sites and 2 reintroductions (total of 6 sites); these sites could substitute for other recovery sites (noted on Table B1) should they meet recovery criteria.

Refer to Appendix A for a key to acronyms and abbreviations.

Source: This table derived from Table 4 and Table B1 in the KBB recovery plan (USFWS 2003).

APPENDIX C
Summary of the Status of Karner Blue Butterfly Populations by State and Recovery Unit

TABLE OF CONTENTS

Summary of the Status of Karner Blue Butterfly Populations by State and Recovery Unit

The KBB currently occurs in 7 states across the species range: New Hampshire, New York, Michigan, Indiana, Ohio, Wisconsin, and Minnesota. The KBB recovery plan (USFWS 2003) recommends recovering KBB metapopulations in 13 recovery units (RUs) that capture the variation in the ecoregions found within the KBB range. The RUs were established to preserve possible geographically associated KBB genetic variation across the species range and to buffer against large-scale stochastic variation (e.g., from weather events or catastrophic disturbance) by providing an adequate number of widely dispersed metapopulations in a wide range of habitat types (USFWS 2003). Appendix B, Table B1 includes the KBB RUs, and the numbers and locations of metapopulations (VPs and LPs) recommended for reclassification and delisting in the KBB recovery plan (USFWS 2003, Table B1) as well as additional potential recovery sites identified since completion of that plan.

Information on the status of the KBB in each state and at each recovery site is summarized below by state and RUs within each state. The status of the KBB in potential recovery units (PRUs) is also summarized below. Refer to section 2.2.3 for a review of the recovery goals and recovery criteria in the KBB recovery plan (USFWS 2003). Refer to Table 1 (in section 2.2.3) for a summary of the recovery sites that have sufficient KBB second flight population estimates to determine whether the reclassification or delisting criteria as recommended in the KBB recovery plan (USFWS 2003) have been met.

Table C1 (at the end of this Appendix) summarizes the amount of occupied habitat (in acres), and number of subpopulations present on KBB recovery sites across the range, and on other larger forested landscapes in Wisconsin. Appendix D, Table D1 summarizes available KBB second flight population data for sites across the range.

RECOVERY UNITS

New Hampshire

Merrimack/Nashua River System Recovery Unit

One KBB metapopulation is being restored in this RU in Concord.

1. *Concord metapopulation (Reclassification: VP; Delisting: VP)*

The KBB has been monitored at the Concord site since about 1985. The site is a remnant of the Concord Pine Barrens, the pitch pine/scrub oak barrens that once stretched along the Merrimack River Valley from Canterbury to Nashua, New Hampshire (NHF& GD 2007). The KBBs numbered in the thousands here during the 1980s, declined to less than 24 in 1999, and likely disappeared completely in 2001. From 1993 to 2000 (prior to the reintroduction program) there were attempts to captive rear small numbers of the remaining KBBs in New Hampshire. In

2000, a KBB reintroduction program began with eggs collected from New York; the first release of captive reared KBBs at Concord occurred in 2001. The goal is to restore a VP to the site.

The *Concord Municipal Airport Development and Conservation Management Agreement*, an agreement between the city of Concord, New Hampshire Fish and Game (NHFGD), the USFWS, NH Department of Resources and Economic Development, NH Army National Guard, and NH Department of Transportation - Division of Aeronautics allows management of KBBs on 434 acres of habitat located on airport safe-ways and in areas outside of the airport fence at the Concord Municipal Airport (CMA) in the Concord pine barrens. This includes a 29 acre easement held by the USFWS that began as the initial release site for the reintroduced population. The area under this agreement area is divided into 8 conservation zones. The 8 conservation zones are divided into 52 management units and managed by NHFGD with assistance from conservation partners (Heidi Holman, NHF&GD, pers. comm., 2011). The Habitat Management and Monitoring Plan for the Concord Municipal Airport (Fuller et al. 2007) provides guidelines to implement the preservation, protection, and propagation of Federal and State threatened and endangered species and their habitats in the Concord pine barrens. That plan includes the goal of meeting the KBB viability goals recommended in the KBB recovery plan (USFWS 2003).

KBBs are also being managed on a small parcel of land along a power line right-of-way north of the airport conservation zones and on 15 acres of land on the State Military Reservation managed by the Army National Guard (the captive rearing facility is also located here) (Heidi Holman, NHF&GD, pers. comm., 2011). Management includes mowing, forest reduction, herbicides, fire and planting. Habitat management on 323 acres (2001-2010) has increased the heterogeneity of woodlands, shrublands and grasslands across the airport property, allowing successful establishment of new lupine and nectar habitat patches (Holman and Fuller 2011).

KBBs have been reintroduced in all the conservation zones except for the South Airport Zone. Several thousand captive reared butterflies have been reintroduced since the start of the program e.g., in 2011, 666 adult butterflies were released (Webb and Gifford 2011). The KBB population at Concord represents the eastern most extent of the species' range and is separated from the nearest population in New York by over 225 kilometers (140 miles). The Concord metapopulation currently contains 9 KBB subpopulation areas, with 6 of them occupied. Each subpopulation is located no more than 500 meters away from its nearest neighbor (Heidi Holman, NHF &GD, pers. comm., 2011).

Results from mark-recapture surveys conducted in 2004 to 2010 indicate that wild KBB numbers have been increasing for both spring and summer broods annually, with second brood recapture numbers remaining above 300 butterflies since 2007 (Lindsay Webb, NHF&GD, pers. comm., 2010). The peak estimates for the 2010 spring and summer population were 1212 and 2442 KBBs respectively (Holman and Fuller 2011). Mark-Release-Recapture (MRR) is used to confirm the extent of KBB establishment at the CMA every year and presence/absence surveys are conducted in each zone every-other year (NHF&GD 2007). Partners in the reintroduction program include NHF&GD, Air National Guard, NH Army National Guard, City of Concord, the USFWS, Roger Williams Park Zoo, and the New England Conservation Collaborative.

Concord Schools have also been growing lupine and planting it in the conservation area for 10 years (Heidi Holman, NHF&GD, pers. comm., 2011).

New York

Glacial Lake Albany Recovery Unit

Partners are working on restoring 3 KBB metapopulations within this RU: Albany Pine Bush (APB), Saratoga Sandplains, and Saratoga West. The New York State Department of Environmental Conservation (NYSDEC) is also working on recovering the KBB at a fourth site, Queensbury (recovery here is above and beyond the recovery goals identified in the KBB recovery plan).

Results of studies conducted by Bried et al. (2006) at the 4 New York recovery sites noted above indicated habitat suitability varied greatly and over-story cover was often too low or too high at sites. Bried (2008) found that of 46 patches examined at the 4 recovery sites, 80% achieved a score of "good" or better. Restoration efforts have been successful in improving available lupine at all locations, and all but two of the 46 habitat patches sampled were above the recovery plan objective (500 lupine stems for small habitat patches). The most frequent source of low habitat quality ratings were linked to habitat structure with high grass cover, low over-story cover and low shade heterogeneity equally common across the recovery sites. Conditions at recovery sites varied with low lupine abundance a limiting factor in the Albany Pine Bush recovery area and inadequate habitat structure as the primary habitat management issue to address in the other three recovery sites (Saratoga Sandplains, Saratoga West (Airport) and Queensbury).

1. *Albany Pine Bush metapopulation (Reclassification: VP; Delisting: VP)*

The Albany Pine Bush Preserve (APBP) is approximately 1,255 hectares (3,200 acres) in size (Bried and Gifford 2010) and supports 10 KBB sub-populations on a fragmented landscape. About 300 acres are occupied by the KBB and another 1,150 acres of potential KBB habitat is present. Of the 10 sub-populations, 9 are located within 1 kilometer (0.62 miles) of at least one other subpopulation, and most are within 1 kilometer (0.62) of two subpopulations (Neil Gifford, APBPC, pers. comm., 2010). The "Management Plan and Environmental Impact Statement for the Albany Pine Bush Preserve" was completed in 2010 (APBPC 2010); the plan includes recovery of a KBB metapopulation consistent with the recovery criteria in the KBB recovery plan (USFWS 2003).

The KBB population at the APBP increased significantly in the last year (2011), reflecting efforts made to restore habitat and increase connectivity between subpopulations and to augment the population. Population abundance has been determined from about one half of the occupied sites that contain most of the KBB population. Second flight population numbers from 2007 to 2010 were: 414, 265, 345 and 450-650 KBBs respectively (Jason Bried, APBC, pers. comm., 2010). In 2011, the population increased to about 2,182 KBBs second flight (Gifford et al. 2011) (refer to Table D2). The population increase likely reflects the success of the on-going population augmentation program. Since 2008, captive reared KBBs (late instar pupae) have

been released at various APBP sites. In 2008 and 2009 releases numbered about 1000 and 660 KBBs respectively. In 2010, due to a 4th of July heat wave (greater than 100 °F for at least 2 days), of 2,146 pupae released, 1,538 successfully eclosed and 608 suffered mortality due to the heat wave (Neil Gifford, APBPC, pers. comm., 2008-2010). In 2011, 1,715 adults were released across 113 acres at 7 sites in the APBP (Webb and Gifford 2011).

2. Saratoga Sandplains metapopulation (Reclassification: VP; Delisting: VP)

The Saratoga Sandplains KBB metapopulation is being restored through the combined efforts of the Wilton Wildlife Preserve and Park (WWPP), The Nature Conservancy (TNC), and NYSDEC. This metapopulation is located within and to the northeast of the City of Saratoga Springs in the towns of Wilton and Northumberland. Restoration efforts have focused on restoring and maintaining early successional habitat for a suite of species whose populations have declined with the suppression of fire and the increase in development. Currently the Saratoga Sandplains metapopulation supports the largest KBB population in the eastern United States. Since 2003, KBB habitat has increased significantly at this site, from 5 acres to over 125 acres. The restoration work which included tree removal (e.g., dense locust stands) and planting of lupine, grasses, and nectar species resulted in a dramatic population increase of from less than 1,000 KBBs in 2003 to more than 20,000 butterflies in 2010 (Chris Zimmerman, TNC, pers. comm., 2010) (refer to Table D1). The recovery of this population is a success story demonstrating how the combined efforts of partners and funding opportunities are successfully restoring a viable KBB metapopulation. The total estimated grant funding applied to restoration activities from a number of sources is estimated to be $432,000 (Chris Zimmerman, TNC, pers. comm., 2010).

Work is currently underway on a draft Unit Plan for the Saratoga Sandplains KBB metapopulation. The vast majority of this metapopulation is concentrated in protected sites owned by the NYSDEC and TNC where most of the habitat restoration work has taken place. Seven occupied subpopulation areas occur on these protected lands as well as an additional 3 potential habitat areas that were historically occupied by KBBs. Five of the subpopulations have been identified as core subpopulations that have the potential to meet the KBB viable subpopulation criteria recommended in the KBB recovery plan (USFWS 2003). It is possible that some satellite subpopulations may be expanded in order to meet the viable subpopulation criteria as additional lands are protected (Kathy O'Brien, NYDEC, pers. comm., 2011).

The southwestern portion of the Saratoga Sandplains metapopulation area is heavily developed along Route 50 which bisects the metapopulation area, however, it is presently not considered a barrier to dispersal. The majority of the area remaining in the Saratoga Sandplains metapopulation area is characterized by forest and agriculture. Management is needed to improve connectivity. A railroad corridor along with roadside lupine patches is thought to currently serve as a means to foster movement between sites (Kathy O'Brien, NYDEC, pers. comm., 2011).

3. Saratoga West metapopulation (Saratoga Airport) (Reclassification: VP; Delisting: VP)

The Saratoga West metapopulation is composed of 9 KBB subpopulations, the largest being Saratoga Airport which includes 293 acres of KBB habitat; the remaining sites are small (4 to 6 acres in size with some less than 1 acre in size) and most sites are either in power line rights-of-way or are small patches imbedded in grassy or forested matrices (Kathy O'Brien, NYSDEC, pers. comm., 2011). The metapopulation is very fragmented. One subpopulation, Saratoga Spa State Park, is separated from other subpopulations by manicured lawns, a golf course, a wide road and wetland. The most connected sites are those within a large power-line corridor running through an industrial park (Geyser Road Railroad). While the power-line corridor is located within dispersal distance of the Saratoga Airport, wetlands and multiple private ownerships in the power-line right-of-way make creating habitat within substantial portions of the power-line route difficult, but not impossible. Fragmentation from residential and commercial development separates the other sites. Except for the airport and Spa Park, none of the sites receive management meant to benefit the KBB.

The Saratoga County Department of Public Works (County) manages KBB habitat as part of their normal vegetation management activities through authorizations from a USFWS Biological Opinion to the Federal Aviation Administration (USFWS 2011a). A major limiting factor to the KBB population at the airport site is the homogeneity of the habitat which decreases the butterfly's probability of survival e.g., from adverse weather conditions, such as frosts or high winds. Other threats include poorly distributed nectar plants, some management practices and uses at the site, and limited opportunities to create new habitat patches adjacent at the airport (USFWS 2011a). In 2010, the KBB population at Saratoga Airport was 1,450-2,050 KBBs based on distance sampling (Jason Bried, TNC, pers. comm., 2010). Numbers at the remaining subpopulation sites (found by doing searches) were very low ranging from 0 (Spa Park, Geyser Road and Rowland Street) to 35 KBBs (Geyser Road Railroad). KBB trend data has shown a long term population decline at several of the smaller Saratoga West sites (Kathy O'Brien, NYSDEC, pers. comm., 2008). The Saratoga County Airport Master Plan includes a Draft Management Agreement between the NYSDEC and the County for Endangered Species Management and a Draft Operations Agreement for Glider Activity at the airport between the NYSDEC, County, and the Saratoga Soaring Association. The two agreements are in draft form, but are being used by the County to minimize impacts to KBB (USFWS 2011a). The management agreement will be finalized in the form of an incidental take permit under New York State's new incidental take regulations.

Other sites in the Glacial Lake Albany RU:

Queensbury: As mentioned above, this metapopulation is part of the State of New York's recovery plan, and goes beyond the recovery goals identified in the Federal KBB recovery plan (USFWS 2003). In 2010, this population was reduced to one habitat area along a power-line, with low numbers of KBBs observed (Kathy O'Brien, New York State Department of Environmental Conservation, pers. comm., 2010).

Michigan

Muskegon Recovery Unit

The Huron-Manistee National Forest (HMNF) is recovering two KBB metapopulations in this RU, the White River and Otto metapopulations (Kelly 2004) located north of the Muskegon River (John Lerg, MDNR pers. comm., 2010). Recovery goals for the KBB noted in HMNF's Draft Habitat Management Strategy Plan (Kelly 2004) are consistent with the KBB recovery plan (USFWS 2003). Dunn (2008) advises that management is urgently needed to release lupine and nectar plants from the heavy cover of over-story tree shade and the invasion of sedge and woody plants in the Muskegon RU in Michigan. Information on the two metapopulations is summarized below:

*1. Otto metapopulation (Reclassification: VP; Delisting: LP***)**

The Otto KBB metapopulation totals about 240 acres in about 40 subpopulations. Second flight KBB population numbers ranged from a low of 1,631-2,308 in 2006 to a high of 6,727-9,420 in 2007 (refer to Appendix D, Table D1 for a complete summary of second flight population data from 2006-2009). In 2009, the average relative abundance was estimated at 13 KBBs/ kilometer (0.62 miles), and distance monitoring estimated the metapopulation at between 3,423 and 3,993 butterflies. Subpopulations appear to be well connected (Keough 2009). The metapopulation supports at least 5 subpopulations with an average lupine stem density of ≥500 stems per acre, and at least 5 subpopulations with an average lupine stem density of ≥1,000 stems per acre. The Otto metapopulation is located within what was historic oak/pine and oak/pine barrens ecosystems The climate is moderated by Lake Michigan and there is considerable topographic relief in this area.

*2. White River metapopulation (Reclassification: VP; Delisting: LP***)**

The White River KBB metapopulation totals about 199 acres in 21 subpopulations. Second flight KBB population numbers ranged from a low of 441-617 in 2006 to a high of 2,433-3,406 in 2008 (refer to D1 for a complete summary of second flight population data from 2006-2009). In 2009 only 8 of the 21 subpopulations were occupied; the average relative abundance was estimated at 2 KBBs/kilometer (0.62 miles); distance sampling estimated the KBB population to be between 760 and 885 butterflies. There appears to be two isolated subpopulation groups within the White River metapopulation separated by approximately 2 miles. This lack of connectivity may be improved with management. White River is the only other metapopulation on the HMNF other than the Otto metapopulation that has at least 5 subpopulations with an average lupine stem density of ≥500 per acre, and at least 5 subpopulations with an average lupine stem density of ≥1,000 per acre (Keough 2009).

Connectivity between subpopulations in the Otto and White River metapopulations suggest that a re-evaluation may be necessary to determine if the two separate metapopulations should be combined to form a single metapopulation (Keough 2009). This is because the farthest distance between the two metapopulations appears to be about a half mile (Keough 2009) well within the

2 km (1.24 miles) maximum distance between subpopulations recommended in the KBB recovery plan (2003).

Other KBB Sites in the Muskegon RU

Burns Lake: This area is located approximately 8.8 kilometers (5.5 miles) southeast of the Otto metapopulation in the HMNF, and is composed of five isolated subpopulations covering 15 acres. These five subpopulations occur as two groups that are isolated from one another as well as from the Otto and White River metapopulations. Population numbers have been declining, with distance samplings estimating minimum KBB abundance at 93-130 in 2006, 46-64 in 2007, and 0 in 2008 and 2009 (Keough 2009).

Newaygo Recovery Unit

The HMNF is working to recover two KBB metapopulations in this RU, the Bigelow and Brohman metapopulations (Kelly 2004).

1. Bigelow metapopulation (Reclassification: VP; Delisting: LP)

The Bigelow metapopulation is made up of 4 subpopulations on about 81 acres in the HMNF. Second flight KBB population numbers ranged from a low of 1,011-1,058 in 2009 to a high of 7,617-10,663 in 2007 (refer to Appendix D, Table D1 for a complete summary of second flight data from 2006-2009). When monitoring was conducted in 2009, all 4 subpopulations were found to be occupied; average relative abundance was estimated at 13 KBBs/kilometer (0.62 miles). Three of the 4 subpopulations occur within 1 kilometer (0.62 miles) of each other, while 1 subpopulation is located at least 4.9 kilometers (approximately 3 miles) away to the east (Keough 2009), further than the 2 kilometer (1.42 miles) maximum distance recommended for connectivity by the recovery plan (USFWS 2003).

2. Brohman metapopulations (Reclassification: VP; Delisting: VP)

The Brohman metapopulation in Newaygo County is likely extirpated. It contained 4 KBB subpopulations that were well connected [within 1 kilometer (0.62 miles) of each other] on a total of 20 acres. No KBBs were reported present in any of the subpopulations from 2006-2009 (Keough 2009).

3. Hayes Road metapopulation (new metapopulation)

Due to the lack of KBBs in the Brohman metapopulation area, HMNF is recommending shifting the recovery site to the Hayes Road area which includes a 15 acre parcel (Hayes) of good habitat on land owned by Ducks Unlimited; Ducks Unlimited will be transferring this property over to the U.S. Forest Service securing the site for recovery purposes (Heather Keough, HMNF, pers. comm., 2011). The Hayes Road subpopulation is located about 5.8 kilometers (3.6 miles) north of the Brohman metapopulation. Second flight KBB population numbers at the Hayes Road site ranged from a low of 1,986-2,780 in 2006, to a high of 8,423-11,792 butterflies in 2007 with

2008 numbers similar to those of 2007. When monitoring was conducted in 2009 at the Hayes Road site, average relative abundance was estimated at 216 KBBs/kilometer (0.62 miles) and distance sampling revealed a drop in KBB abundance to 3,767- 4,395 butterflies (Keough 2009), however, the site still met the annual VP criteria of 3000 KBBs.

The Newaygo Prairies Conservation Area Plan includes land management goals for most of east-central Newaygo County, Michigan. Those goals focus on creating an interconnected landscape of prairie, savanna, forest, and marshes that spans multiple public and private ownerships connected where possible by corridors or "stepping stones." Habitat will be maintained through prescribed burning, and mechanical/manual vegetation removal. The KBB is a primary focus of this effort. Plans include excluding deer from small, highly sensitive areas in order to document the effects on the butterfly (Legge and Pearsall 2009). It is anticipated that this conservation planning effort will compliment recovery efforts for the KBB in the Newaygo RU.

Other KBB sites in the Newaygo RU:

Four KBB subpopulations occur on a total of about 22 acres east of the Bigelow metapopulation. These subpopulations lack connectivity (are isolated), occur at least 3.3 kilometers away from one another, and 7.6 kilometers from the nearest subpopulations within the Bigelow metapopulation. Population numbers here have ranged from a low of 0 in 2008 to a high of 93-130 in 2006 (2007: 46-64 KBBs). When monitoring was conducted in 2009, only one of the four subpopulations was found to be occupied, average relative abundance was estimated to be 0.3 KBBs/kilometer (0.62 miles), and distance sampling estimated overall KBB abundance to be one butterfly (Keough 2009).

Allegan Recovery Unit

The KBB recovery plan (2003) recommends recovery of two KBB metapopulations in this RU. The Michigan Department of Natural Resources (MIDNR) is working to restore 3 metapopulations as noted below. The climate of this RU is moderated by Lake Michigan, and there is minimal topographic relief (John Lerg, MIDNR, pers. comm., 2010).

1. Allegan State Game Area (Reclassification 2 VPs; Delisting 1 VP and 1 LP)

Allegan SGA which is approximately 50,000 acres in size is located in the sand lake plain ecosystem (oak and oak/pine barrens communities) in west-central Allegan County and supports one of the largest remaining populations of the KBB in the state of Michigan. KBBs occur on about 2,199 acres. In addition, there are about 57 potential habitat acres at Allegan SGA and additional occupied habitat on nearby private land. In 2011, 916 KBBs were recorded from transect counts (this is not a population estimate but likely indicates a more stable population); the overall KBB density was 0.04 KBBs/meter of transect (4 KBB/km), and presence/absence surveys confirmed KBBs at 38 sites (Maria Albright, MIDNR, pers. comm., 2011). Efforts to recover two KBB metapopulations are on-going in and around Allegan SGA as further discussed below.

a. Sand Plains metapopulation: The MIDNR goal is to recover a LP. Covering over 10 square miles, about 2/3 of the Sand Plains metapopulation is located on the Allegan State Game Area (SGA) with the remaining habitat on private lands. MIDNR has informal arrangements at the local level with some of the private landowners that enhance KBB management. The KBB metapopulation area is bounded by the Kalamazoo River on the north and Swan Creek on the east and includes over 5 robust, well connected subpopulations (John Lerg, MIDNR, pers. comm., 2010).

b. Pine Plains metapopulation**:** The MIDNR goal is to recover a LP. Covering over 10 square miles, the Pine Plains metapopulation is largely included on Allegan SGA with the remaining sites on private lands. MIDNR has informal arrangements at the local level with some of the private landowners that enhance KBB management. The metapopulation is bounded by the Kalamazoo River on the north and Swan Creek on the west. The metapopulation includes over 5 KBB subpopulations, less well connected than in the Sand Plains metapopulation but with the potential for improvement (John Lerg, MIDNR, pers. comm., 2010).

- The above two metapopulations are bisected by Swan Creek and its associated river bottom which may be a barrier to KBB dispersal (more so than the Flat River at the Flat River SGA), however this is as yet unknown. Genetics samples were taken from one KBB subpopulation in each of the Sand Plains and Pine Plains metapopulations during the summer of 2010 which may help determine whether these two sites are separate metapopulations or one large metapopulation. If they are one metapopulation, then the Muskegon South takes on added importance. The KBB metapopulation on Allegan SGA was considered stable in 2010 due to very favorable habitat growing conditions (John Lerg, MIDNR, pers. comm., 2010).

The Allegan SGA Master Plan is compatible with management for the KBB and at least a dozen other threatened and endangered species and imperiled natural communities (John Lerg, MIDNR, pers. comm., 2010). Protection and recovery efforts have been initiated for the KBB and all recovery plan elements applicable to the SGA are being implemented (MIDNR 2004).

c. Muskegon South metapopulation: The goal is to recover a LP. The Muskegon South metapopulation is located south of the Muskegon River in northern Muskegon County and southern Newaygo County. The metapopulation includes over 5 KBB subpopulations (John Lerg, MIDNR, pers. comm., 2010) which occur mostly along powerline rights-of ways (ROW) in both Muskegon and Newago counties; a total of about 5 miles of ROWs contain scattered KBB habitat (Nick Kalejsg, MI DNR, pers. comm., 2011). While 10 square miles of local landscape has been identified for the metapopulation, there is still a need to identify the 640 acres of potential habitat that can be managed for the KBB. Less than half of the 10 square miles is in state ownership, and therefore development of a LP here would require management cooperation between private, County (e.g., Muskegon County Waste Water Facility), and State owners, probably utilizing the Michigan Statewide KBB HCP as the medium for that cooperation. As the Muskegon SGA Master Plan is developed, the intent is that it will be compatible with KBB recovery criteria (John Lerg, MIDNR, pers. comm., 2010).

Ionia Recovery Unit *(Reclassification: 2 VP or 1 LP; Delisting: 2 VP or 1 LP)*

The climate of this RU is somewhat moderated by Lake Michigan and the RU has considerable topographic relief.

1. Flat River State Game Area

A large KBB metapopulation (LP) is being recovered on a combination of Flat River SGA and private lands. Some private owners are informally coordinating locally on conservation of the butterfly. Habitat consists of oak barrens in southern Montcalm and northern Ionia counties. Over 5 KBB subpopulations are scattered throughout a 10 square miles area, some of which are robust while others continue to struggle despite habitat management efforts (John Lerg, MIDNR, pers. comm., 2010). During the last eight years, sites on the Flat River SGA have been managed for KBBs; some of the sites are likely isolated due to the presence of habitat barriers (e.g., closed canopy forest and dense lowland brush). Management efforts include removing and reducing canopy through hand-cutting, mowing, limited herbicide, and prescribed fire to encourage lupine and other nectar plants and to promote dispersal among subpopulations. In 2011 the Flat River SGA supported a total of about 145 acres of KBB habitat spread over 6 sites (John Niewoonder, MIDNR, pers. comm., 2011). More lupine is present on KBB sites at Flat River SGA than at Allegan SGA. In 2011, 1,147 KBBs were recorded from transect counts (this is not a population estimate but likely indicates a more stable population); the overall KBB density was 0.05/KBBs per meter (5 KBBs/km) of transect **(**Maria Albright, MIDNR, pers. comm., 2011).

The Flat River SGA Management Plan was completed in 1989 and currently does not address KBB recovery. The management plan is in the process of being updated and will include information on, and management for KBBs; it is anticipated that it will support recovery of a viable metapopulation of KBBs at the Flat River SGA compatible with the recommendations of the KBB recovery plan (USFWS 2003) (John Niewoonder, MIDNR, pers. comm., 2011).

Indiana

Indiana Dunes Recovery Unit

KBB metapopulations are being recovered in two locations within this RU, Indiana Dunes National Lakeshore (IDNL) and West Gary. Extant populations in Indiana are restricted to dune and lake-plain communities associated with Lake Michigan.

1. IDNL metapopulation (Reclassification: 2VP; Delisting: 2VP)

IDNL currently supports 8 KBB sites on about 1,450 acres. Those sites are: Inland Marsh, Tolleston Dunes, Marquette Trail, West Beach, Miller Woods, Burns Ditch, Long Lake, and Howes Prairie. Most sites, based on trend data, have shown a long term decline, with the exception of the Miller Woods and Long Lake sites which have displayed more stable populations. The largest total KBB count for this metapopulation was in 1999 with a first brood count of 526 butterflies and a second brood count of 779 butterflies. From 2007-2011 KBB

trend data yielded the 4 lowest total population numbers; the deceasing trend continued in 2011 (Randy Knutson, NPS, pers. comm., 2010 and 2011). The National Park Service (NPS) has a draft KBB management plan that requires updating; the plan includes the recovery of 2 KBB VPs that meet the recovery criteria in the KBB recovery plan (2003).

2. West Gary metapopulation (Reclassification: VP; Delisting: VP)

The West Gary KBB metapopulation is composed of a series of fragmented natural areas in Gary, Hammond, and East Chicago, Indiana, and represents the western extension of the KBB's range in the state. Currently there are approximately 1,000 acres of dune and swale topography remaining in the West Gary area, and of this approximately 650 acres are potentially suitable KBB habitat. The Safe Harbor Agreement (SHA) between TNC and the USFWS (USFWS 2006b) describe these areas as fragmented, 15 to about 200 acres in size, and imbedded in a matrix of residential and industrial land uses. The metapopulation includes three core areas (on a total of about 380 acres), each of which will support one permanent KBB subpopulation consistent with the core-satellite metapopulation model in the KBB recovery plan (USFWS 2003), and the metapopulation strategy envisioned in the original West Gary KBB Reserve Design developed by John Shuey (undated). The three core areas are Ivanhoe Dune and Swale Nature Preserve (NP), Dupont Natural Area, and the Gibson-Woods Tolleston Ridges Complex; these core areas support large areas of high quality to moderately degraded oak savanna sufficient to support KBB subpopulations (USFWS 2006b). The SHA core site restoration plans are designed to create a network of habitat patches in each core area that maximize available habitat and allow the site to be divided into multiple burn units (Paul Labus, TNC, pers. comm., 2011). A brief description of the three core reserves (KBB subpopulations) follows:

Ivanhoe Dune and Swale Complex

This complex is composed of two units, Ivanhoe east (approximately 40 acres) and Ivanhoe west (approximately 80 acres). Both of these units are dedicated nature preserves owned and managed by TNC. TNC's restoration and management plan for this area which is part of the KBB augmentation program requires five years of KBB monitoring following release of KBBs at the site.

DuPont Dune and Swale

This area is comprised of approximately 180 acres of remnant natural area owned by The DuPont Corporation, adjacent to their East Chicago facility. TNC has a legal agreement with the company that permits ecological management at the site. Indiana DNR was granted a conservation easement on the property as part of a Natural Resources Damage Claim. TNC has a signed management agreement with the State that allows for implementation of the SHA restoration plan for the DuPont property (Paul Labus, TNC, pers. comm., 2011).

Gibson Woods and Tolleston Ridges Complex

Both of these areas are State dedicated nature preserves that are owned and managed by Lake County Parks and Recreation Department and TNC. Gibson Woods and Tolleston Ridges are about 120 and 50 acres in size respectively. A mowed pipeline right-of-way

at Tolleston Ridges is the only remaining occupied KBB habitat between the two preserves.

Based on surveys conducted in 2011, the KBB West Gary metapopulation currently consists of 1 subpopulation at Ivanhoe Dune and Swale Complex occupying about 80 acres, 1 subpopulation at Tolleston Ridges NP occupying about 4 acres, and 1 subpopulation at Dupont Dune and Swale Natural Area occupying about 40 acres (John Drake, TNC, pers. comm., 2011).

Multiple potential KBB satellite sites are interspersed within the landscape that separates the three core reserve sites. The satellite sites provide supplemental habitat patches that are anticipated to support temporary populations of KBBs and/or (when occupied) boost gene flow between the three core areas. Since the landscape of the West Gary metapopulation is heavily modified and includes many physical impediments to dispersal (such as highways and buildings), the 1 kilometer average nearest-neighbor distance between habitat patches (recommended in KBB recovery plan) is considered too large to ensure successful interaction between sites in this metapopulation area. In order to enhance the chances for success, potential satellite sites are located within 500 meters of the core reserve sites with preference given to potential project sites located within 500 meters of more than one core site (USFWS 2006b).

Per the SHA (USFWS 2006b), "the most important ecological goal relative to KBB conservation is to expand available habitat in the core preserves. Ideally, habitat patches will include canopy openings of at least 20 meters and a minimum of 500 stems of lupine growing in both full sun and partial shade. This can be accomplished by 1) restoring open canopy structure in oak savanna areas, 2) controlling understory shrubs and saplings, and 3) supplementing lupine populations. After restoration, ongoing ecological management will be required to maintain early successional habitat conditions. The majority of tracts that comprise the core preserves are currently managed for conservation purposes. KBB related management activities will need to be integrated into the broader ecological objectives and management regimes for each site." Pollard-Yates KBB surveys will be done by the TNC at core sites and habitat that has reached the above noted habitat goals will be mapped. At satellite sites habitat assessments will be conducted as well as KBB presence/absence surveys (USFWS 2006b). Due to limited habitat it may be difficult to achieve the 3,000 KBB metapopulation goal in West Gary (John Drake, TNC, pers. comm., 2011).

The SHA enables The Nature Conservancy to work with private landowners to restore and manage KBB habitat in the West Gary metapopulation area. The USFWS's Partners for Fish and Wildlife Program, cooperated with the Shirley Heinz Land Trust (a KBB satellite site) between 2005-2008 to restore dune and swale habitat for the KBB on their preserve immediately south (across U.S. Highway 20) from Ivanhoe Dune and Swale (Forest Clark, USFWS, pers. comm., 2011).

From 2006 to 2010, TNC conducted a KBB captive rearing program, raising butterflies that were used to augment the West Gary and IDNL KBB metapopulations. Several hundred butterflies were raised over the 5 year program and released at Ivanhoe Dune and Swale NP, Dupont Natural Area, and Tolleston Ridges NP in West Gary and at Howe's Prairie at IDNL. Surveys indicated that captive reared butterflies successfully colonized previously unoccupied areas

within Ivanhoe Dune and Swale NP and Dupont Natural Area over the course of the program. There were two unconfirmed reports of KBBs, one from Ivanhoe South (Shirley Heinze Land Trust) and another located north of I-90 within the Gary-Chicago Regional Airport. Both unconfirmed and confirmed records were located within 500 meters of known occupied habitat. TNCs captive rearing program ended in 2010. In coming years, TNC plans to focus on monitoring to assess the KBB population response to the augmentation and habitat work and to continue to restore and manage habitat for the butterfly (John Drake, TNC, pers. comm., 2011).

Wisconsin

Morainal Sands Recovery Unit

The Wisconsin DNR and a private landowner are working on recovering the KBB at three metapopulation areas in this RU: the Hartman/Emmons/Welch Complex, White River Marsh State Wildlife Area (SWA), and Greenwood SWA.

1. Hartman/Emmons/Welch Complex metapopulation (Reclassification: LP; Delisting: LP)

The Hartman/Emmons/Welch Complex has a goal of restoring one LP on three contiguous properties in Portage and Waupaca counties: Hartman Creek State Park (SP), Emmons Creek State Fisheries Area (SFA) and private property owned by Bob Welch. This metapopulation includes the Emmons Creek Barrens which supports a semi-open oak savanna and is located within Hartman Creek SP and Emmons Creek SFA. The KBB population estimates for 2008-2011 for this metapopulation complex were 5,850, 3,509, 6,219 and 6,403 respectively (WDNR 2011); refer to Appendix D, Table D1. More information on the individual recovery properties is summarized below.

Emmons Creek SFA: The Emmons Creek SFA is approximately 1500 acres in size and is located along the southern edge of Hartman Creek State Park. About 208 acres of KBB habitat exists on the property, with 101 acres occupied by KBBs. Natural openings and old fields from past farming practices that have been planted with native grasses and forbs (including lupine) provide habitat for the butterfly.

Hartman Creek SP: Hartman Creek SP is adjacent to Emmons Creek SFA. About 13 acres of occupied KBB habitat exists on the property and there are plans to restore an additional 165 acres of habitat for the KBB (Bob Hess, WDNR, pers. comm., 2011).

Welch Property (Waupaca Field Station): This property located in Portage and Waupaca counties about 8 miles west of Waupaca and is owned by Bob Welch, a private landowner and ecologist who is actively maintaining and restoring KBB habitat on the property. It includes a 155-acre easement purchased by the WDNR that comprises about 77.5% of the Emmons Creek Barrens SNA (Bob Welch, pers. comm., 2011); the SNA supports a semi-open savanna and dense patches of wild lupine. The remaining portions of Emmons Creek Barrens SNA lie within Hartman Creek SP (20-acres) and Emmons Creek SFA (25-acres). The KBB sites on the Welch property provide an important link to KBB sites in Hartman Creek SP and Emmons Creek SFA.

Currently a total of 75 acres of KBB habitat are present on the Welch tract (including the conservation easement) supporting 2 KBB subpopulations (Bob Welch, pers. comm., 2011). The land has been managed for KBBs since 1990. Further management involves converting pine plantation and oak woodland to oak savanna and sand prairie. The Welch property has operated since 1982 as the Waupaca Field Station (a not-for-profit organization) for the purpose of land stewardship, research, and education. The USFWS's Partners for Fish and Wildlife Program has assisted with KBB habitat restoration work on this property.

2. White River Marsh SWA metapopulation (Reclassification: None; Delisting: VP or LP)

White River Marsh SWA is a 12,000 acre property in northwest corner of Green Lake County and northeast corner of Marquette County. Current management programs include upland dry prairie and oak savanna restoration to promote KBBs and other related wildlife (WDNR 2010). Second flight population monitoring conducted in 2008-2011 found 2,547, 2,225, 2,583 and 7,715 KBBs present respectively. About 40.5 acres (5 subpopulations) of KBB habitat are currently present on this property with the potential to restore up to 500 additional acres of habitat (Jim Holzwart and Bob Hess, WDNR, pers. comm., 2011).

3. Greenwood SWA metapopulation (Reclassification: None; Delisting: VP)

Greenwood SWA is located in west central Waushara County, on the edge of a pitted outwash plain creating a flat sandy topography and a wooded hilly moraine comprised mostly of oak (WDNR 2010). KBB population surveys conducted during 2008 -2010 revealed numbers too low to generate a population estimate. It is suspected that dryness of the sites is a factor in the low numbers consistently found at this site (Bob Hess, WDNR, pers. comm., 2012). In the past, about 37 acres of habitat have been occupied. Currently Greenwood SWA has 3 potential KBB habitat areas on a total of about 60 acres (Bob Hess, WDNR, pers. comm., 2011).

Other KBB sites in the Morainal Sands RU

A private landowner in Marquette County is managing for savanna species including the KBB. Surveys conducted in 2010 and 2011, found 4,300 and 6,622 KBBs respectively present on the property. The 110 acre property includes 50 acres of restored prairie (Bob Hess, WDNR, pers. comm., 2010 and 2011) that supports the KBB and that is included in an 82.56 acre permanent conservation easement with the U.S. Department of Agriculture (USDA) Grassland Reserve Program. The grassland reserve program promotes enhancement of plant and animal biodiversity and protection of grassland and land containing shrubs and forbs under threat of conversion (USDA 2009). A management plan has been developed for the property that is compatible with KBB recovery. The Wisconsin DNR and USFWS's Partners for Fish and Wildlife Program have assisted with the restoration and management of KBB habitat on the property. This site has the potential to become one of 3 recommended KBB recovery sites in this RU, potentially replacing Greenwood SWA. However, to date the property owners have not committed to KBB recovery on their land.

Glacial Lake Wisconsin Recovery Unit

There are five recovery areas within this RU: Necedah National Wildlife Refuge (NWR), Meadow Valley State Wildlife Area, Sandhill State Wildlife Area, Hardwood Range, and Quincy Bluff and Wetlands.

1. Necedah NWR metapopulation (Reclassification: LP; Delisting: LP)

The KBB recovery goal of restoring one large viable KBB population has been met at Necedah NWR (Refuge). The 43,656 acre Refuge supports a variety of habitats (wetlands, open water, pine, oak and aspen forests; grasslands; and savannas) (USFWS 2004). KBBs occur in 10 complexes (management areas) distributed throughout the Refuge containing a total of about 4,467 acres. KBB surveys are conducted using a Pollard-Yates type survey and "Distance" methodology to determine the density of KBBs. Since 1993, extrapolated population estimates at the Refuge have well exceeded 6,000 KBBs (and generally exceed 20,000 KBBs annually). In 2010, the KBB population was estimated to be about 66,000 butterflies; this population estimate was extrapolated from surveys done on about 10 % of occupied habitat. The Refuge maintains 4 permanent no burn KBB refugia areas as part of their KBB management strategy (USFWS 2011b). Management of KBBs at the Refuge is conducted per the USFWS's March 21, 2002, Biological Opinion (and associated amendments) completed for implementation of the Draft Comprehensive Conservation Plan for Necedah NWR (USFWS 2002) and is consistent with recovery criteria in the KBB recovery plan (USFWS 2003).

2. Meadow Valley SWA metapopulation (Reclassification LP; Delisting: LP)

Meadow Valley SWA is located in Juneau County in central Wisconsin adjacent to, and north of Necedah NWR. About 850 acres of permanent barrens habitat are being restored for the KBB east of State Highway 173. Restoration sites include three Broadhead Barrens Units (200 acres total), two Eisfeldt units (88 acres total) and Silver Creek (8 acres). All sites are in early development stages of restoration and may take between 15-20 years to produce mature barrens habitat (Wayne Hall, WDNR, pers. comm., 2009). The remaining forested lands are managed using a shifting mosaic strategy which is anticipated to help preserve KBBs across the larger landscape. No KBBs were reported present from any of the Meadow Valley sites in 2008 and 2009 (Hess 2009). In 2010, KBBs were observed at both Silver Creek and the Eisfeldt South sites following brush removal the previous winter. It is likely that KBBs are still present at these sites; a total of 90 acres of KBB habitat are present at the 2 sites. The Eisfeldt fields are over two miles south of Silver Creek (Bob Hess, WDNR, pers. comm., 2010). WDNR's Draft Sandhill-Meadow Valley Work Unit Master Plan includes recovery of a KBB VP at Meadow Valley SWA.

3. Sandhill SWA metapopulation (Reclassification: VP; Delisting: VP)

Sandhill SWA in Wood County currently supports the largest known KBB metapopulations in Wisconsin on State property; that population mostly occurs on the 168 acre eastern bison enclosure which is grazed on a rotational basis. Population estimates on the bison range were

12,065, 10,185, 22,799 and 11,057 KBBs in 2008-2011 respectively (WDNR 2011) (Bob Hess, WDNR, pers. comm., 2011), well above the recommended 3,000 KBBs for a VP. A small 15 acre KBB site (West Field) also occurs at Sandhill WA; work is needed to improve connectivity between subpopulations**.** WDNR's Draft Sandhill-Meadow Valley Work Unit Master Plan includes recovery of a KBB LP at Sandhill.

4. Hardwood Air to Ground Weapons Range metapopulation (Reclassification: VP; Delisting: VP)

The Hardwood Air to Ground Weapons Range – Air National Guard (WIANG) manages the Hardwood Air-to-Surface Gunnery Range (Hardwood Range) as part of the Volk Field Combat Readiness Training Center. Hardwood Range is a 7,263 acre facility (Dan Gonnering, WIANG, pers. comm., 2010) located in northern Juneau County and used as a practice area for live combat simulations of bombing and air-to-surface weapons fire. The impact area of the weapons range is managed by periodic burning to maintain the area in an open condition, to enhance visibility and facilitate use (Gonnering 2001). Originally, of 11 areas (totaling about 18 acres) that contain lupine, nine were occupied by the KBB from 1996 to 2008. In 2009 trend monitoring was discontinued at two sites and an additional site was added to retain the approximate 18 acres of KBB habitat monitored. Currently, the KBB is found at all the monitoring sites in the impact area. Six sites in the buffer zone are monitored; since 1998 only 6 KBBs have been counted at these sites (Dan Gonnering, WIANG, pers. comm., 2010). The 18 acres occupied by KBBs are considered one population (Dan Gonnering, pers. comm., 2011). KBB habitat areas range from 0.1 acres to 5.2 acres in size. Management of the habitat includes prescribed burning on a rotational basis except for three sites, two of which are located in the impact area and cannot be protected from fire and a third site in the forested buffer zone surrounding the bombing range, where no regular management activities take place (USFWS 2006). Average trend counts have ranged from a high of 78.2 butterflies in 2002 to low of 7 in 2004. The 2010 trend count was 75.3 KBBs (Dan Gonnering, WIANG, pers. comm., 2010). The trend count for 2011 was 60 KBBs, however this is likely low as sites were not surveyed as often due to weather and logistics issues (Dan Gonnering, WIANG, pers. comm., 2011). To derive the trend count, the sum of all KBBs counted at each site during both the first and second flights are summed and divided by the number of counts conducted; generally 6 counts are conducted per year, 3 during first flight and 3 during second flight (Dan Gonnering, WIANG, pers. comm., 2010). Management of the KBB at Hardwood Range is conducted per the USFWS's August 3, 2006 Biological Opinion (USFWS 2006a).

5. Quincy Bluff and Wetlands (Reclassification: None; Delisting: VP east of Wisconsin River)

The Nature Conservancy (TNC) and the Wisconsin DNR own Quincy Bluff and Wetlands which is located in Adams County in south central Wisconsin. Both entities are restoring oak savanna and pine barrens habitat at the site. During KBB recovery planning it was anticipated that KBBs would occupy the site once habitat was restored as KBBs still occurred within a couple miles of this site at that time. To date, no KBBs are known present at Quincy Bluff and Wetlands and there are no plans to reintroduce the butterfly. Quincy Bluff was designated a State Natural Area in 1993.

West Central Driftless Recovery Unit

There are 3 metapopulation sites within this RU: Black River State Forest, Fort McCoy, and Jackson County Forest. The Black River State Forest and Fort McCoy are active recovery partners. Jackson County Forest is a WI Statewide KBB partner and while conducting activities to help conserve and protect the KBB has not committed to long term recovery of the butterfly.

1. Black River State Forest (Reclassification: VP; Delisting: VP)

The Black River State Forest (BRSF) is located in Jackson County. KBB management is currently focused in 2 regions of the BRSF however, management of KBB occurs in other areas as well. The 2 regions are: "Area 3: Robinson Creek Basin" Forest Production Management Area (14,198 acres) and "Area 4: Jack Pine Area" Jack Pine Habitat Management Area (about 4,277 acres). "Area 3:Robinson Creek Basin" is a large connected block of forested habitat including some sites near the town of Millston that contain dry jack pine and scrub oak barrens habitat. Substantial management has occurred over the last 2 years in this area for the KBB.

KBBs have been documented along many roadways and forest trails in Areas 3 and 4 which provide dispersal corridors for the species. In addition, several scattered sites within these 2 areas are receiving barrens treatments. A KBB recovery site has been designated in Area 4 at the Komensky Barrens (Ralph Weible, WDNR, pers. comm., 2011). The potential exists to secure a stable KBB metapopulation on the BRSF if management is applied to maintain barrens habitat (Bob Hess, WDNR, pers. comm., 2011). More detailed information pertaining to KBBs on the BRSF is presented below.

"Area 4: Jack Pine Area" is made up of several non-connected parcels ranging in size from 100-2,000 acres and is dominated by jack pine barrens. According to the BRSF Master Plan (WDNR 2010), high quality barrens vegetation sites within Area 4 will be identified and maintained in conjunction with timber production. There are about 132 acres of occupied habitat in the designated recovery sites located in the Komensky Barrens (in Area 4) where substantial management for the KBB has occurred (Bob Hess, WDNR, pers., comm., 2011). The KBB population was surveyed at a single key site within Area 4 (Compartment 16, Stand 4) from 2008-2011with populations of 0, 651, and 1,309 KBB reported from 2008-2010 respectively. The 1,309 estimate (2010) was based on 15 acres surveyed compared to 8.3 acres surveyed in 2009. In 2011 a population of 1,758 KBBs was recorded on 67 acres in this same area (WDNR 2011).

A small KBB population is present in the Millston Road area (in Area 3) just north of Fort McCoy (Bob Hess, WDNR, pers. comm., 2011).

The BRSF Forest also includes Area 5 (Dike 17 Wildlife Habitat Management Area) which supports a small KBB population. A long term goal for Area 5 (Dike 17 Wildlife Habitat Management Area) is to provide a total of approximately 5,000 acres of high quality, ecologically functional grass, shrub, barrens, and wetlands habitats for a variety of endangered, threatened, special concern, and rare species, including the KBB (WDNR 2010). Swengel and Swengel (2011) report that Dike 17 ranks in their top 4 central Wisconsin long-term monitoring

sites in total KBB numbers. The site is managed via limited brush cutting, periodic partial mowing, and spot herbicide treatments (Swengel and Swengel 2011).

The KBB is considered a species of greatest conservation need at the BRSF, and pine and oak barrens are being directly managed for the butterfly and other associated barrens species. The regional ecologist systematically inventories every jack pine stand, and assesses their potential (based on the location of KBB sites) to further the conservation of the KBB. Management options are then identified to restore and/or maintain pine barrens habitat. The very best sites will be maintained, including some with permanent openings of variable size, using mechanical brushing, selective use of herbicides, and prescribed fire. Timber harvests will be strategically applied using the shifting mosaic methodology to open up the very best forested sites to assist in restoring degraded pine barrens habitat. In areas where woody material is non-merchantable, a brush mover and chainsaws will be used to set back succession in conjunction with cut stump treatment with herbicides. Timber harvesting, brushing, and selective use of herbicides will also be used along roadsides and between stands containing quality barrens vegetation to increase and maintain width of open barrens areas. Invasive species will be controlled via hand pulling and selective use of herbicides. Much of this work has been completed or is in progress. The results of monitoring these sites will ultimately lead to a determination of the best, most viable long term management sites for the KBB (Peter Bakken, WDNR, pers. comm., 2011).

2. Fort McCoy metapopulations (Reclassification: 2LPs; Delisting: 2LPs)

Fort McCoy (Fort), a Department of the Army (DOD) installation is about 60,000 acres in size and located in west central Wisconsin. The Fort supports two large KBB metapopulations, one on North Post and one on South Post. In addition, a third small KBB population is located in the most southwestern portion of the Fort known as the A1/A2 population. Straight line transect surveys using distance sampling techniques are conducted at 22 locations (12 permanent transects and 10 randomly selected transects) to derive KBB population abundance numbers for the spring and summer flights. The total KBB population at the Fort is extrapolated from that transect data (Wilder 2010). KBB populations continue to do very well on both North Post and South Post**.** Second brood population estimates on South Post from 2001-2011 have never fallen below 9,400 butterflies, with the highest estimate of 129,153 KBBs recorded in 2011. North Post second brood population estimates have remained at or above 8,357 butterflies during 2001-2011, except in 2004 when there was an abnormally low estimate of 918 KBBs. The highest population estimate for North Post, 200,201 KBBs occurred in 2011 (Wilder 2006a, Wilder 2010, Wilder 2012) (Appendix D, Table D1). KBB population numbers are relatively small at the A1/A2 site; survey numbers from 2005-2010 indicate the population at or less than 444 butterflies annually (Wilder 2011a, 2012).

Based on surveys conducted during 2001-2006 there are about 3,806 acres of lupine scattered throughout the Fort in open and semi-open savanna areas as well as in more open forested areas. In 2002, surveys indicated that over 90% of the lupine on the Fort was occupied by the KBB. In 2006, 726 acres of lupine were surveyed on South Post with 98% of those lupine patches occupied by the butterfly KBBs (Wilder 2011a). This survey data indicates that the habitat (lupine) patches are well connected throughout the Fort. Note: There are about 3,382 lupine acres on North Post and South Post combined; the remaining about 424 acres of lupine are in

area A1/A2 (Wilder 2011b). The Fort's Draft Integrated Natural Resource Management Plan (INRMP) identifies oak savanna restoration as a major priority. Seventeen areas totaling 298.0 hectares (735.5 acres) are designated as KBB management areas on the Fort and will be managed to help enhance habitat for the KBB (Wilder 2011b).

Guiney et al. (2010) investigated the KBB metapopulation structure and population trend at the Fort. Results indicated a long term population trend with a half-period length of approximately two-and-a-half years (full-period of 5 years). The research also found that the KBB metapopulation at the Fort could be described as a patchy population and not as a classic metapopulation (Guiney et al. 2010). (Refer also to section 2.3.1.2, KBB Metapopulation Dynamics and Population Growth Rates).

The conservation goals in the Fort's KBB Endangered Species Management Plan (2006b) include meeting the recovery criteria in the KBB recovery plan (USFWS 2003), which they have successfully accomplished. The Fort's KBB Endangered Species Management Plan is currently being revised and will become part of the Fort's Integrated Natural Resources Plan for 2011-2016 (Cathy Carnes, USFWS, pers. comm., 2011).

Management techniques such as herbicide, physical and mechanical removal of woody species, mowing, and controlled burning are used to improve KBB habitat at the Fort (Wilder 2011a).

3. Jackson County Forest metapopulation (Reclassification: LP; Delisting: LP)

The KBB recovery plan (2003) identifies Jackson County Forest as a potential location for one recovery site.

The Jackson County Forestry and Parks Department forest plan (2005) includes management of three barrens areas for the KBB, totaling about 710 acres in Jackson County. The Bauer Brockway Barrens SNA includes about 170 acres of barrens habitat that has been managed for more than 10 years for the KBB, in partnership with the WDNR and the USFWS. About 39 acres of the Bauer-Brockway Barrens owned by WDNR supports KBBs (1,837 KBB in 2011) and may have the potential to support a VP (Bob Hess, WDNR, pers. comm., 2011).

KBBs are also common in Glenn Creek Barrens which consists of two units totaling approximately 140 acres; management here includes regeneration harvests and small, controlled fires to help restore barrens species. Millston Sand Barrens (about 400 acres) supports an abundant KBB population; management here includes thinning oaks and occasional controlled burns after the thinning and removal of invasive species (Jackson County Forestry and Parks 2005). Jackson County Forestry and Parks is also a HCP partner and as such has recently renewed its commitment to conserving the KBB on their lands for another 10 years (2010-2019) through implementation of the HCP protocols and guidelines.

Based on information from Mr. Jim Zahosky (Jackson County Forest, pers. comm., 2011) between 2000 and 2010 about 19 KBB sites have been identified on the Jackson County Forest. There are likely more sites than this as surveys are only done on tracts that have some sort of management scheduled for example timber sales or recreation trails; no acreage information is available on these sites.

Wisconsin Escarpment and Sandstone Plateau Recovery Unit

The KBB recovery plan (2003) identified one potential recovery area within this RU on the Eau Claire County and Clark County Forests.

1. Eau Claire and Clark County Forests metapopulation (Reclassification: VP; Delisting: LP)

The Eau Claire County Forest and Parks comprehensive land use plan (1995), includes management of jack pine to maintain KBB habitat. Eau Claire County Forest and Parks is also an HCP partner and as such has recently renewed its commitment to conserving the KBB on their lands for another 10 years (2010-2019) through implementation of the HCP protocols and guidelines. The county forest includes two barrens areas that are SNAs, Coon Fork and South Fork Barrens SNAs. The Coon Fork Barrens SNA (580 acres) is located between two Eau Claire River tributaries; it consists of open woodlands with jack pine and oak and contains areas of open savanna and brush prairie. The South Fork Barrens SNA (120 acres) is located on rolling uplands and the steep south-facing bluff above the south fork of the Eau Claire River; it is dominated by jack pine with bur oak, Hill's oak, and red pine; numerous prairie grasses and forbs are also present throughout the area (WDNR 2009). KBBs occur at both Coon Fork and South Fort Barrens on a total of about 30 acres. Overall the KBB is known to occur on 9 sites on the Eau Claire County Forest; most of which were surveyed between 2000 and 2004 (Jody Gindt, Eau Claire County Forest, pers., comm., 2011). Jack pine is declining due to forest succession. The forest is being managed to reduce the transition of jack pine to mostly oak and/or white pines. The goal is to maintain the jack pine cover-type due to its importance as a primary habitat for the KBB. The scarification method preceding harvest is the most successful method in naturally regenerating this tree species, and is the most advantageous from both economic and ecological viewpoints (Eau Claire County Parks and Forest 1995). KBBs also occur at Hathaway Creek near the Eau Claire River and Canoe Landing SNA as well as at other locations in the forest (Jody Gindt, Eau Claire County Forest, pers. comm., 2011).

Clark County Forest is also a HCP partner that has also recently renewed its commitments to KBB conservation for another 10 years (2010-2019). Currently there are 6 KBB sites totaling 271 acres of occupied habitat in one township on the forest which includes a 36 acre permanent habitat area all of which is occupied; this exceeds the 20 acres of long term KBB habitat committed to by Clark County Forest in their Species and Habitat Conservation Agreement (SHCA) (Andrew Sorenson, Clark County Forest, pers. comm., 2011). (Note: Each WI KBB HCP partner has completed a SHCA, a contractual commitment with the WDNR to carry out KBB conservation measures). The KBB sites are located within Pine Barrens Ecological Management Unit (EMU) 3 on the forest. Non-traditional management practices used within EMU 3 include: utilizing the shifting mosaic strategy to assist in providing continual early successional habitat, planting lupine, restricting access to dry roads (which reduces the risk of invasive species and preserves KBB habitat), using fire as a management tool, and converting red pine plantations to jack pine plantations over time (Clark County Forestry and Parks 2005).

Superior Outwash Recovery Unit

There is one metapopulation site within this RU, the Glacial Lake Grantsburg Work Unit which is reviewed below.

1. *Glacial Lake Grantsburg Work Unit metapopulations (Reclassification: 2VP; Delisting: 2 VP or 1 LP)*

The Glacial Lake Grantsburg Work Unit composed of Crex Meadows and Fish Lake WAs located in Burnett County are part of the Northwest Wisconsin Pine Barrens. The southern portions of the "Barrens," where these wildlife areas are located, contain extensive sedge marshes which are remnants of Glacial Lake Grantsburg. Extensive management occurs on these two properties to restore and maintain wetland and brush prairie habitat. KBB population numbers in these areas have been dramatically lower in recent years than in the past, likely due to dry conditions over the past several years. A longer-term drying trend in northwest Wisconsin has been documented over the past 50 years, and over the same period this region has also experienced a more pronounced acceleration of spring onset than the rest of the state (WDNR 2011). Improved environmental conditions and survey timing produced a combined second flight population estimate of 3,139 KBBs in 2010 from two sites at Crex Meadows WA and one site at Fish Lake, up from 518 KBBs recorded from sites surveyed in 2009 (WDNR 2011)**.** In 2011, 10,418 second brood KBBs were recorded from 2 sites (totaling 111 acres) at Crex Meadows and Fish Lake WA (Bob Hess, WDNR, pers. comm., 2011).

The KBB population at the Glacial Lake Grantsburg Work Unit appears to be that of one large patchy metapopulation with two large patchy subpopulations, one at the Crex Meadows WA and one at the Fish Lake WA**.** Of a total of 168 burn units on the Glacial Lake Grantsburg Work Unit (Crex Meadows, Fish Lake, Amsterdam Sloughs and Danbury WAs), 73 units (about 15,267 acres) have documented KBBs. KBBs were documented by a completed survey which identified KBB's somewhere within these units; the majority of the KBBs observations were made in the last 5 years (Pete Engman, WDNR, pers. comm., 2011). According to Bob Hess (pers. comm., 2010) there are 13 KBB sites of interest at Glacial Lake Grantsburg. One site has very good habitat, 2 sites fair habitat and 10 are poor generally needing more lupine and nectar plants and less heavy brush. Some occupied KBB sites on adjacent or nearby Burnett County Forest lands likely contribute to the KBB metapopulation at Glacial Lake Granstburg (refer to "*Other sites in Superior Outwash RU*" below).

The master plan for Crex Meadows and Fish Lake is over 30 years old, however its goals include restoring barrens habitat which is compatible with the recovery of the KBB (Pete Engman, WDNR, pers. comm., 2010).

<u>Other sites in Superior Outwash RU</u>

Potential habitat on the Kohler-Peet SNA of the Governor Knowles State Forest in northwest Wisconsin has been surveyed for KBB and habitat conditions to assess its potential for addition

to the KBB habitat base for this RU (WDNR 2011). To date no KBBs have been found present on the property (Bob Hess, WDNR, pers. comm., 2011).

Other Larger Forested Landscapes with KBBs in Wisconsin

Several industrial and county forests in Wisconsin provide habitat for the KBB. Of the 13 industrial and county forest partners to the Wisconsin Statewide KBB HCP, 6 have no, or a small number of KBB sites; those are Johnson Timber Company-Futurewood, Thilmany Papers, Wausau Paper Corporation, Monroe and Washburn county forests (Dave Lentz, WDNR, pers. comm., 2011) and New Page Wisconsin Systems Inc.. Wausau Paper Corporation has found at least 1 KBB site on approximately 200 acres of the land in the KBB HPR over the last 17 years; that area has since grown and is not currently prime KBB habitat. In 2010, KBBs were found on a new 20 acre site. Wausau Paper Corporation plans to sell all their land in Wisconsin including 875 acres that are included in their SHCA (Patrick Scheller, Wausau Paper Mills, LLC, pers. comm., 2011). New Page Wisconsin Systems Inc. has 7-8 sites that support lupine but no KBBs have been found as yet on these sites (Gordy Mouw, New Page Wisconsin Systems Inc., pers. comm., 2012).

The remaining 7 county and industrial forest entities (that are part of the HCP) have larger landscapes supporting multiple KBB sites; those are: Burnett, Clark, Eau Claire, Jackson, Juneau and Wood county forests, and Plum Creek Timber Company. Refer to the "Wisconsin Escarpment and Sandstone Plateau RU" for information on Clark and Eau Claire county forests and to the "West Central Driftless RU" for information on the Jackson County Forest. In addition to the above, the Black River State Forest supports KBBs; refer to "West Central Driftless RU."

KBBs occur in the Burnett County Forest adjacent to Glacial Lakes Grantsburg and therefore likely contribute to the KBB metapopulation associated with Crex Meadows and/or Fish Lake WAs. Although there is no one area designated for management of the butterfly, forest management promotes habitat for the KBB. For example, in cooperation with the DNR, three fuel breaks on the forest (Deer Lake, Johnson Lake, Clam Lake) are managed as savanna/barrens community type habitat as part of a fire control strategy (Nichols 2006). Two of the fire breaks managed by the WDNR (Clam and Deer Lake), support KBBs (Jason Nichols, Burnett County Forest, pers. comm., 2011) and provide core habitat and a dispersal corridor for the butterfly. The County Forest Plan identifies that high consideration should be given to maintaining jack pine (important habitat for the KBB and species of management concern). Modification of forest and wildlife management practices are considered that conserve or enhance habitat for various species including the KBB while allowing compatible land management to occur (Nichols 2006). As a partner to the HCP forest practices are designed to avoid or minimize harm to the butterfly. Since 2002, KBBs have been found at about 37 sites (each site = a 40 acre block) on the forest scattered across 8 townships. The 37 sites (a maximum of 1,480 acres) are part of about 26,056 acres of forest land considered occupied or potential habitat for the KBB. These areas support jack pine, red pine, scrub oak, grass, and upland brush. In total Burnett County Forest is about 106,556 acres in size (Susan Ingalls, Burnett County Forest, pers. comm., 2011). A shifting mosaic of habitat along with connecting roads, and management of early successional habitat on the fuel breaks is contributing to the maintenance of KBBs on the forest.

Wood County contains about 4,260 acres of KBB potential habitat (moderately dry sandy soils) on forest lands and other areas (e.g., parks) (Wood County 2009); several KBB sites are likely present in this forest. Juneau County Forest and Parks has about 18,911 acres enrolled in the HCP (Juneau County Board of Supervisors 2009) of which about 15 acres have been managed more specifically for the KBB. These managed areas are firebreaks and forest road rights-of-way (Brian Loyd, Juneau County Forest and Parks, pers. comm., 2012). While the current number of KBB sites in the Juneau County Forest is not available, there are likely several sites present as data provided by Mr. Loyd (pers. comm., 2012) identified 1 to 8 KBB sites present in annual surveys conducted from 1998 to 2005. Plum Creek Timber Company (Plum Creek) has the greatest amount of land, 53,000 acres, enrolled in the HCP. The majority of KBB habitat on Plum Creek lands is located in Adams, Burnett, Clark, Eau Claire, Jackson, Juneau and Wood counties (Plum Creek Timber Company 2009). While the current number of KBB sites on Plum Creek lands is not available, based on the WDNR's NHI data base, many KBB sites are likely present.

In summary, KBB survey data collected by Wisconsin KBB HCP forest partners has identified that several forests in Wisconsin support one to many KBB sites; some of these sites are along road and trails that can act as dispersal corridors for the species. In addition some forests have dedicated barrens areas (including some firebreaks) that can act as core areas for KBB metapopulations providing refugia and a source of butterflies to colonize suitable habitat as it becomes available. These larger forested landscapes currently support the KBB and offer more secure habitat than private lands due to their size and shifting habitat mosaic management regime. However, a better understanding is needed of the metapopulation structure and dynamic on these forests to assess the ability for viable KBB metapopulations to persist for the long term on these landscapes. Information that would be helpful for this assessment includes locations of current KBB sites, KBB population sizes at dedicated barrens areas, and an understanding of how the shifting habitat mosaic created by forest activities contributes to the metapopulation dynamic and/or how it could be modified to ensure support of viable KBB metapopulations. The number and locations of secure, dedicated barrens areas (that can act as metapopulation core areas) appears key to insuring viable metapopulations though the long term.

Threats that could adversely affect the KBB population pertaining to forest lands include the sale of land containing KBB sites, planting of red pine in a manner that eliminates understory vegetation, and reduced timber sales due to the slowing economy. Plum Creek Timber Company and Wausau Paper are planning to sell their lands including those that support KBBs. These activities would likely result in habitat fragmentation adversely affecting KBB metapopulation dynamics. Other threats to KBBs are discussed in section 2.3.2 Five-Factor Analysis.

Minnesota

Paleozoic Plateau Recovery Unit

There is one metapopulation area within this RU, Whitewater Wildlife Management Area (WMA) which is reviewed below.

1. Whitewater WMA metapopulation (Reclassification: 2 VP or 1LP; Delisting: 2VP or 1 LP)

KBBs were historically present in Turkey, Cuthrell, Historic, and Lupine Valleys within the Whitewater Wildlife Management Area (WMA). As of 2010, KBBs were only found in Cuthrell Valley. No KBBs were found at WMA in 2011 (Jaime Edwards, MNDNR, pers. comm., 2011).

Cuthrell Valley

As of 2010 KBBs occurred in the central portion of the Cuthrell Valley. This valley is 131 acres in size and consists of a mixture of open, high quality oak barrens, fire suppressed oak woodland, and degraded sand prairie. Lupine is patchy in distribution, being most abundant in a few north-facing dune bowls and along the southwest portion of the Bench Area; it is scattered throughout the remainder of the site, particularly on south and west-facing slopes. Currently, much of the barrens at this site are degraded due to fire suppression and/or invasion by non-native grasses. The north-facing dune bowls that contain the bulk of the KBB population are nearly completely covered with a woody canopy of oaks, cherries and jack-pine. To create suitable KBB habitat, much of this woody vegetation, including many large (>8inch DBH) trees need to be cut and the stumps treated with herbicide to prevent re-sprouting. Management applications in Cuthrell Valley will continue to give special consideration for KBBs, and will work towards maintaining and increasing this population through selective habitat restoration (Jaime Edwards, MNDNR, in litt. 2010). KBB monitoring has been conducted in the Cuthrell Valley since 1992 revealing continually low butterfly numbers. Data from 2006-2009 estimated that KBBs ranged from 0.19 (2008) to 0.44 (2006) butterflies/1000 m^2. Bess (2009) estimated that the second brood KBB population in Cuthrell Valley in 2008 was 160 to 400 butterflies and that a more conservative estimate of 80-160 butterflies is likely present. No KBBs were found in Cuthrell Valley in 2011 (Jaime Edwards, MNDNR, pers. comm., 2011).

Historic, Lupine, Fabel and Turkey Valleys

Historic, Lupine, Fabel and Turkey valleys all contain degraded oak barrens and dry prairie with scattered lupine (Bess 2008). While Historic and Lupine Valleys both appeared to contain ideal KBB habitat they are highly isolated and lupine is a restricted to a narrow band along the base of the dune slopes and on the edges of the valley floor. These low areas are frost pockets possibly making the temperature fluctuation here too harsh for KBB survival. Fabel Valley which is fairly large (132 acres at present) occurs on a broad sand terrace, part of which is bisected by a small intermittent tributary of the Whitewater River which has cut a deep valley. One of the larger blowouts in the valley is covered with thousands of lupine plants. Turkey Valley is small (41 acre), located near Cuthrell Valley and composed primarily of closed canopy oak woodland, with a small oak barrens remnant. All four valleys are in need of habitat restoration and management. Based on past surveys and the 2008 survey by Bess, KBBs are no longer considered present in these 4 valleys. Habitat management efforts have been successful in creating suitable habitat for the butterfly in some areas of the valleys, but the population is not responding. Overall management of these areas will continue to strive towards restoring oak savanna habitat (Jaime Edwards, MNDNR, in litt. 2010).

POTENTIAL RECOVERY UNITS

Potential Recovery Units (PRUs) are areas in which the KBB occurred historically or may exist in low numbers. The KBB recovery plan (2003) identifies 6 PRUs. In February 2011, the USFWS updated the recovery plan by adding a seventh PRU, the Michigan Oak Opening PRU. There are no assigned recovery goals identified for PRUs, however, if a KBB population is recovered in any PRU it can be used to offset the need to recover a KBB population in the next nearest RU (refer to the KBB recovery plan, p. B-27).

There are two PRUs where active KBB reintroduction programs are on-going; those are the Oak Opening PRUs in Ohio and the newly added Oak Openings PRU in Michigan. KBB reintroduction activities in these PRUs are reviewed below.

KBB reintroductions follow the captive propagation techniques for the KBB in the Captive Propagation Handbook for the KBB (Webb 2010) which is available on the USFWS's Midwest Ecological Services, Endangered Species website at:
http://www.fws.gov/midwest/endangered/insects/kbb/index.html

Oak Openings Potential Recovery Unit (Ohio)

1. Northwest Ohio Oak Openings reintroduction

The reintroduction of KBBs has been on-going in the Oak Openings Region of northwestern Ohio since 1998 with the help, expertise, and dedication of the Toledo Zoo, The Ohio Department of Natural Resources Division of Wildlife, The Nature Conservancy, and Metroparks of the Toledo Area. The KBB source population used in the captive rearing program is from the Allegan SGA in Michigan. KBBs are reared at Toledo Zoo and released to sites on TNC's 700 acre Kitty Todd Preserve (near Toledo) and more recently at two additional sites, Campbell Prairie (Metroparks of the Toledo Area – Oak Openings Preserve) (9.6 acres) and Meilke Road Wildlife Area (22 acres) owned by the Ohio Division of Wildlife (Ellsworth 2010). Thousands of KBBs have been released to these reintroduction sites since 1998. Toledo Zoo opened a new Butterfly Conservation Center in 2009 that can accommodate rearing of about 2,000 KBB eggs (Ellsworth et al. 2011).

In 2010, KBBs were located at a fourth site, the Cactus Hill Prairie Management Unit (TNC), located approximately 1.5 km southwest of Kitty Todd Preserve and 700 meters east of Moseley Barrens (Kitty Todd Preserve); both male and female adults were observed flying. This is a new habitat area colonized by the butterfly that is very near to a utility cut owned by Lucas County Commissioners supporting wild lupine (*Lupinus perennis)*, New Jersey tea (*Ceanothus americanus)*, butterfly milkweed (*Asclepias tuberosa)*, and dotted horsemint, (*Monarda punctata*) (Ellsworth et al. 2010). Occupied KBB habitat at Cactus Hill Prairie (including the Sweet Fern Savanna) is about 14 acres in size (Steve Woods, TNC, pers. comm., 2011).
Wild KBB populations now exist at Kitty Todd Preserve and Campbell Prairie. In 2010 monitoring at Campbell Prairie found 29 and 105 butterflies in the first and second broods respectively (Menard and Gallaher 2010); in 2011, 28 and 116 KBBs were documented during the first and second flights respectively (Menard and Gallaher 2012). At Kitty Todd Preserve

proper, no KBBs were reported on Julia's Savanna; KBBs appear to be concentrated on the South Piels and Candee's Dune management units as in the past (Ellsworth et al. 2010). The KBB population is considered stable at Kitty Todd NP with populations moving around based on management actions. There are about 18 acres of occupied habitat at Kitty Todd NP (Steve Woods, TNC, pers. comm., 2011).

In 2010 a total of 893 adult KBBs were reintroduced at the Meilke Road Savanna, 542 at the Campbell Prairie release site, and 159 KBBs were donated to the Detroit Zoo for their reintroduction work at the Petersburg SGA in Michigan (Ellsworth et al. 2010). In 2011, a total of 1205 KBB adults were released from larvae raised at Toledo Zoo. Of the 1205 KBBs released, 327 adults were released at Campbell Prairie and 644 at the Meilke Road Savanna. Detroit Zoo released 234 adults (from 332 larvae provided to them by the Toledo Zoo) at Petersburg SGA (refer to Oak Openings Potential Recovery Unit (Michigan) (Ellsworth, et al. 2011).

Managing and maintaining suitable habitat for the KBB remains a challenge. Woody encroachment and invasive species management is continuing at several sites. Invasive species at Campbell Prairie include glossy buckthorn, Asiatic bittersweet, and multi-flora rose; nectar sources for both sites for both KBB flights need to be increased. Habitat within Moseley Barrens varies from suitable to excellent and is sustaining the wild KBB population at Kitty Todd Preserve. Habitat conditions are excellent at Meilke Road Savanna Wildlife Area.

The Ohio Conservation Plan 1998-2010 (OH DNR 2005) recommends establishing three KBB metapopulations within the Oak Openings Region of Ohio. The Plan outlines goals as well as management and monitoring strategies to help restore viable KBB metapopulations. The KBBs located at Kitty Todd Preserve, Campbell Prairie, and Meilke Road Savanna Wildlife Area are currently considered to be separate populations except for Cactus Hill which is regarded as part of Kitty Todd Preserve; discussion is still underway as to whether or not the populations should be considered as one or more metapopulations (Scott Butterworth, OH DNR, pers. comm., 2011).

The Ohio Oak Openings PRU lies to the south of the Michigan Oak Openings PRU where an active KBB reintroduction program is on-going as well. It is unlikely that populations in the Ohio and Michigan Oak Openings PRUs could be managed as one metapopulation. Maps from about 1800 show a swath of soils (about 6 miles wide at the narrowest) more amenable to beech-sugar maple forest lies between the Petersburg SGA and the Ohio KBB reintroduction sites (Chris Hoving, MIDNR, pers. comm., 2010) providing a likely barrier to dispersal.

Oak Openings Potential Recovery Unit (Michigan)

1. Petersburg State Game Area reintroduction

In February 2011, the USFWS updated the KBB recovery plan (USFWS 2003) by adding a seventh PRU, the Michigan Oak Opening PRU. A KBB population is being restored at the Petersburg SGA in Monroe County in this PRU. This site lies within the clay lake plains ecosystem overlain with broad channels of lacustrine sand. The climate is moderated by Lake

Erie, and there is minimal topographic relief. Increased soil moisture and richer soils accelerate ecological succession and suppress lupine and other nectar plants at this site. No KBBs have been found in this area since the early 1990's when at least 2 subpopulations were known to occur here (John Lerg, MIDNR, pers. comm., 2010). While the Petersburg SGA Strategic Plan does not specifically outline a management plan for the KBB, the overall management goal and land management activities appears compatible with recovery of the species (MIDNR 2003).

Aggressive habitat management to maintain and restore oak barrens is underway as part of the KBB reintroduction program (John Lerg, MIDNR, pers. comm., 2010). Reintroductions began in 2008 with 193 adult KBBs being released by the Detroit Zoological Society (DZS). From 2009-2011, 277, 504, and 589 KBBs were released respectively. In 2010 and 2011, 17 and 28 KBBs were observed during the first flight by DZS staff at release locations indicating the presence of a small wild KBB population. The captive rearing work is being done by the Detroit Zoo (Michigan) with assistance from the Toledo Zoo (Ohio) (Schneider 2011) (Joe Robison, MIDNR, in litt. 2011).

NE Morainal Sands Potential Recovery Unit (Wisconsin)

KBB sites in this PRU occur in or near the Menominee Indian Reservation along roadsides or in forested tracts. The USFWS works with the tribe on conservation efforts for the butterfly.

Rome Sand Plains (New York)
Tonawanda Potential Recovery Units (New York)
Kenosha Potential Recovery Unit (Wisconsin/Illinois)
Anoka Sand Plains Potential Recovery Unit (Minnesota)

No KBBs are known to occur in these 4 PRUs.

Table C1. Summary of KBB habitat size and subpopulation number on recovery sites and other larger forested landscapes.

Recovery Unit (RU) (RU unless otherwise noted)	State	*Potential Recovery Locations	Occupied Acres (# subpops.) at Potential Recovery Locations	**Other Larger Forests that Support KBB Sites Occupied Acres (# subpops.)
Merrimack/Nashua River System	*NH*	Concord (includes Great Bay NWR) (reintroduction)	~450 (6)	
Glacial Lake Albany	*NY*	Albany Pine Bush Saratoga Sandplains Saratoga West Queensbury (NY Recovery Area, not Federal)	~300 (10) 125 (7) 293 (Airport) + 8 small ,1-6 acres, sites (9) 1 small site on power line ROW	
Oak Openings PRU	OH	NW Ohio Oak Openings (reintroduction)	~64 (at least 4)	
Ionia	*MI*	Flat River SGA	~145(6)	
Allegan	*MI*	Allegan SGA/ *private lands –Sand Plains* Allegan SGA/private lands - *Pine Plains* Muskegon SGA/private lands (Muskegan South)	2,199 (> 10) Total acres for Sand Plains and Pine Plains metapopulations; more KBBs on nearby private lands. small (>5) (sites along ~5 miles of powerline corridors)	
Newaygo	*MI*	HMNF/private lands – Bigelow ***HMNF- Brohman*** HMNF - Hayes Road (likely replacement for Brohman)	~81(4) ***0 (0) Prior to 2006: 20(4)*** 15 (1)	
Muskegon	*MI*	HMNF/private lands - White River HMNF/private lands - Otto ***HMNF -Burns Lake***	~199 (8) ~240 (40) ***0 (0) Prior to 2008: 15(5)***	
Oak Opening PRU	MI	Petersburg SGA (reintroduction)	small	

Recovery Unit (RU) (RU unless otherwise noted)	State	*Potential Recovery Locations	Occupied Acres (# subpops.) at Potential Recovery Locations	**Other Larger Forests that Support KBB Sites Occupied Acres (# subpops.)
Indiana Dunes	*IN*	IDNL West Gary on TNC/other private lands	1450(8) 124 (3)	
Morainal Sands	*WI*	Hartman/Emmons/Welch Complex White River Marsh WA ***Greenwood WA*** Private Landowner (Marquette Co.)	189 (at least 4) ~41(5) ***Low(few) Potential habitat 61(3)*** 50(1)	
Glacial Lake Wisconsin	*WI*	Necedah NWR Meadow Valley WA Sandhill WA Hardwood Range – Air National Guard ***Quincy Bluff (TNC)***	4,467(10 complexes) ~90 (2) 181 (2) 18 (1) ***0(0) Not active recovery site***	Plum Creek Timber Co. (large) (many) Juneau County Forest (large) **(several?)** Wood County Forest (large) **(several?)**
West Central Driftless	*WI*	Black River State Forest Fort McCoy (North Post and South Post) (possibly) Jackson County Forest	Large (several) 132 occupied acres at Komensky Barrens recovery area. 3,382 lupine acres (2 large patchy metapops.) large (at least 19) (includes KBBs management on 3 barrens areas totaling 710 acres)	
Wisconsin Escarpment and Sandstone Plateau	*WI*	(possibly) Eau Claire County Forest (possibly) Clark County Forest	(>30 acres) (9) 271 (6 sites)	
Superior Outwash	*WI*	Glacial Lakes Grantsburg (Crex Meadows and Fish Lake State WAs)	15,267 (at least 13 of interest) (acres = total acres of management units that had KBBs somewhere in the unit in last 5 years).	Burnett County Forest; 1,480 acres (37 forty acre forest compartments scattered across 8 townships, extent of KBB occupation of entire forest unknown)
Paleozoic Plateau	*MN*	***Whitewater WMA***	***0 (0) No Kbbs recorded in 2011***	

Table Cl Key:

* Regarding potential recovery locations:

- sites in black text are original recommended recovery sites identified in Table B1, KBB recovery plan (USFWS 2003)
- sites with gray shading are additional potential KBB recovery sites of note
- sites in ***black bold italics*** are original recovery sites with no, or very few KBBs.

** Data is approximate for forests; not all KBB sites and sizes of occupied areas known, occupancy is based on KBB presence/absence surveys.

metapop. = metapopulation
subpop. = subpopulation
RU = recovery unit

Note: some subpopulation numbers may actually represent the number of occupied sites rather than the number of subpopulations.

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APPENDIX D

Karner Blue Butterfly Second Flight Population Abundance on Recovery Properties

Table D1. Summary of KBB second flight population abundance on recovery properties.

Recovery Unit	Recovery Metapopulation			Reclass. Goals	Delist. Goals	KBB Population - 2nd Flight										
	State	County	Name			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Merrimack Nashua River System	NH	Rockingham Merrimack	Concord	VP	LP							> 300	> 300	> 300	2442	
Glacial Lake Albany	NY	Saratoga	Saratoga West (Airport Site)	VP	VP							900-1,300		550-800	1,450-2,050	
			Saratoga Sandplains	VP	VP							2,836 (median); range 2,335-3,336		6,000-8,571	17,718-25,312	
		Albany	Albany Pine Bush Preserve	VP	VP							414	265	345	450-650	2,182
Muskegon	MI	Muskegon Oceana	Otto (HMNF)	VP	LP						1,631-2,308	6,727-9,420	4,161-5,827	3,423-3,993		
		Oceana	White River (HMNF)	VP	LP						441-617	2,163-3,027	2,433-3,406	760-885		
Newaygo	MI	Newaygo	Bigelow (HMNF)	VP	LP							7,617-10,663	4,687-6,562	1,011-1,058		
			Brohman (HMNF)	VP	VP						0	0	0	0		
			***Hayes Road**								1,986-2,780	8,423-11,792	8,204-11,792	3,767-4,395		
Morainal Sands	WI	Portage Waupaca	Hartman/Emmons/Welch Complex	(1 LP)	LP								5,850	3,509	6,219	6,403
		Green Lake Marquette	White River Marsh State WA		VP or LP								2,547	2,225	2,583	7,175
		Waushara	Greenwood State WA		VP or LP								Few	Few	Few	Few
		***Marquette**	***Private Landowner**												4,300	6,622
Glacial Lake WI	WI	Juneau	Necedah NWR	LP	LP	40,000	119,000	61,000	59,000	38,000	22,000	42,000	145,000	89,000	66,000	
		Wood	Sandhill State WA	VP	VP								12,065	10,185	22,799	11,057
West Central Driftless	WI	Jackson	Black River State Forest	VP	VP								0	651	1,309	1,758
			Bauer-Brockway Barrens	VP	VP											1,873
		Monroe	Fort McCoy-South Post	LP	LP	22,027	9,410	107,711	46,186	40,102	72,121	18,651	9,737	33,674	99, 424	129,153
			Fort McCoy-North Post	LP	LP	36,656	22,170	8,357	918	70,005	16,494	16,199	50,777	26,590	74, 109	200,201
Superior Outwash	WI	Burnett	Glacial Lakes Grantsburg Work Unit	2 VP	2 VP or 1 LP								0	518	3,139	10,418

Notes:

Reclass. = Reclassification Goal

Delist. = Delisting Goal

* = New recovery sites since completion of the KBB recovery plan (USFWS 2003)

(1 LP) = Location of large viable metapopulation not designated to a specific site, can occur at any of the locations in the RU.

KBB monitoring methods used by States to derive the KBB second flight population abundance numbers noted on Table D1.

New Hampshire

Population estimates were derived using the mark-release-recapture (MRR) method (Heidi Holman, NHF&G, pers. comm., 2011).

New York

Distance modeling was used to obtain KBB population densities (numbers/acre). To derive brood size and to be able to account for butterflies that eclose and die between surveys (i.e., how many recruits came and went between surveys), the regression equation from Nowicki et al. (2005, p. 208) (which factors in lifespan) was used. The equation approximates the value derived from an MRR survey. Information used in the population estimate included peak count, life span, and flight period length. The KBB count ranges provided in the table are based on the assumption that adults live an average of 3.5 to 5 days. The upper range assumes a 3.5 day average life span and the lower range assumes 5 days (Jason Bried, TNC, APBP, pers. comm., 2011). See also Gifford et al. 2011.

There is one caveat in looking across years at the Saratoga Sandplains data. Each year from 2007-2010 more habitat patches were added to the distance sample. Therefore, while KBB numbers have been going up at this site, the upward trend in KBBs is partially a reflection of sampling more habitat over time (data from Jason Bried, APBPC, Email dated 4/5/2011). KBB population estimates for Saratoga West, Saratoga Sandplains, and APBP are from Jason Bried via Emails dated 8/17/2010, 8/23/10, and 8/19/2010 respectively.

Michigan

Hayes Road: Due to the lack of KBBs in the Brohman metapopulation area, HMNF is recommending shifting the recovery site to Hayes Road, this would shift the VP goal from Brohman to Hayes Road (refer to Appendix C, Michigan, Newaygo RU, 2. Brohman metapopulation). KBB population numbers were derived using Distance sampling or modified Pollard-Yates walks during the second flight (Keough 2009).

Wisconsin

Necedah NWR: KBB population estimates are derived using the following methods. Pollard-Yates type surveys are conducted on each KBB site three times during the peak of second flight with at least 7 day spacing between surveys. Results of the 3 counts are summed. Distance methodology is used to

determine the density of KBBs at each site; the density is then multiplied by the size of each unit, determined with Geographic Information Systems (GIS) technology (USFWS 2011b). Necedah NWR has met or exceeded the annual 6,000 KBB recovery criteria every year since 1993. Population estimates are approximate, obtained by applying the KBB density on surveyed units to unsurveyed units with the surveyed units representing about 10% of the Refuge's occupied habitat (USFWS 2011b). Not all KBB sites are surveyed every year.

Private Landowner (Marquette Co). This site is being considered as a new recovery property (since listing) and may replace another recovery property in the state where recovery goals are considered difficult to meet. For purposes of this review a VP criterion (3,000 KBBs) has been assigned to this property.

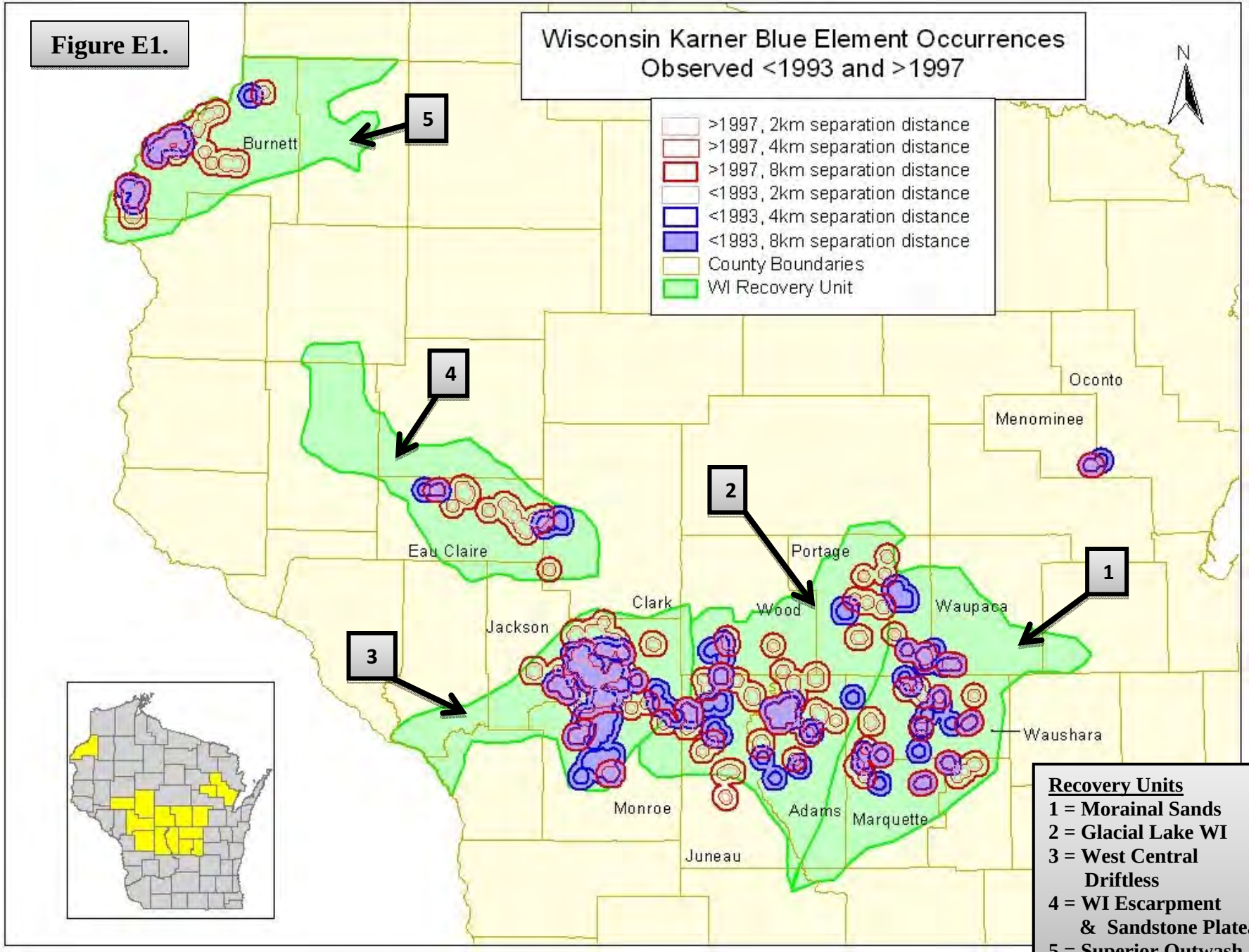
Fort McCoy: Straight line transect surveys are conducted using Distance sampling techniques at 22 locations (12 permanent transects and 10 randomly selected transects) to derive KBB population estimates for the spring and summer flights. Generally, sites are surveyed every seven days, the distance (in meters) the KBB is from the transect line when first observed is recorded using a 3 meter pole. The population estimates are derived by summing individual line transect surveys at a site to get an estimate of the site's total first or second brood population. A separate population estimate is derived for annually surveyed sites and randomly selected sites. The population estimate for the randomly selected sites is used to derive an extrapolated population estimate for the remainder of the installation. A final population estimate for each brood is arrived at by adding the extrapolated estimate to the estimate for the annually surveyed sites (Timothy Wilder, Ft. McCoy, pers. comm., 2011).

Wisconsin State-owned Recovery Sites: The KBB population estimates were derived by summing individual line transect surveys at a site to derive an estimate of the site's total second brood population. Surveys are spaced >=7 days apart in order to assume that the butterflies counted in the second week are a different set from those counted in week 1, etc. To obtain this sum, as well as confidence intervals around the sum, the data is entered into Program Distance as if each survey date in a site were a different stratum in the site (Gregor Schuurman, WDNR, pers. comm., 2011). The KBB population estimates are from WDNR 2011, and from an Email provided by Bob Hess, WDNR, dated 10/6 /2011. Note: The KBB population numbers are likely low as they do not include an estimate of the actual brood size as the New York data does.

APPENDIX E

WISCONSIN AND MICHIGAN ELEMENT OCCURRENCE

Figure E1.


Wisconsin Karner Blue Element Occurrences
Observed <1993 and >1997
>1997, 2km separation distance
>1997, 4km separation distance
>1997, 8km separation distance
<1993, 2km separation distance
<1993, 4km separation distance
<1993, 8km separation distance
County Boundaries
WI Recovery Unit
N
Burnett
Oconto
Menominee
Eau Claire
Portage
Clark
Wood
Waupaca
Jackson
Waushara
Monroe
Adams
Marquette
Juneau
1
2
3
4
5
Recovery Units
1 = Morainal Sands
2 = Glacial Lake WI
3 = West Central Driftless
4 = WI Escarpment & Sandstone Plateau
5 = Superior Outwash

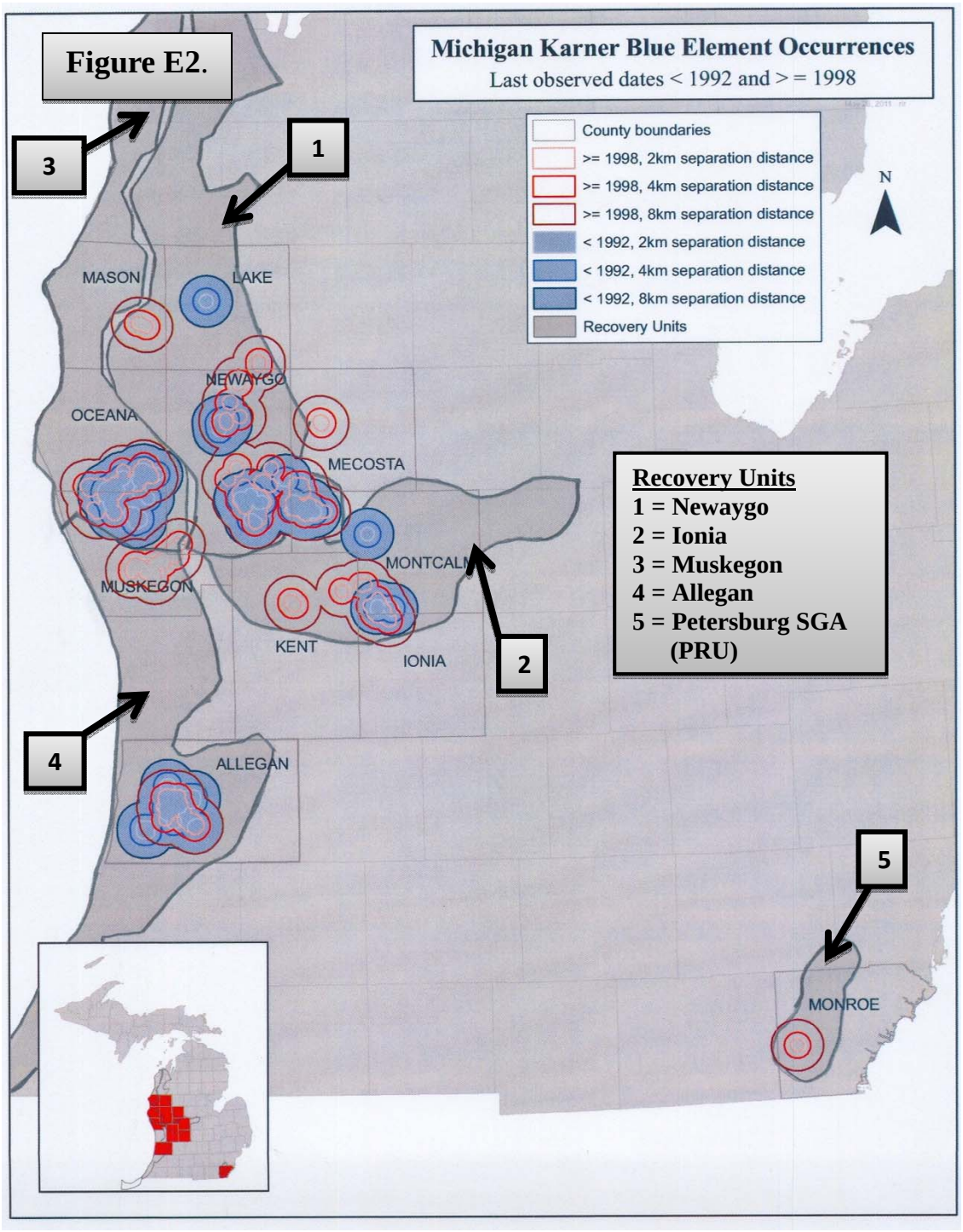


Figure E2.
Michigan Karner Blue Element Occurrences
Last observed dates < 1992 and > = 1998
County boundaries
>= 1998, 2km separation distance
>= 1998, 4km separation distance
>= 1998, 8km separation distance
< 1992, 2km separation distance
< 1992, 4km separation distance
< 1992, 8km separation distance
Recovery Units
N
MASON
LAKE
NEWAYGO
OCEANA
MECOSTA
MONTCALM
MUSKEGON
KENT
IONIA
ALLEGAN
MONROE
1
2
3
4
5
Recovery Units
1 = Newaygo
2 = Ionia
3 = Muskegon
4 = Allegan
5 = Petersburg SGA (PRU)

APPENDIX F

KBB VIABILITY ASSESSMENT CRITERIA FOR GLACIAL LAKE ALBANY RECOVERY UNIT (NEW YORK)

AND

CONCEPTUAL ECOLOGICAL MODEL

Table 1. Recovery goals and viability criteria for the Albany Pine Bush Karner blue butterfly metapopulation recovery unit. Descriptions and justification for the selection of categories, key ecological attributes, indicators, and rating schemes are described in the Tear et. al (in prep). Definitions and quantitative indicator ratings are derived from the Federal recovery plan (USFWS 2003). The shaded portion of this table highlights the contribution of habitat-based metrics (see Table 2) to population-based metrics emphasized in the federal recovery plan.

Metapopulation Recovery Area Evaluation Criteria			**Rating Scheme**			
Category	**Key Ecological Attribute**	**Indicator**	**Poor**	**Fair**	**Good**	**Very Good**
Size	Population size	Number of viable subpopulations in the metapopulation[a]	≤1	2-4	5-9	>9
		1st and 2nd flight mean number of individuals in a metapopulation[b]	≤3,820	3,820-7,640	7,641-12,960	≥12,960
Condition	Habitat suitability	Total acres of suitable habitat in the recovery area[c]	<160	160-319	320-638	≥640
Condition	Habitat suitability	Total lupine stems in the metapopulation[d]	<576,593	576,593 - 769,790	769,790 - 1,153,185	>1,153,185
Landscape Context	Connectivity	Number of subpopulations with at least 1 connection to other viable sub-populations[e]	≤1	2-4	5-9	>9

[a] It is desirable to have multiple subpopulations in order to retain metapopulation dynamics that provide refugia (sources for recolonization, and prevent threats such as wildfire from eliminating an entire recovery area). The federal recovery plan (USFWS, 2003) defines a viable subpopulation as supporting at least 500 butterflies (USFWS, 2003; pg E-62), and containing at least 12.4 acres of high quality habitat (USFWS, 2003; pg G-84). The habitat should be configured as one or more habitat patches within 200 m edge to edge (based on the mean flight distance of Kbb's - see USFWS, 2003; pgs G-74 to G-80), and not divided by barriers that limit exchange of individuals (e.g extensive dense forest, roads with high traffic volume (comparable to Rt. 155 in APB) during the majority of the Kbb daily active period) below a biologically significant threshold. Adjacent habitat areas may be divided into separate subpopulations by differences in management regime, so long as they support a sufficiently large shared population of butterflies. It is expected that butterflies can move freely among and recolonize all patches constituting a single subpopulation within 1 year following extirpation. Fuller 2008 prescribes 5 – 9 subpopulations to achieve greater than 50% probability of maintaining viability. The criteria for defining high quality habitat are described in Table 2.

[b] Fuller 2008 established a minimum viable population size of a 1st and 2nd flight average of 7,641 – 12,960 in order to ensure that the federal recovery plan viability thresholds are not violated. The minimum metapopulation threshold for a "large viable population" is set at 6,000 individuals for 4 out of 5 years (USFWS, 2003; pg. F-68) and 3,000 individuals for a "viable population" (USFWS, 2003; pg E-60).

[c] Total acreage of suitable habitat was calculated based on a series of four separate but nested criteria. It included the sum of habitat patches (1)more than 0.62 acres in size (USFWS, 2003; pg G-84)), (2) with good or better condition (as defined in Table 2), which (3) either occur within a subpopulation that is at least 12.4 acres in total size OR that occur within 1 km of other subpopulations. In some cases a subpopulation outside the 1 km distance may be connected by not more than two small patches of lupine or nectar ("stepping stones"), which are themselves at least 0.62 acres in size and not surrounded by forested matrix. Habitat patches included nectar areas within 200m of lupine patches. The good-fair boundary was set at half that for a large viable population (USFWS, 2003; 640 acres, pg. F-67).

[d] Based on Fuller 2008 estimate of stems needed to maintain an MVP for 9 subpopulations, capturing a range of egg/stem estimates (Table 4.6, pg 119).

[e] The goal of connectivity is to provide options for movement between subpopulations, based on the need for recolonization and genetic exchange. Two connections are preferred for redundancy, but all subpopulations should have at least one other viable subpopulation within a dispersal distance of 1 km, or connected by stepping stones as described in footnote 'c' (USFWS, 2003; pg G-73).

Table 2. Indicators and ratings used for estimating the quality of habitat patches for the Karner blue butterfly in the Glacial Lake Albany federal recovery unit in New York.

	Indicator Rating			
Indicator	**Poor**	**Fair**	**Good**	**Very Good**
lupine stem density/ acre[a]	≤1,801	1,802-2,401	2,402-3,603	>3,603
Spring nectar species richness	0	1	2-3	≥4
Summer nectar species richness	0	1	2-4	≥5
nectar density (percent quartiles)	≤25	25.1-50	50.1-75	>75
nectar evenness (index)	≤25	25.1-50	50.1-75	>75
grass cover (%)	<5, >95	5-20, 71-95	21-30, 51-70	30-50
overstory cover[b] (%)	<5, >50	50-31	30-16	15-5
shade heterogeneity	0-5 or 80.1-100	5.1-20 or 60.1-80	20.1-60	20.1-60, ≥5% each[c]

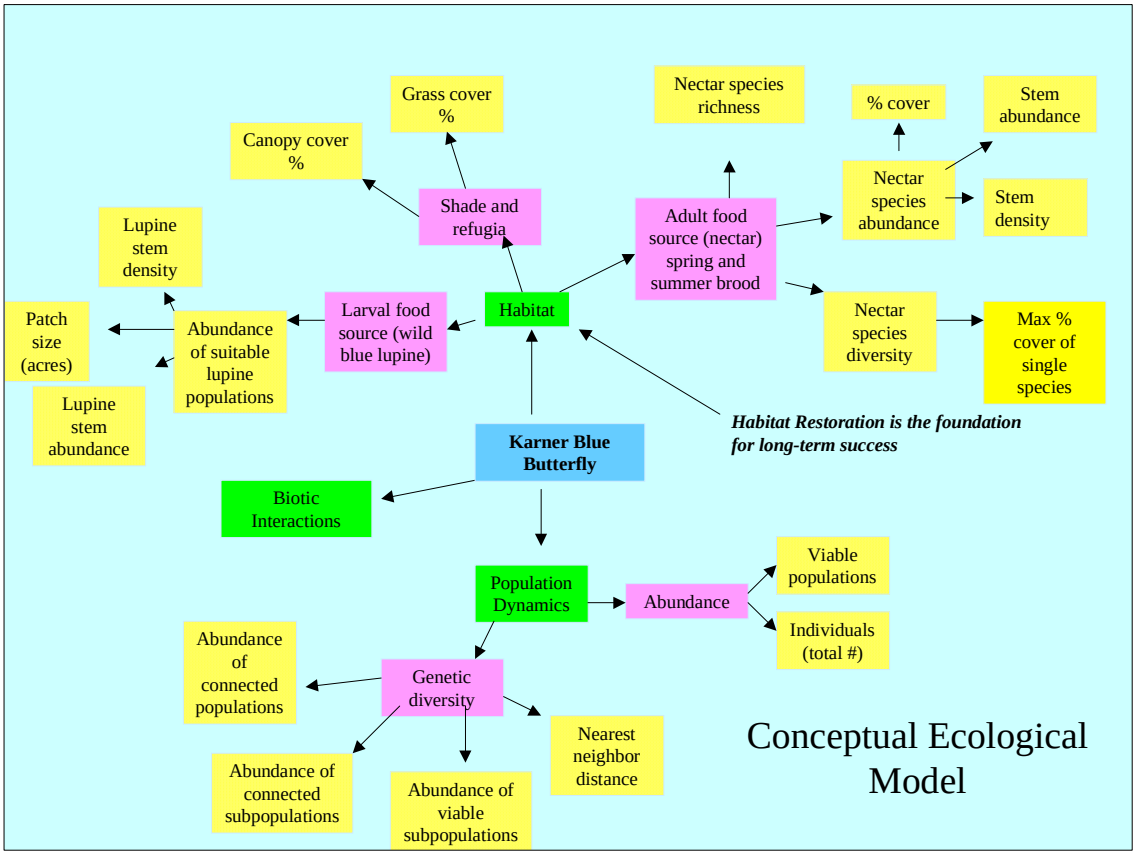
[a]Lupine density = Fuller (2008) stem estimate as a function of a range of carrying capacities (eggs/stem) (page 119 – Table 4.6); based on stem total for metapopulation divided by 320 acres.

[b] Overstory = woody overhead canopy (>2 m height, measured via periscope densitometer).

[c]Shade heterogeneity is Very Good when shade is contributed by both trees and shrubs, such that each type accounts for >30% density in at least 5% of the sample transects.

Source: Tables 1 and 2 derived from Gifford et al. 2011

Figure F1. KBB Conceptual Ecological Model



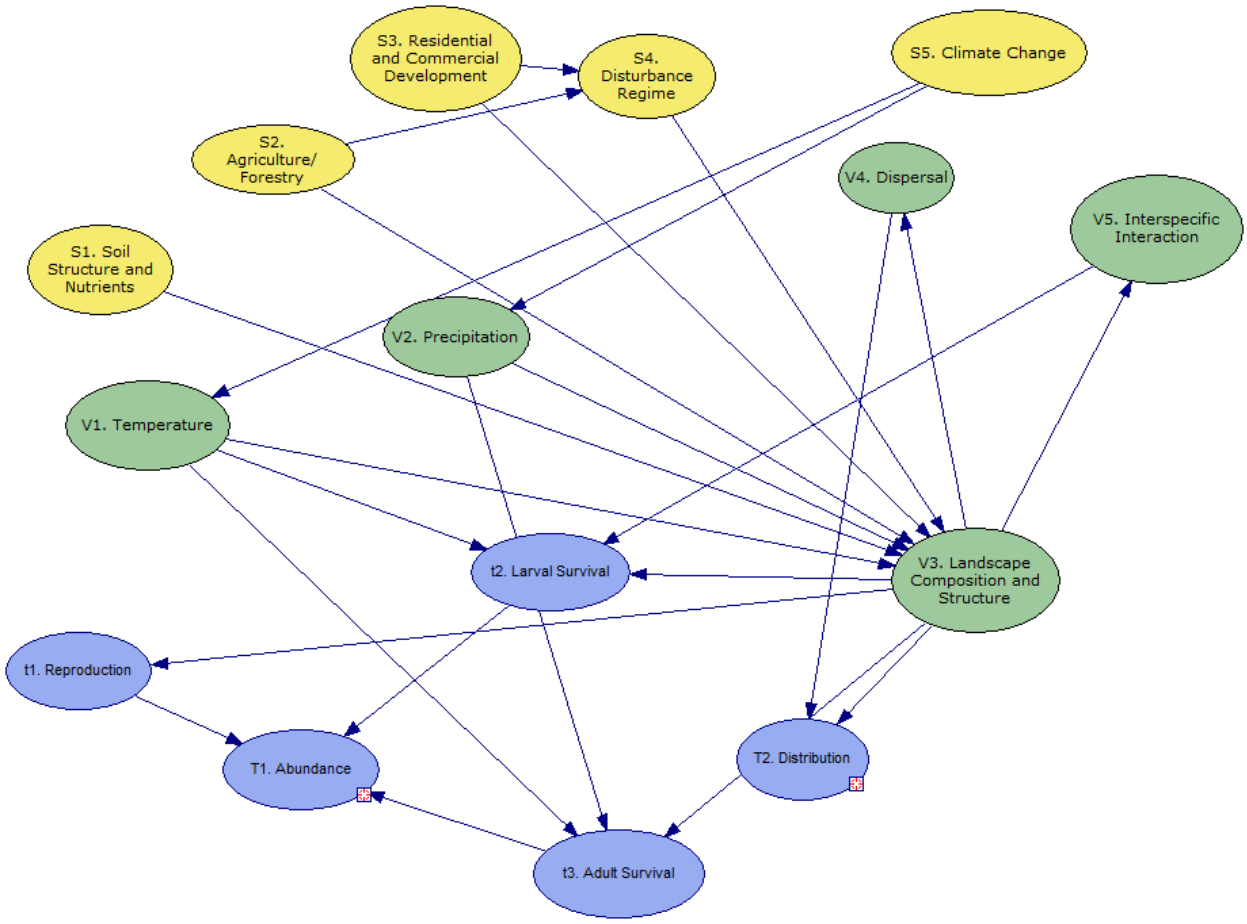
Source: Rebecca Shirer, TNC (Albany, NY), pers. comm., 2012.

APPENDIX G

CONCEPTUAL MODEL OF CLIMATE IMPACTS ON THE KARNER BLUE BUTTERFLY

FIGURE G l.

Conceptual Model of Climate Impacts on Karner Blue Butterfly
Blue: Assessment Endpoints
Green: Primary Factors
Yellow: Secondary Factors



Source: LeDee WICCI Wildlife Working Group June 2011