Karner Blue Butterfly
(Lycaeides melissa samuelis)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service, Midwest Region
Minnesota – Wisconsin Field Office
Bloomington, Minnesota

5-YEAR REVIEW
Karner blue butterfly (*Lycaeides melissa samuelis*)

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office: Region 3, Laura Ragan (612) 713-5157

Lead Field Office: Minnesota/ Wisconsin Field Office, Jill Utrup (952) 252-0092, ext. 207

Cooperating Field Offices:
Indiana Field Office, Lori Pruitt, (812) 334-4261, ext. 213
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Cooperating Regional Offices:
Region 5, Martin Miller, (413) 253-8615

1.2 Methodology used to complete the review:

The U.S. Fish and Wildlife Service's (USFWS) Minnesota/Wisconsin Ecological Services Field Office conducted this 5-year review. Data for this review were solicited through a *Federal Register* notice announcing this review on April 17, 2017 (82 FR 18156). We also contacted all partners associated with the Karner blue butterfly (KBB) recovery team, including (but not limited to): Michigan Department of Natural Resources (MI DNR), Michigan Natural Features Inventory, U.S. Forest Service (Huron Manistee National Forest), Minnesota Department of Natural Resources (MN DNR), University of Minnesota, Minnesota Zoo, New York Department of Environmental Conservation (NY DEC), Albany Pine Bush Preserve Commission (APBPC), Toledo Zoo and Aquarium, Wisconsin Department of Natural Resources (WDNR), Fort McCoy, U.S. Geological Survey, and the National Park Service (including Indiana Dunes National Park) to request any data or information we should consider in our review. Additionally, we conducted a literature search and a review of information in our files. Other USFWS Field Offices within the range were provided a draft of this 5-year review for their input. The information below summarizes substantive new information since our 2012 5-year review.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review:

82 FR 18156 (April 17, 2017) – Endangered and Threatened Wildlife and Plants; Initiation of a 5-Year Status Reviews of Eight Endangered Animal Species: Iowa Pleistocene snail (*Discus macclintocki*), Karner blue butterfly (*Lycaeides melissa samuelis*), Kirtland's warbler (*Setophaga kirtlandii* [=*Dendroica kirtlandii*]), Ozark hellbender (*Cryptobranchus alleganiensis bishop*), rayed bean (*Villosa fabalis*), sheepnose (*Plethobasus cyphyus*), snuffbox (*Epioblasma triquetra*), and spectaclecase (*Cumberlandia monodonta*).

1.3.2 Listing history

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

1.3.3 Associated rulemakings: none

1.3.4 Review History:

U.S. Fish and Wildlife Service. 2012. Karner Blue Butterfly *(Lycaeides melissa samuelis)* 5-year Review: Summary and Evaluation. Green Bay Field Office, New Franken, WI. 129 pp. Finalized September 17, 2012.

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

2.2.2.1 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)?
There has been additional analysis since the last 5-year review indicating that the KBB is more highly sensitive to direct and indirect impacts from climate change than was previously known (see section 2.3.2). As additional information is learned regarding recovery options for the KBB in light of the effects of climate change, we may decide that altering recovery criteria is appropriate.

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 progress toward the recovery and delisting criteria from the Karner Blue Butterfly Recovery Plan (USFWS 2003).

Reclassification and Delisting Criteria

Reclassification goals set forth in the Recovery Plan include the establishment of either 19 viable metapopulations (VPs) and 8 large viable metapopulations (LPs, viable metapopualtions with larger areal extent, more suitable habitat, and a more robust metapopulation structure) or 23VPs and 6 LPs within 13 Recovery Units (USFWS 2003, pp. 55-56). Each VP and LP must meet specific reclassification criteria as identified in the Recovery Plan (USFWS 2003, p. 57). Delisting goals set forth in the KBB Recovery Plan include the establishment of either 13 viable metapopulations (VPs) and 16 LPs or 21 VPs and 11 LPs within 13 Recovery units (USFWS 2003, pp. 57-58). Each VP and LP must meet additional delisting criteria as identified in the Recovery Plan (USFWS

2003, p. 57). The locations of recovery sites by Recovery Unit as identified in the recovery plan (USFWS 2003, Table 4) plus 6 additional potential recovery sites of note (USFWS 2012) are outlined in Table 1.

Both the reclassification and delisting criteria (or goals) have been met for one of the 13 Recovery Units, the Merrimack/Nashua River System in New Hampshire. That Recovery Unit has one VP (the Concord reintroduction site) that meets all the reclassification and delisting criteria for a VP. The Albany Pine Bush site in the Glacial Lake Albany Recovery Unit in New York has also met the reclassification and delisting criteria for a VP; however additional VPs are recommended in that Recovery Unit for the entire Unit to meet the reclassification criteria. Additionally, 3 LP sites in Wisconsin meet the reclassification and delisting criteria for an LP; those sites are Fort McCoy-North Post and Fort McCoy-South Post (in the West Central Driftless Recovery Unit) and Necedah National Wildlife Refuge (NWR, in the Glacial Lakes Wisconsin Recovery Unit) (Table 1).

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

Substantive new information on the KBB's biology and habitat, abundance and population trends, genetics, spatial distribution, and habitat or ecosystem conditions published since the previous 5-year review (USFWS 2012) is summarized below.

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

Habitat factors affecting KBB presence

Through surveys carried out at Concord Pine Barrens, New Hampshire, within native and restored wild lupine (*Lupinus perennis*) KBB habitat, Pascale and Thiet (2016, p. 633) found that both native and restored wild lupine (*Lupinus perennis*) supported both KBBs and larval-tending ants. They suggested that managers encourage the interaction between ants and butterflies by managing for particular habitat characteristics attractive to both. The authors also recommended additional studies to evaluate which ant species provide the most benefit to KBBs and noted that this may be an especially important consideration in management and conservation of KBBs and their habitat (Pascale and Thiet 2016, p. 640).

Walsh (2017) found that factors affecting KBB microclimate were primary predictors in a model designed to predict KBB occupancy in Michigan and Ohio. He found that the heat load variable (index of incident solar radiation adjusted for differences in site aspect, slope, and elevation) accounted for 64-67% of the variation in the model. Density of flowering lupine, the density of ant tunnel

entrances, and heat load were higher in occupied sites (Walsh 2017, pp. 222-224). Overall, the author found that habitat management for the species should incorporate a "heterogeneous habitat structure throughout the range" where there is canopy cover that can provide refugia balanced with enough openness to allow lupine to thrive. Further, the author suggested that managing for the persistence of higher lupine density and ant presence may allow for increased long-term health of KBB populations (Walsh 2017, pp. 224-227).

Hallfors et al. (2016, p. 1157) performed principal component analyses to explore whether occurrences of KBBs are segregated by climatic variables and to identify potential climatically distinct populations. The KBB was used as one of two study species to determine, in part, the possibility of errors related to this type of analysis and modeling. Their analyses found that KBB showed distinct clustering; two distinct groups were identifiable. The eastern population (KBB-East) consisted of occurrences in Illinois, Indiana, Michigan, Ohio, New York, and New Hampshire and Ontario, Canada and the western population (KBB-West) consisted of occurrences in Minnesota and Wisconsin. The authors urged considering both whole-species and population-level modeling before moving forward with management decisions (Hallfors et al. 2016, pp. 1158, 1167).

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:

Swengel and Swengel (2018) compared survey trends on Wisconsin sites over 17 years for the KBB and two other species, the frosted elfin (*Callophrus irus*) and Persius Duskywing (*Erynnis persius*), which are found throughout much of the same habitat in the State. Although the authors reported declines for all 3 species, they found higher trends in abundance for all species at "reserve" properties (those “where recovery would be expected to occur”) than rights-of-way and forestry land and suggested a higher level of habitat management as the reason for this result. In light of observed population declines, the authors suggested continued conservation management (as was observed in “reserve” sites) as a means to promote conservation of the KBB and the other evaluated species (Swengel and Swengel 2018, pp. 8-9).

In 2015, the MI DNR funded the Michigan Natural Features Inventory (MNFI) to develop an occupancy-based survey for KBB within Allegan and Flat River State Game Areas (SGA). The MI DNR had been conducting distance sampling surveys at occupied sites within these areas. They were interested in maintaining distance surveys at these sites to continue building a long-term data set with a consistent methodology while expanding KBB monitoring to a greater number of sites using an occupancy approach. MNFI recommended a modification to the layout and design of the distance sampling transects within both SGAs and additional occupancy surveys that allow for tracking populations at both high

priority sites and lower priority sites (surveyed on a rotational basis; Monfils and Cuthrell 2015, entire). Data collected from 2015-2018 suggest an increasing trend in occupancy on the State lands that were monitored over the four-year period, which included Allegan State Game Area and a small number of areas surveyed in Flat River SGA (southern Newaygo County; Table 3). These observed trends may indicate that the KBB population is rebounding from the declines in 2012 that were associated with high spring temperatures and summer drought (Monfils and Cuthrell 2018, p. 8).

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

Saarinen (2015) recommended special considerations for endangered butterfly species, such as the KBB, when doing conservation genetics projects. Mitochondrial DNA sequencing has been successfully used for the KBB particularly in issues of mitochondrial introgression from the Melissa blue (*Lycaeides melissa melissa*) (Saarinen 2015, p. 79). A range-wide genetics project consisting of collection of wing clip samples from 30 individuals from across the range along with development of a set of polymorphic microsatellite markers was initiated to evaluate genetic diversity across the range of the species and to determine gene flow between populations. This project was on hold temporarily, but continued processing of samples began in 2018 (R. Grundel, USGS, 2018, pers. comm.). Saarinen (2015, pp. 93-94) is also using these markers to evaluate dispersal and population dynamics at the metapopulation level for a single population in Michigan.

2.3.1.4 Taxonomic classification or changes in nomenclature:

There are no changes in taxonomic classification or nomenclature.

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

Changes in the distribution of the KBB within its historical range have occurred since the last 5-year review (USFWS 2012; Figure 1) and the number of KBB populations has decreased since listing. Of the eight states with KBBs at the time of listing in 1992 (Illinois, New Hampshire, New York, Indiana, Ohio, Michigan, Wisconsin and Minnesota) (USFWS 1992), KBBs are likely no longer present in Illinois, Minnesota, and Indiana. As reported in the last 5-year review, spatial distribution at the metapopulation level has improved at some KBB recovery sites as a result of habitat restoration and management activities, but habitat degradation and loss from plant community succession and the presence of invasive plants continue to be a stressor to the species at many or all recovery sites (USFWS 2012).

Indiana: When the KBB was listed in 1992, the Indiana Dunes National Park (INDU) population was among the species' largest, with 5000-10,000 butterflies (USFWS 2003, KBB Climate Response Sub Team Report DRAFT 2017). The KBB populations in Indiana are now believed to be extirpated (Hellmann et al. 2016, p. 93). At the time of the last 5-year review, there were still 3 occupied sites in the West Gary metapopulation (site): Ivanhoe Dune and Swale Nature Preserve Park, Dupont Natural Area, and Tolleston Ridges Nature Preserve (USFWS 2012). The last 2 KBBs found in Indiana were seen in 2014, one in Miller Woods and the other at the Long Lake site (both within INDU). Extensive surveys were conducted in 2015-2017, however, no KBBs were found (KBB Climate Response Sub Team Report DRAFT 2017). Although KBBs have not been found at INDU since 2014, habitat management, restoration, and enhancement conducive to KBB continues to occur throughout previously occupied habitat and adjacent areas in Indiana.

Michigan: Monfils and Cuthrell (2018) conducted distance and occupancy surveys over 4 years on State lands in Michigan (see section 1.2 above). Results and analysis from their study suggested an increasing trend in occupancy on the State lands monitored, with the probability of colonization by KBB being greater than the probability of extinction. Maximum second flight abundance increased each year when all sites were considered, but abundance for those sites visited in all four years was more variable across the period (Table 3). Overall, their results may indicate that the KBB population is rebounding since declines in 2012 that were associated with record high spring temperatures and summer drought (Monfils and Cuthrell 2018, p. 8).

The Huron-Manistee National Forests (H-M NF) manage for the KBB within 5 metapopulation areas located within the Newaygo (Hayes, Brohman, and Bigelow) and Muskegon (Otto and White River) Recovery Units. All known KBB subpopulations within the H-M NFs occur on the Baldwin/White Cloud Ranger District. The number of subpopulations monitored and survey methods used on USFS lands has varied over the years based on resource constraints. Distance sampling was previously used to monitor all metapopulations, but in 2018 distance sampling was discontinued. However, inventory surveys, which are used to collect presence/absence surveys for KBB, have been used consistently over the years. On non-federal lands within the 5 metapopulations, minimal monitoring has been done recently; and similar to federal lands, starting in 2015 only inventory surveys for KBB presence/absence were conducted. None of the metapopulation areas within the H-M NF have consistently met recovery goal estimates of over 3,000 second brood adults to date. Long-term presence/absence trend data shows that the species was in decline for the past few decades, but now seems to be stabilizing and the species' distribution is expanding on the H-M NF, which the Forest reports is likely due to continued, increasing management efforts (H. Keough, H-M NF, 2019, pers. comm.; Figure 2). Continued expansion of the KBB's distribution has been observed as

additional savanna habitat is created, with KBBs recently found on 25 restored areas. By 2026, the Huron-Manistee National Forests plan to restore an additional 3,000 acres of high-quality savanna to promote the establishment of 5 viable KBB metapopulations (H. Keough, H-M NF, 2019, pers. comm).

Minnesota: Although there has not been a concentrated survey effort at Cuthrell Valley within Whitewater WMA where KBBs were previously found, there have been surveys conducted by an independent entomologist for other butterflies during which no KBBs where observed (D. Hansen 2019, pers. comm.). The species is likely extirpated from the State; however, restoration efforts continue at Whitewater Wildlife Management Area and St. Croix State Park, where lupine and suitable nectar plants have been observed, but there are currently no records of KBBs (A. Hess, MN Department of Natural Resources, 2018, pers. comm.).

New Hampshire: The population in New Hampshire met the recovery criteria of 3,000 individuals set forth in the Recovery Plan (USFWS 2003) in 2016; however the population declined in 2017 to 1,500 individuals (H. Holman, New Hampshire Dept. of Fish and Game, 2018, pers. comm.). Habitat management work continues on a rotational schedule to maintain existing habitat and increase the amount of lupine available, but more land area may be necessary to support a larger population. Invasive plants are not considered a significant threat at this time to KBB habitat. Population augmentation through captive rearing continues for the population and it is unclear at this time when that effort will cease (H. Holman, New Hampshire Dept. of Fish and Game, 2018, pers. comm.).

New York: The Glacial Lake Recovery Unit in New York has approximately 29 KBB sub-populations spread across 4 metapopulations (sites; Service 2012). The Saratoga West population (includes area surrounding Saratoga Airport) previously was the largest New York population (with numbers close to 10,000 in 1989). It is now declining and it is currently challenging to find KBBs at the site (R. Niver, USFWS, 2017, pers. comm. and K. O'Brian, NY DEC, 2017, pers. comm.). Within the Saratoga West population, there are few sub-populations (9) with poor connectivity to each other and with little management except for at the Saratoga County Airport and a state park (Saratoga Spa State Park). There are limited opportunities for restoration and expansion of habitat. The Queensbury population has a similar number of small sub-populations focused along power line rights-of-way and is considered a stable to declining population. A Habitat Conservation Plan (HCP) developed to address impacts from operations and management of an electricity and gas company includes habitat management and restoration actions for this KBB population.

The Saratoga Sandplains and Albany Pine Bush sites are considered stable or increasing. At the time of the last 5-year review, the Saratoga Sandplains population supported the largest KBB population in the eastern United States (>20,000 butterflies) (Service 2012). Habitat has increased significantly at this site, from 5 acres to approximately 140 acres over the past 15 years. Restoration

work, consisting of land acquisition, tree clearing, planting, and mowing resulted in a dramatic population increase from less than 1,000 KBBs in 2003 to more than 20,000 KBBs in 2010 (Service 2012). Peak counts associated with distance sampling estimates continued to increase in 2011-2016; however, 2017 counts were down at the few sites that were surveyed (NYSDEC 2018). Population estimates derived from the 2017 counts are not yet available but they are similar or higher than 2011-2013 counts.

The Albany Pine Bush population has also increased in recent years. The most recent survey year marks the sixth consecutive year that the Albany Pine Bush population exceeded the Recovery Plan population target (3,000 adults in either the first or second brood) and the fourth time it exceeded the population target set by the APBPC (7,640 adults) (N. Gifford, Albany Pine Bush Preserve, 2018, pers. comm.) (Figure 3). There are currently over 700 acres of potentially occupied lupine habitat within Albany Pine Bush (N. Gifford, Albany Pine Bush Preserve, 2018, pers. comm.).

Ohio: KBBs are still present at only one site in Ohio, Kitty Todd Nature Preserve (where they were reintroduced), and the species is subsisting at low numbers (J. Finfera, USFWS, 2018, pers. comm.). The Toledo Zoo continues to augment the Kitty Todd population with KBBs raised in captivity. The source population for this effort is butterflies from the Allegan State Game Area in Michigan. KBBs have also been released at Mielke Road (Ohio DNR), but have not been found in subsequent years after release.

Wisconsin: Wisconsin still supports the largest and most widespread KBB populations range-wide. There are 5 recognized Recovery Units in Wisconsin; the Morainal Sands Unit, Glacial Lake Wisconsin, West Central Driftless, Wisconsin Escarpment and Sandstone Plateau, and Superior Outwash. The WI DNR conducts surveys and maintains survey records on the majority of the State's larger known KBB occupied sites. After the drought-like conditions experienced throughout much of the Midwest in 2012, populations in Wisconsin declined significantly; however, many (especially larger populations) are starting to rebound (Table 2). Many sites are not large enough to use distance sampling (the standard survey method used on Wisconsin State recovery properties); this is especially the case for populations within the Wisconsin Escarpment & Sandstone Plateau Recovery Unit (C. Gunther, WI DNR, 2018, pers. comm.). Also, although there have been gaps in survey effort for some sites, it appears that KBB populations on Wisconsin State properties follow a cyclical pattern and, presently (in 2017 and 2018), the KBB is on a downward trend. Restoration and enhancement efforts continue throughout all recovery units in Wisconsin (C. Gunther, WI DNR, 2018, pers. comm.).

In 2019, as part of obligations related to the Incidental Take Permit associated with the Wisconsin Habitat Conservation Plan, the WI DNR updated the Karner blue butterfly High Potential Range (HPR) map. The map was developed using a model to identify areas where the KBB has the highest probability of occurrence,

but does not represent the species' distribution. The probability model analyzed variables including known locations of KBB, soil type, land cover, water table, and climate. The HPR currently includes portions of 20 counties. WI DNR will continue to update the map as new information becomes available (https://dnr.wi.gov/topic/endangeredresources/karner/range.html, Figure 4).

Fort McCoy and Necedah National Wildlife Refuge continue to maintain two of the largest known metapopulations of KBBs and have both met delisting criteria for LPs as outlined in the Recovery Plan (USFWS 2003). Straight-line transect surveys at Fort McCoy have shown some fluctuations in population numbers (decline observed in 2014; Table 4); however, habitat managers at Fort McCoy do not consider these 'dips' to be cause for concern as Fort McCoy has a large amount of wild lupine over a large area of varying habitats (T. Wilder, Fort McCoy, 2018 pers. comm.). Although there may be fluctuations within the larger sites, both properties consider their KBB populations to be stable (T. Wilder, Fort McCoy, 2018, pers. comm.; B. Strobel, USFWS, 2019, pers. comm.).

Ontario: KBBs occurred in the province of Ontario, Canada until about 1991, when they were likely extirpated (USFWS 2003, USFWS 2012). Jarvis (2014) assessed the habitat conditions for KBB suitability in 2014. He found that the largest individual lupine population in Ontario just exceeds 19,000 stems in each of the 5-9 subpopulations that make up a greater metapopulation (Jarvis 2014, p. 32). That amount of lupine is far less than the 128,130 stems Fuller (2008) found to sustain a viable population of KBBs. Jarvis (2014) also found that extensive lupine planting at and around existing sites is necessary prior to attempting reintroduction of the KBB in Ontario. There are a few sites that may offer suitable KBB habitat in the future, however, even the complex of sites that currently has the most available lupine was 10 years or more away from being able to support a minimum viable population of the KBB (Jarvis 2014, p. 39).

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

Habitat suitability:

New York: Bried et al. (2014, p. 1386) implemented a framework to integrate habitat monitoring with species recovery efforts to assess which recovery areas in New York they considered valuable for investing conservation resources and where site-specific restoration work is needed. The Albany Pine Bush and Saratoga Sandplains "emerged as priority recovery sites due to having the most habitat potential and infrastructure to support restoration (enough protected land base and strong financial and sociopolitical backing)." This study also found that reducing woody canopy cover, both to increase patch size and promote better shade heterogeneity (from trees and shrubs), is a priority site-level action, which is consistent with other findings that decreased and differing canopy structure

promotes KBB and lupine survival (Grundel et al. 1998; Pickens and Root 2008; Pavlovic and Grundel 2008, p. 1395)

Wisconsin: There has been an abundance of recent research evaluating habitat conservation programs or management in Wisconsin. Hess (2013, p. 103) developed models with the purpose of identifying potential KBB and lupine habitat and showing the relative habitat suitability based on ground measurements. The models allow identification of the highest quality areas based on KBB suitability variables and provide land managers with insights on areas to target for monitoring and identifying areas that may be suitable if restored (Hess 2013, p. 102). Building on this information and incorporating additional sites will continue to increase the effectiveness of model results (Hess 2013, pp. 103-104; Hess and Hess 2015). At Sandhill Wildlife Area (Wisconsin), which retains a permanent herd of bison (*Bison bison*), researchers found that KBBs were positively associated with bison usage and that KBB presence and wild lupine is positively associated with areas with greater bison usage. Bison activities reduced woody growth, promoting wild lupine and other nectar forbs, and provided nutrients and minerals by way of bison feces (Hess 2013, pp. 144, 154; Hess et al. 2014).

Kleintjes Neff et al. (2017) evaluated the KBB-SAFE (State Acres for Wildlife Enhancement- USDA Farm Service Program) to determine if it provides suitable habitat for the KBB. The authors concluded that KBB-SAFE provides habitat for many grassland species and serves as a surrogate for KBB habitat, particularly during the second flight period. Although the program was found to complement KBB recovery efforts on public and private lands, the authors provided additional management recommendations to allow the program to better meet the needs of the KBB and other sensitive butterfly species, including adding a more diverse suite of first flight nectar plants (Kleintjes Neff et al. 2017).

One private landowner in Wisconsin chronicled the use of KBBs in restored (planting wild lupine only) habitat via presence and absence surveys conducted from 2009 through 2015 in Central Wisconsin. KBBs were found using these small patches as early as 3 years post-planting, leading the author to suggest that interested private landowners could help strengthen larger metapopulations by restoring habitat (Shillinglaw 2016, pp. 113-114)

Habitat adaptability:

Handel (2015) tested whether a captive bred KBB population was adapted to local wild lupine. The study found an apparent absence of local adaptation to wild lupine, suggesting that some individuals could be translocated from native populations of wild lupine to new or unfamiliar reintroduction sites. However, this study was limited by wild lupine samples (a small portion of range was included) and by the fact that the tested KBB population had been bred in

captivity for several generations, thereby limiting genetic variation and reducing fitness levels (Handel 2015, p. 16).

2.3.2 New Information on threats, conservation measures, and regulatory mechanisms since the last 5-year review

Recreational use:

As previously reported in the 2012 5-year review, recreational use of KBB habitat is considered a concern for the species (Bennett et al. 2010; USFWS 2012). Bennett et al. (2013) used a modeling approach to address the response of the KBB to recreational use of its habitat. They found that KBB adults react to intruding humans in the same way they react to potential predators, by rapidly flying away from the perceived threat (Bennett et al. 2013). This has negative implications for fecundity and host plant selection, both of which strongly influence population dynamics (Bennett et al. 2013).

KBB and Climate Change

The KBB is now thought to be extirpated at the southern edge of its range in Indiana. The population at Indiana Dunes National Park (INDU) declined in conjunction with documented warming conditions, despite habitat management, restoration, and population augmentation efforts (Hellmann et al. 2016, p. 93). Due in part to this discovery, the KBB recovery team recently designated a climate change sub-team tasked with exploring the species' sensitivity to climate change and its adaptive capacity. The sub-team developed a report and submitted it to the larger recovery team for their review in December 2017.

Although the report from the sub-team is still in draft, it presents several key findings. The report used the population at INDU as a case study to explore the KBB's sensitivity and exposure to climate change. Findings indicate that the population's decline occurred in conjunction with documented warming conditions. The documented decline is considered consistent with scientists' expectations for how a population of a low-motility species at the trailing edge of climate-induced range shift would respond. It was found that the KBB likely has low adaptive capacity to tolerate changes associated with climate change, due to the limited capacity to adapt via dispersal, changing behavior (e.g., single larval host plant), or evolving in place. Further, the species' vulnerability to the direct and indirect effects of climate change to it and its host plant, wild lupine, is high. The sub-team suggested many possible strategies in light of the impact that climate change is and will have on the species. These strategies fall in one of two categories: persistence or directed change. The report defines a persistence strategy as one that "responds to climate change impacts to KBBs by seeking to maintain or restore the species, as we know it, where it has historically occurred (i.e., within its historical range and general habitat, including matching genotypes

to specific historical geographies as closely as possible)," whereas a directed change strategy "does not resist climate change impacts or allow autonomous response to them, but instead attempts to steer change towards specific future desired conditions. In a KBB context, managers would pursue such strategies based on a conclusion that 1) some historical KBB sites are, or soon will be, outside their historical range of climate variability and unsuitable for their historical KBB genotype, and 2) the KBB populations lack the adaptive capacity to respond effectively to these changes." (see below for **Recommendations for Future Actions** for additional information; USFWS 2003; KBB Climate Response Sub Team Report DRAFT 2017)

2.4. Synthesis:

The KBB should continue to remain listed as endangered because, since the species was listed, it has been extirpated from recovery units in Minnesota and Indiana. Additionally, although some populations have demonstrated some improvement, others have remained low or are demonstrating a decline. In addition, the KBB has been found to be highly sensitive to both direct and indirect climate change impacts. Other threats present at the time of listing, such as loss of habitat due to natural succession, lack of management, invasive species and commercial, industrial and residential development, also continue to persist for the species.

RECOMMENDATIONS FOR FUTURE ACTIONS:

- Restore and protect habitat in areas that do not have sufficient KBB numbers or acres to support them.
- Continue to manage currently suitable habitat to ensure long-term availability to KBBs.
- Continue to evaluate the impact of climate change on the species. The KBB Climate Response Sub-Team plans to finalize their report in the near future. Some of the recovery actions that were recommended in the draft report include:
    - Encourage entities (city, state, county, tribal, federal) with sandy soils north of the current range to plant wild lupine.
    - Collect and store KBB genetic material from all sites, prioritizing extirpated and most-at-risk populations.
    - Experiment with creating or maintaining habitat in cooler and wetter microsites within areas that are currently managed for KBB and provide tools for managers (with findings incorporated).
    - Reach out to different jurisdictions and new agency and private landowners that may have suitable soils and climate for KBB in the future.

    - Develop capacity to maintain captive populations for augmentation of existing small populations or establishing new populations.
- Continue to plan and implement regular surveys, monitor occurrences, and document habitat conditions and population trends at all KBB locations throughout the range.
- Increase standardization of KBB surveying and monitoring to allow better comparisons among survey locations.
- Support research of poorly understood aspects of KBB biology (especially those relevant to adaptive capacity) and habitat management
    - Gain a better understanding of the quantity and quality of nectar resources available to KBBs, which could be important for restoration purposes (current research)
- Conduct a KBB Species Status Assessment (SSA) to inform potential updates of the KBB Recovery Plan

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of the Karner blue butterfly

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

_X_ No change needed

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Sarah J Quan Date 12/17/2019

The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

Literature Cited

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Tables and Figures:

Table 1. Locations of recovery sites by recovery unit [includes sites in Table B1 of KBB recovery plan (USFWS 2003) and additional potential recovery unit (PRU) noted in the previous 5-year Review (USFWS 2012)]. Locations where recovery goals have been met are in bold text (all 3 sites have met goals for reclassification and delisting). Sites that are believed to be extirpated have an asterisk.

Recovery Unit *(unless otherwise noted)*	**State**	**Recovery Goals**		**Recovery Sites and Potential Recovery Sites**
		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 (Muskegon SGA/private lands)
Oak Opening PRU	MI	-	-	Petersburg SGA (reintroduction)
Indiana Dunes	IN	2VP VP	2VP VP	*Indiana Dunes National Lakeshore *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 and South Posts)** 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

VP = viable population, LP = large viable population, SGA= State Game Area, HMNF = Huron Manistee National Forest, WA = Wildlife Area, WMA = Wildlife Management Area, TNC = The Nature Conservancy

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

Bold text = Recovery locations that have met recovery criteria (all 3 have met both reclassification and delisting goals)

*= site believed extirpated

PRU = Potential Recovery Units are areas in which the KBB occurred historically or may exist in low numbers. 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 Recovery Unit.

Table 2.

KBB population estimates from Wisconsin State properties where KBBs are monitored or private properties for which survey records are maintained, 2012-2018. All surveys were conducted using distance sampling. Empty cells represent years in which no survey took place.

Recovery Unit	Property	2012	2013	2014	2015	2016	2017	2018
Glacial Lake Wisconsin	Sandhill W.A.	7,771	3,839		57,852	76,347	53,971	12,692
Morainal Sands	Emmons Creek F.A.	5,597	4,733	697	1,335	3,002	4,781	1,629
	Hartman Creek S.P.		409	371		380		
	Welch-Martin	2,842	2,611		6,239	10,856	4,773	3183
	Greenwood W.A.	771		366				
	White River W.A.	7,994	5,264	4,384	5,197	7,748	1,756	1987
	Private Property 1	8,587	599	610	760	4,302	3,580	2,356
	Private Property 2		3,710	3,281	1,729	5,674	4,431	1,860
	Private Property 3						386	1030
West Central Driftless	Black River S.F.	782	261			2,492	4,648	5,375
	Bauer Brockway SNA		316			3,336	2,346	372
Superior Outwash	Crex Meadows W.A.	1,228	213	427	567	2,054	865	871
	Fish Lake W.A.	2,421		1,043	626	1,691	1,690	1,186
Annual Totals:		**29,406**	**17,646**	**7,288**	**71,816**	**107,906**	**74,830**	**27,295**
		37,993	**21,955**	**11,179**	**74,305**	**117,882**	**83,227**	**32,541**

Table 3.

Summary of results from surveys conducted for KBB on State and private lands in Michigan during 2015-2018 (Monfils and Cuthrell 2018).

Measure	2015	2016	2017	2018
Number of sites surveyed	51	62	63	58
Proportion of sites occupied				
All sites surveyed	0.471	0.672	0.672	0.655
Sites visited every year (*n* = 44)	0.546	0.682	0.727	0.659
Maximum second flight abundance (sum of largest number detected between two surveys of each site)				
All sites surveyed	658	4,986	4,867	5,384
Sites visited every year (*n* = 44)	658	1,704	1,596	1,031

Table 4.

KBB Line transect survey results from 2009-2012, 2014, and 2016 during the second flight period at Fort McCoy, Wisconsin.

POPULATION AREA	POPULATION ESTIMATE (RANDOM SITES)	EXTRAPOLATED POPULATION ESTIMATE (RANDOM SITES)	POPULATION ESTIMATE (ANNUAL SITES)	COMBINED POPULATION ESTIMATE
2009				
A1/A2	--	--	140	140
SOUTH POST	393	31,305	2,369	33,674
NORTH POST	105	24,889	1,701	26,590
TOTAL	**498**	**56,194**	**4,210**	**60,404**
2010				
A1/A2	--	--	200	200
SOUTH POST	287	93,417	6,007	99,424
NORTH POST	442	70,629	3,480	74,109
TOTAL	**729**	**164,046**	**9,687**	**173,733**
2011				
A1/A2	--	--	444	444
SOUTH POST	1,011	124,508	4,645	129,153
NORTH POST	528	194,399	5,802	200,201
TOTAL	**1,539**	**318,907**	**10,891**	**329,798**
2012				
A1/A2	--	--	135	135
SOUTH POST	166	32,674	2,034	34,708
NORTH POST	614	78,068	3,311	81,379
TOTAL	**780**	**110,742**	**5,480**	**116,222**
2014				
A1/A2	--	--	60	60
SOUTH POST	141	18,924	1,716	20,640
NORTH POST	15	8,276	1,458	9,734
TOTAL	**166**	**27,200**	**3,234**	**30,434**
2014				
A1/A2	--	--	95	**95**
SOUTH POST	249	73,141	4,009	**77,150**
NORTH POST	198	86,232	3,577	**89,809**
TOTAL	**447**	**159,373**	**7,681**	**167,054**

Figure 1.

Developed by A. Hess (2019) as part of the Draft KBB Climate Response Sub Team Report DRAFT, 2017.

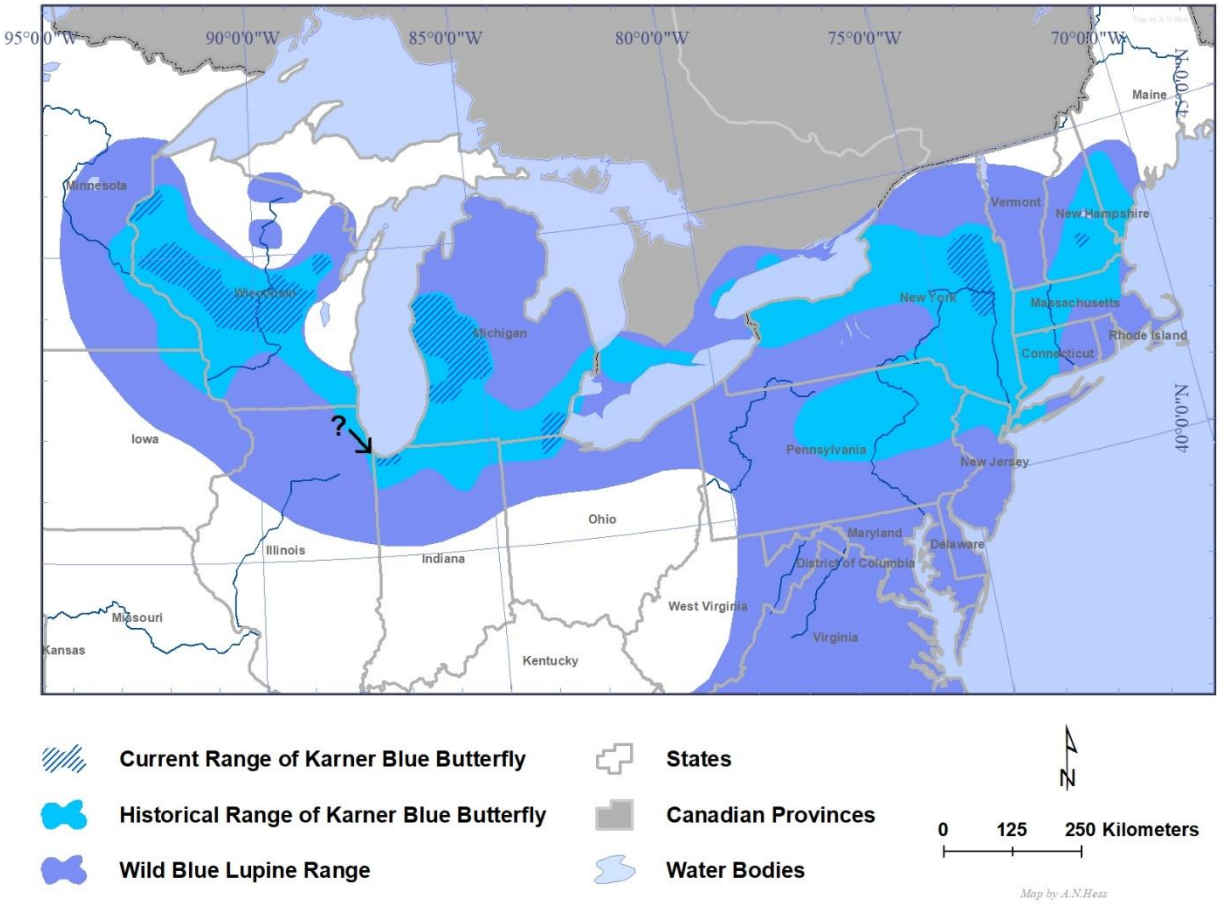


Figure 2.

Long-term trend data for Huron-Manistee National Forest KBB metapopulation 1997-2018. The red bars (% A) represents percentage absence and blue bars (% P) represent precentage presence of KBB.

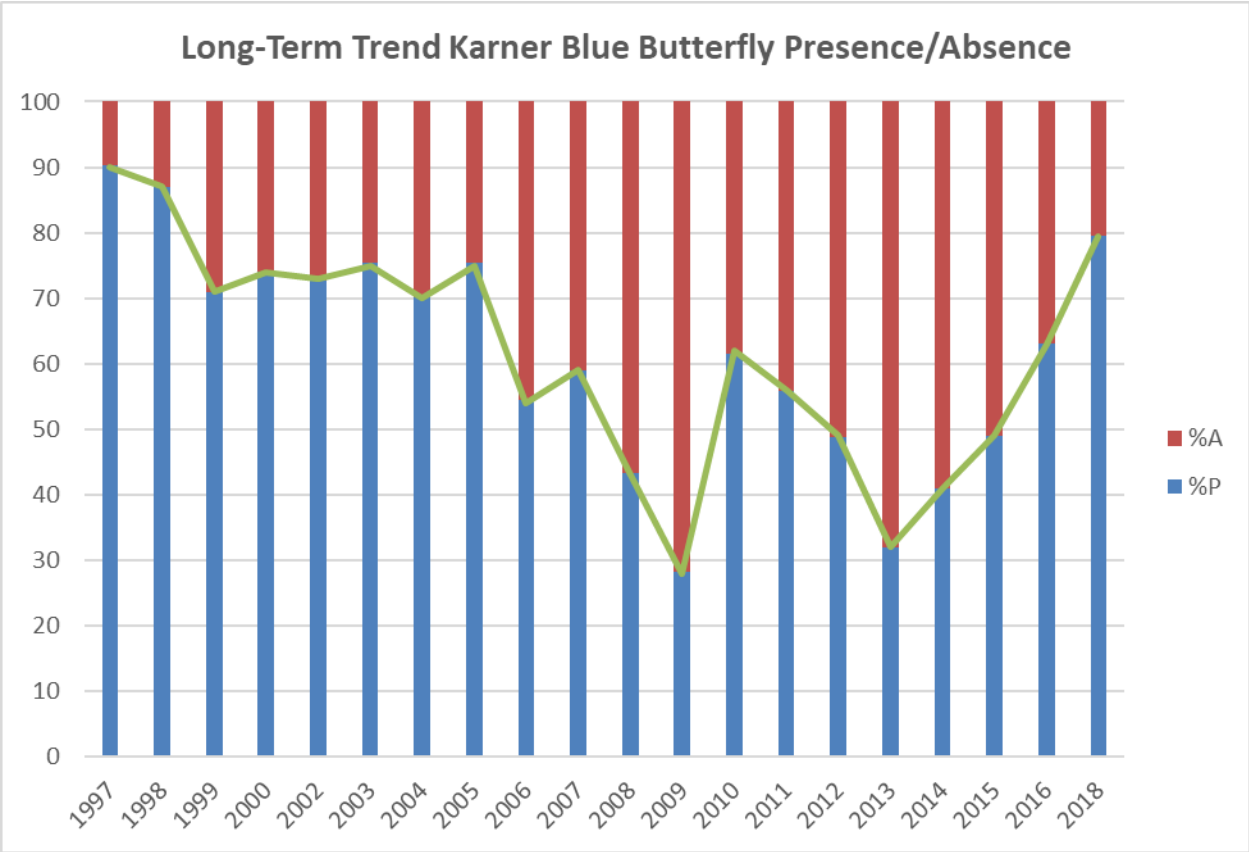


Figure 3.

Albany Pine Bush metapopulation brood size estimates using distance sampling for the KBB, 2007-2018. The dashed line represents the federal (and State) recovery criteria (i.e., 3,000 adult KBBs in the first or second brood).

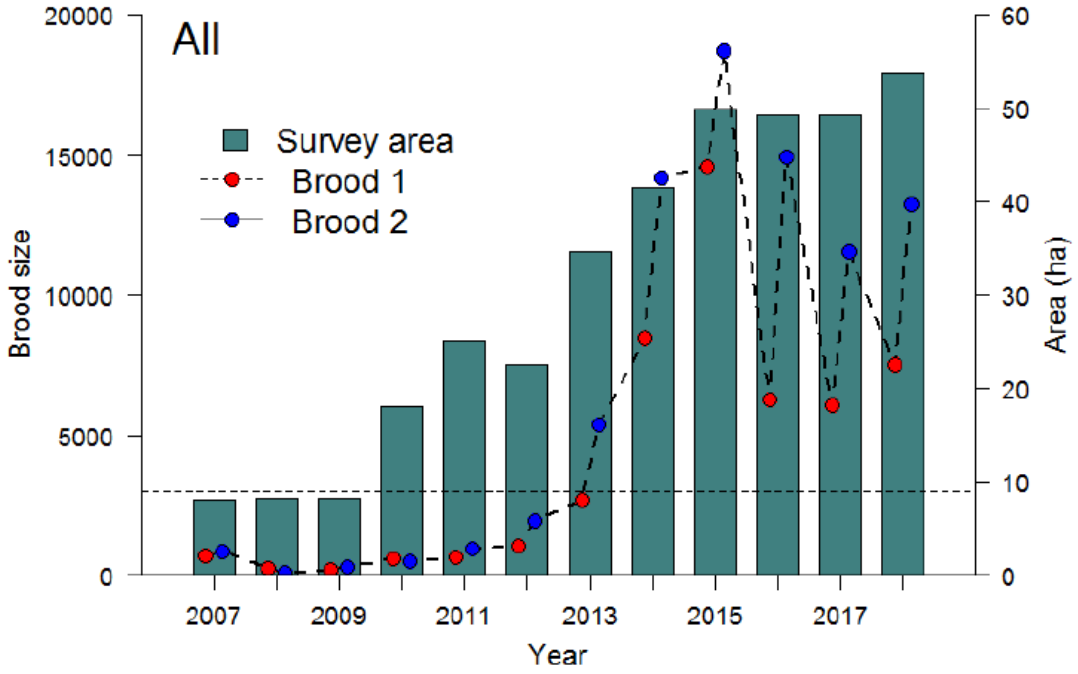
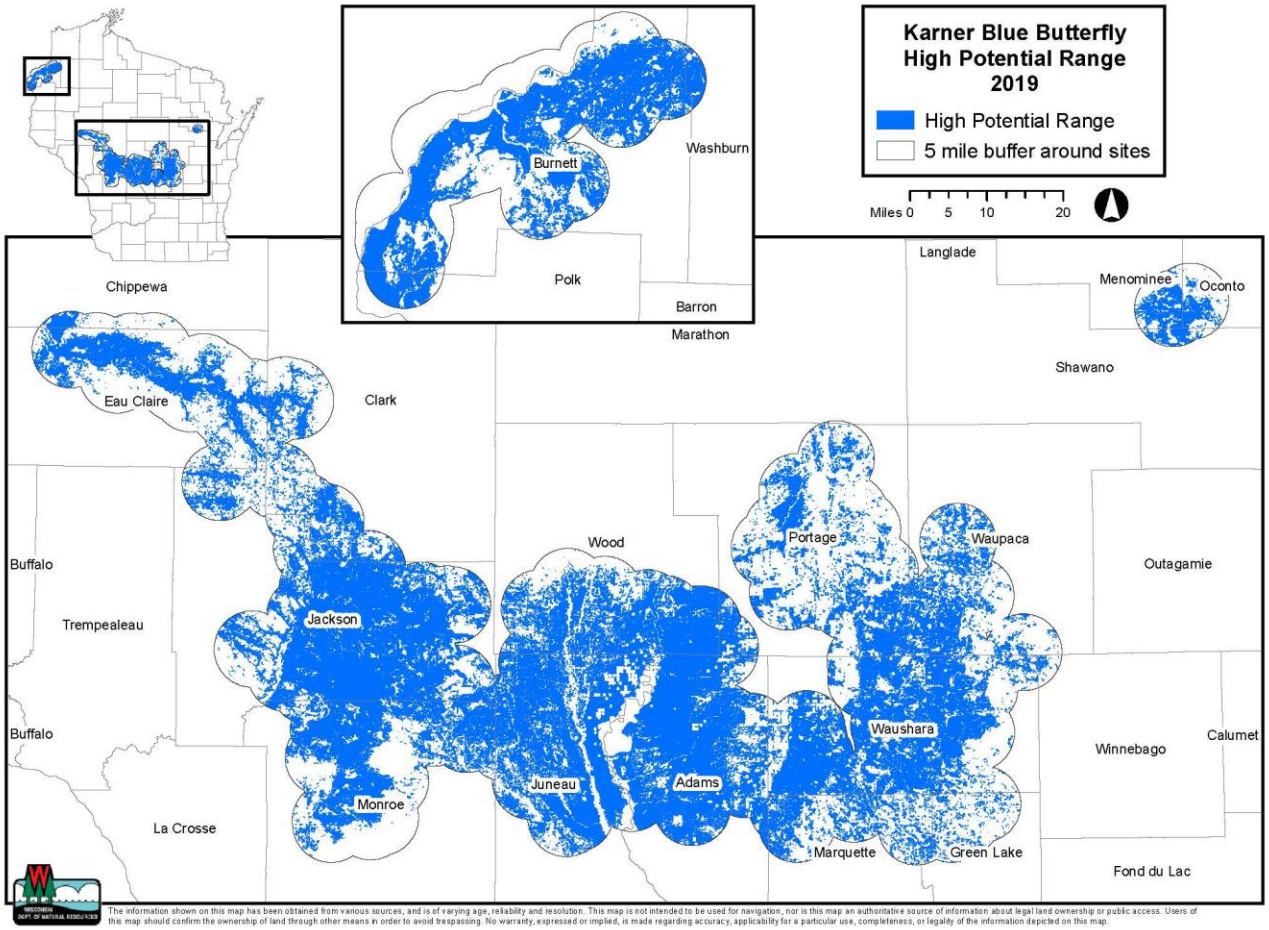


Figure 4.

Updated (2019) Wisconsin State High Potential Range Map. This map was developed using a model to identify areas where the KBB has the highest probability of occurrence throughout Wisconsin. The WI DNR will continue to update the map as new information becomes available. For the most current version see: https://dnr.wi.gov/topic/endangeredresources/karner/range.html