

Development and Implementation of an Occupancy Survey for Karner Blue Butterflies



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EXECUTIVE SUMMARY

In 2015, the Michigan Department of Natural Resources (DNR) funded the Michigan Natural Features Inventory (MNFI) to develop an occupancy-based survey for Karner blue butterfly (*Lycaeides melissa samuelis*; KBB) within Allegan and Flat River State Game Areas. The DNR currently conducts distance sampling surveys at a small number of sites occupied by Karner blue. The DNR was interested in maintaining distance surveys at these sites to continuing building a long-term data set with a consistent methodology, while expanding Karner blue monitoring to a greater number of sites using an occupancy approach. The MNFI proposed to work with the DNR and to develop a new survey to achieve their monitoring goals. Our objectives were to (1) develop a survey plan for KBB on state lands using an occupancy approach; (2) implement pilot occupancy surveys during 2015 to evaluate the survey methodology and sample design; and (3) provide multiple scenarios for future implementation of the occupancy survey with estimated costs for each. The DNR also asked that MNFI evaluate the transects being used for distance sampling and revise them as needed to increase efficiency and improve parameter estimates by excluding areas unsuitable for Karner blue.

For the occupancy-based survey, we identified potential sites using a combination of known KBB element occurrences, lupine areas, and digitized non-forested upland openings occurring within the game areas. Potential survey areas were prioritized by classifying them into ten categories of decreasing survey priority, with each priority level being exclusive of the others. Our goal was to survey as many areas as possible within priorities 1, 2, and 3 and connected areas of other priority levels during 2015. After merging connected sites together, we identified 134 areas for pilot surveys. When in the field, we excluded from surveys areas having one or more of the following conditions: (1) > 60% tree canopy cover; (2) > 75% bare soil and no lupine; (3) planted crops or ground cover (e.g., grassland, lawn) lacking lupine and nectar sources; and/or (4) located on private land. Areas of potential habitat located on public land immediately outside of the polygons were added to the survey. Surveys were not conducted when the temperature was below 15° C (60° F), during rain, or when winds exceeded 25 km/h (15 mph). Observers used a systematic survey approach by positioning a series of transects parallel to the outer boundary of the potential habitat patch. All sites were surveyed at least once during the second Karner flight, but we visited most sites twice. Transects and Karner blue locations were recorded using GPS and tablet computers. After completing pilot surveys, we estimated costs for MNFI to continue Karner blue occupancy surveys using several sample frames and survey designs.

We surveyed approximately 470 hectares (1,156 acres) of potential habitat and detected 876 Karner blues across the two surveys. We recorded a maximum second-flight count of 658 individuals across all sites surveyed by taking the maximum number observed between the two surveys at each site. We detected Karners at 24 (17.9%) of the 134 sites surveyed, but half of the occupied sites had maximum counts ≤ 5 and 76% of the total maximum count (502 individuals) was observed at two sites.

To characterize the many options for continuing occupancy-based Karner blue surveys, we developed cost estimates for three sample frames and several survey designs. We used three sample frames to represent low, medium, and high levels of survey effort with regard to the total area and number of sites covered. We developed several survey designs as examples of the many options available, including surveys that are not conducted every year and panel designs in which only a portion of the available habitat is surveyed in a given year. Each sample frame and survey design has benefits and limitations with regard to the area covered, frequency of surveys, and costs. The second sample frame presented, which consisted of the same set of sites used during 2015 pilot surveys, seemed to be a reasonable balance between focusing on high priority sites and exploring additional sites less likely to

support Karner blue. The survey designs presented included hybrid designs in which core areas (i.e., priorities 1 – 3) are surveyed annually, whereas a portion of the remaining lower priority sites are covered every year. These designs are attractive because they facilitate annual tracking of populations at high priority sites, as well as surveys of lower priority areas on a rotating basis, while also being relatively cost effective. We recommend that annual surveys at a set of core areas (e.g., extant, recently occupied, and adjacent/nearby sites with suitable habitat) be a component of the final sample frame and survey design.

We evaluated the layout and design of the distance sampling transects within Allegan and Flat River State Game Areas based on recent habitat conditions. Our proposed modifications resulted in 86 transects totaling 19.9 km (12.4 miles) in length, compared to the original design consisting of 84 transects totaling 23.7 km (14.7 miles). If distance sampling is a continued priority for the DNR, we recommend these modified transects be implemented during future surveys.

INTRODUCTION

The monitoring approach that has been used for Karner blue butterfly (*Lycaeides melissa samuelis*; KBB) on state lands relies heavily on distance sampling surveys. Distance sampling provides population estimates but is not appropriate for low-abundance sites and requires field time beyond what current resources can support. By maintaining distance surveys at a few representative sites and monitoring a larger number of sites with occupancy surveys, the Michigan Department of Natural Resources (DNR) could continue to monitor the status of the KBB population with reduced field resources. The Michigan Natural Features Inventory (MNFI) proposed to work with the DNR to develop a new occupancy-based survey to meet their monitoring goals. Our objectives were to (1) develop a survey plan for KBB on state lands using an occupancy approach; (2) implement pilot occupancy surveys during 2015 to evaluate the survey methodology and sample design; and (3) provide multiple scenarios for future implementation of the occupancy survey with estimated costs for each. We were also asked by DNR to evaluate transects being used for distance sampling at Allegan and Flat River State Game Areas and revise them as needed to increase efficiency and improve parameter estimates by excluding areas unsuitable for Karner blue.

METHODS

Sample Design Development

We identified potential survey areas using a combination of known KBB element occurrences, lupine areas, and non-forested upland openings occurring within Allegan State Game Area and Flat River State Game Area. We digitized openings in ArcMap using 2014 National Agriculture Imagery Program (NAIP) and 2010 Coastal Change Analysis Program (CCAP) land cover data. Digitization resulted in a layer of polygons representing openings available for survey. Openings consisted of areas dominated by herbaceous vegetation (> 50% of total area) that may have contained scattered shrubs and trees representing < 50% of the area. We excluded herbaceous openings located within areas classified as wetland. Our final sample frame of potential KBB survey sites consisted of a combination of KBB element occurrence (EO) polygons, areas of lupine mapped by DNR/MNFI, and digitized openings.

We prioritized the potential survey areas by classifying them into ten categories of decreasing survey priority (Table 1). Each priority level was exclusive of the other priorities (i.e., they did not overlap). New polygons were developed for each priority level by intersecting KBB EO, lupine, and opening polygons in ArcMap. We prioritized survey areas based on the likelihood for KBB to occur at the site. For example, areas with previous KBB documentation, mapped lupine, and digitized openings would have the greatest priority, whereas sites lacking previous KBB observations and lupine would have lower priority. Similarly, sites located within 200 m of an existing KBB EO were given higher priority than sites more distant from known occurrences. Based on discussions with DNR staff regarding their survey needs and priorities and our evaluation of resources available for 2015 pilot surveys, our goal was to survey as many areas as possible within priorities 1, 2, and 3 (Table 1) and immediately adjacent areas during 2015. To develop our 2015 survey areas, we first merged the priority 1, 2, and 3 GIS layers together. Next we selected any polygons from priorities 5, 6, 7, 8, and 9 that were connected to the merged priorities 1-3 layer. We then merged all of the data layers together to form our new set of survey polygons (Figures 1 and 2). Multiple areas connected to one another at a given location were combined into one area to simplify surveying in the field. Polygons already covered by annual distance sampling were excluded from 2015 pilot surveys.

Table 1. Prioritization of potential Karner blue butterfly survey areas with layer descriptions and total area estimates for Allegan and Flat River State Game Areas.

Priority Level	Layer Description	Polygon Conditions				Area		Number of Areas
		Within KBB EO	Near KBB EO	Mapped Lupine	Digitized Opening	Hectares	Acres	
1	Polygons formed from the intersection of KBB occurrences, mapped lupine, and digitized openings.	X		X	X	75	185	49
2	Polygons formed from the intersection of KBB occurrences and mapped lupine.	X		X		148	365	270
3	Polygons formed from the intersection of KBB occurrences and digitized openings.	X			X	30	74	69
4	Polygons formed from remaining portions of KBB occurrences.	X				71	175	86
5	Polygons formed from the intersection of mapped lupine and digitized openings within 200 m of KBB occurrences.		X	X	X	26	65	138
6	Polygons formed from mapped lupine within 200 m of KBB occurrences		X	X		56	139	247
7	Polygons formed from digitized openings within 200 m of KBB occurrences		X		X	250	618	112
8	Polygons formed from the intersections of remaining mapped lupine and digitized openings.			X	X	23	58	178
9	Polygons formed from the remaining mapped lupine patches.			X		59	146	273
10	Polygons formed from the remaining digitized openings.				X	1,341	3,314	481
Total						2,079	5,139	1,903

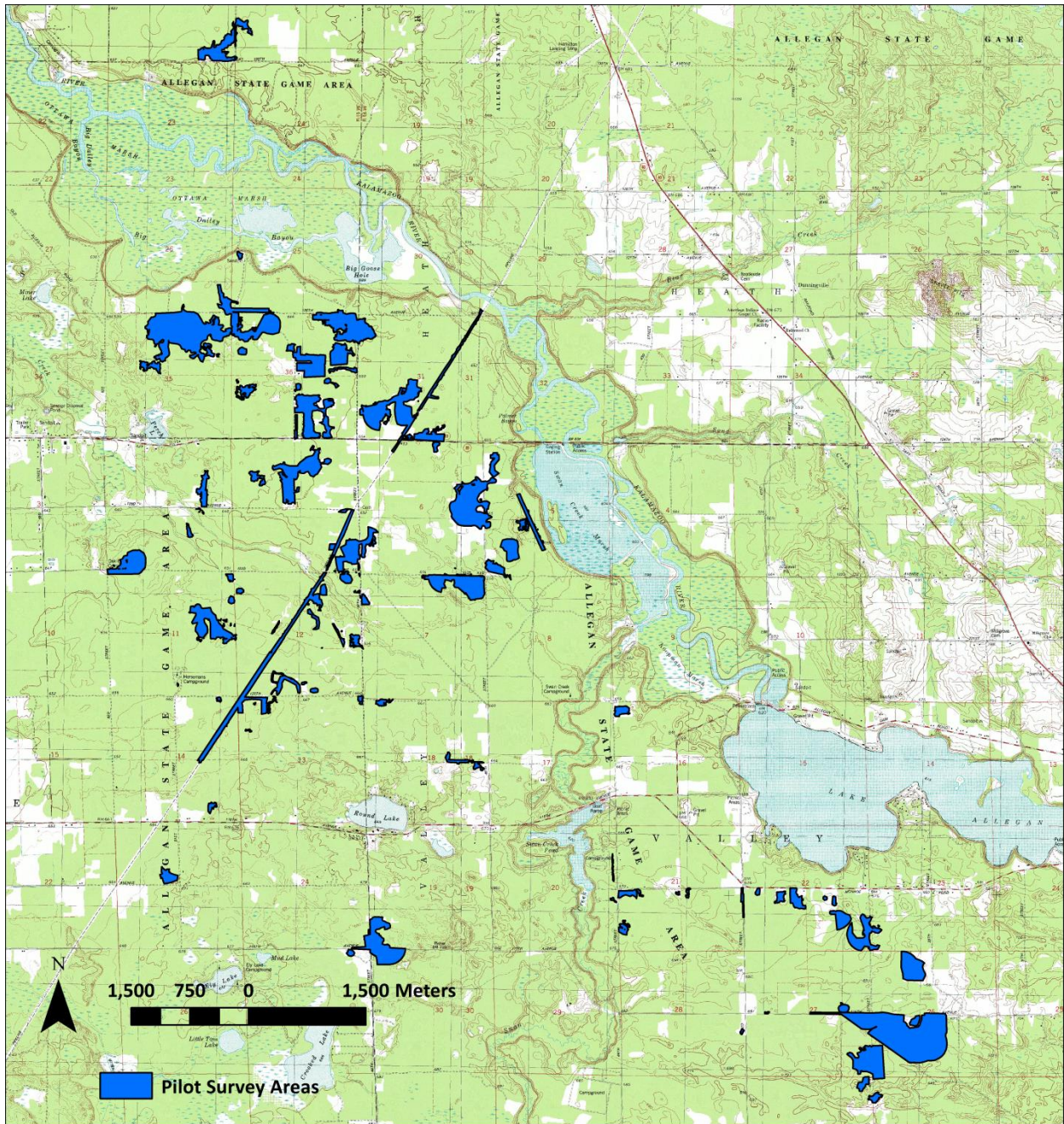


Figure 1. Pilot sites surveyed for Karner blue butterfly by the Michigan Natural Features Inventory during 2015 at Alleghen State Game Area.

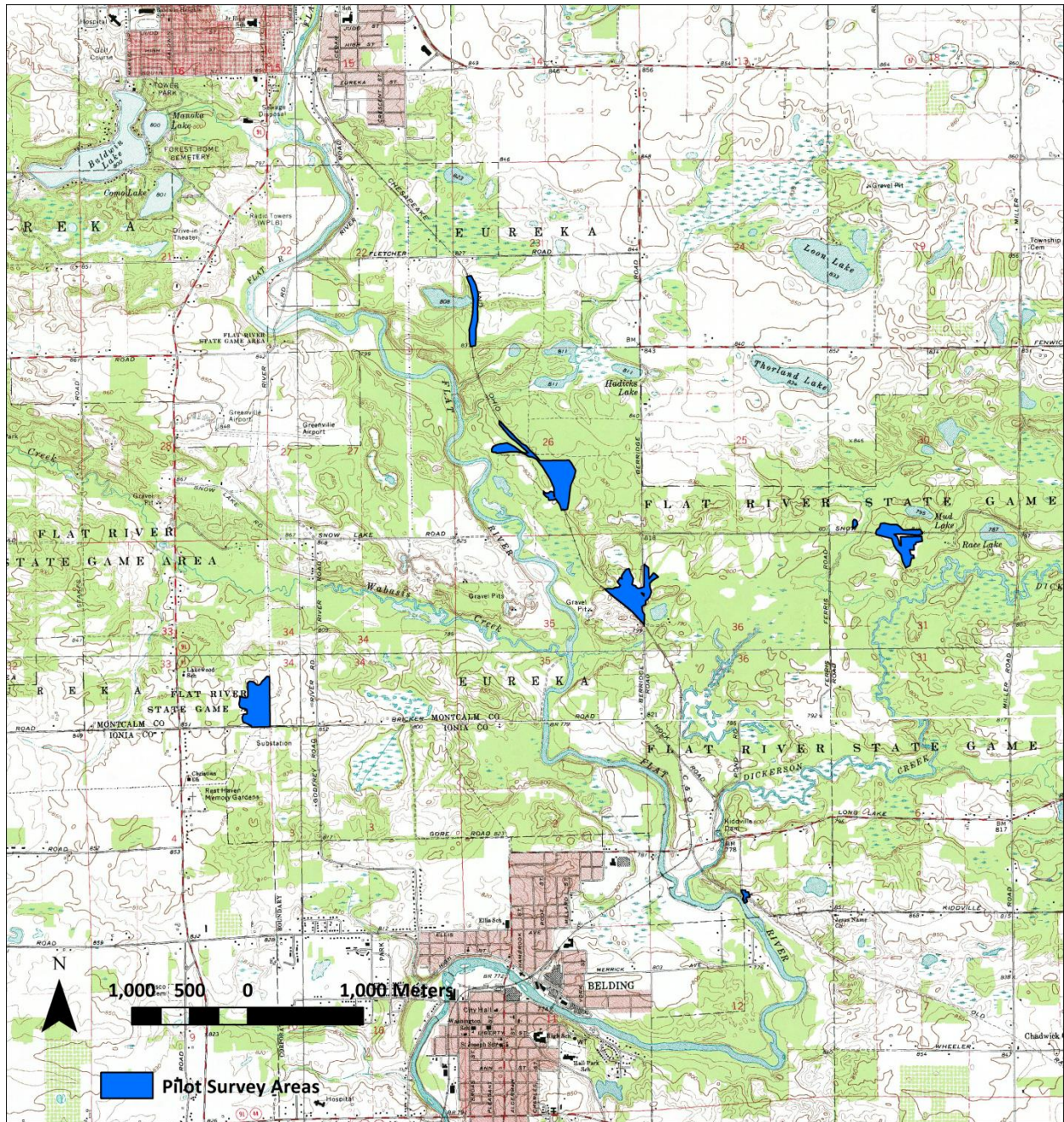


Figure 2. Pilot sites surveyed for Karner blue butterfly by the Michigan Natural Features Inventory during 2015 at Flat River State Game Area.

Survey Methodology

Survey Sites

We focused surveys on the priority 1, 2, and 3 sites (Figures 1 and 2). Although we targeted surveys at these polygons, we used a flexible survey approach allowing final survey routes to be modified as needed in the field. When in the field, areas within the polygons having one or more of the following conditions were excluded from the survey: (1) > 60% tree canopy cover; (2) > 75% bare soil and no lupine; (3) planted crops or ground cover (e.g., grassland, lawn) lacking lupine and nectar sources; and/or (4) located on private land. Areas of potential habitat (i.e., \leq 60% canopy cover with lupine/nectar sources) located on public land immediately outside of the polygons were added to the survey. A copy of the survey protocol and data form used for this project is provided in Appendix A.

Survey Conditions and Timing

We conducted surveys when the temperature was above 15° C (60° F), there was no rain, and when winds were \leq 25 km/h (15 mph). If temperatures were 15 - 21° C (60 - 70° F), surveys were only conducted when cloud cover was \leq 50% of the sky. There was no cloud cover restriction if the temperature was above 21° C (70° F). If weather conditions deteriorated during a visit, observers terminated the survey and resurveyed the entire site on a suitable day. Surveys were conducted between 9 AM and 6 PM (EDT). Two surveys of each site were completed during the second Karner blue flight (approximately early July through early August).

Visual Survey

Surveys consisted of a series of transects paralleling the outer boundary of the identified patch of potential habitat (e.g., savanna, grassland). The first transect will began 5 m inward from the outer edge of the patch, with one surveyor slowly walking along the first transect until the entire periphery of the site was surveyed. A second transect was located 10 m inward from the first transect and was surveyed in the same manner. Additional transects were added until the entire patch was surveyed. At some large sites, two people conducted the survey together, with transects spaced 10 m apart. Observers looked for and counted butterflies within area 5 m to either side of the transect, 5 m forward along the transect, and 5 m above the transect (10 m x 5 m x 5 m, rectangular survey area). Surveyors walked at a steady, slow speed of approximately 35 m/min. If Karner blues flew ahead of an observer, they were ignored if the surveyor was certain that the individual was already counted. When an observer was uncertain as to whether or not an individual was tallied, it was counted and considered a new individual.

To facilitate an accurate count of Karner blues and understand their distribution within and among sites, we collected geospatial information using GPS units or tablet computers. In most cases, a waypoint was collected for each individual Karner observed. For example, if five butterflies were seen on one nectar source, five waypoints were collected at the same location. Observers tried to avoid flushing butterflies when collecting waypoints as much as possible. We also recorded survey transects by gathering track locations at 30-sec intervals during the first visit to sites. During the second survey, observers followed the same tracks to ensure consistency between surveys.

We characterized KBB activity and condition by assigning the total number of individuals detected within several categories. We recorded the number of Karner blues observed within the following behavioral classes: nectaring, flying, perched, copulating, and ovipositing. The condition of Karner blues was ranked according to the following 1 – 5 numeric scale presented by Watt et al. (1977): (1) freshly emerged, wings still damp; (2) wings and other cuticle dry and hard, no visible damage; (3) noticeable wear of scales from wings or body; (4) wings showing fraying or tearing in their cuticle; and (5) wings with extensive scale wear and cuticle damage. Other butterfly species detected during Karner blue

surveys were recorded on a checklist for each site. Because estimating relative abundance would be difficult for multiple species and would distract observers from surveying for Karner blue, observers did not attempt to count species other than Karner blue.

Site Characterization

Observers characterized environmental and habitat characteristics at each site during each visit. We collected information on variables that may influence Karner blue detection and occupancy and could be included in models used to estimate population parameters. At the start and end of a survey, surveyors recorded the temperature (°C), percent relative humidity, cloud cover (expressed as the % of sky occluded), and maximum wind speed (km/h). Surveyors collected general information about potential threats to KBB and its habitats and ranked the relative abundance of lupine, nectar sources, and invasive plant species. At least one representative photograph was taken of each survey site. We used the DAFOR scale to rank the relative abundance of lupine, potential nectar sources, and invasive species as dominant (D), abundant (A), frequent (F), occasional (O), or rare (R). Because lupine is both the larval host plant and a potential nectar source for Karner blue, we ranked relative abundance of flowering lupine and all lupine (both flowering and non-flowering plants) separately.

Future Occupancy Survey Options and Cost Estimates

We developed cost estimates using 2016 rates (e.g., salary, fringe, mileage, etc.) to continue the occupancy-based survey in the future. Because we did not have access to DNR cost rates, we developed all estimates based on what it would cost for MNFI to implement the surveys. We estimated costs for the following sample frames of potential survey sites: (1) priorities 1 – 3 only (connected habitats ignored); (2) priorities 1 – 3 and connected areas (i.e., same as 2015 pilot season); and (3) priorities 1 – 9. The three sample frames represented increasing levels of survey effort, with the total area and number of sites increasing with each scenario. We examined several options for implementation of surveys for the three sample frames. For priorities 1 – 3, we estimated costs to survey all sites annually, biennially (every other year), every five years. For the second and third sample frames, we estimated costs to survey all sites annually, biennially, and every five years, and for hybrid designs in which areas within priorities 1 – 3 are surveyed annually and a portion of the remaining sites is covered each year within a rotating panel of sites spanning two and five years. We estimated the total costs for each sample frame and design over a 10-year period. A three percent annual inflation rate was assumed.

Distance Sampling Transects

We reviewed the transects being used at four sites on State lands for distance sampling surveys of Karner blue. Recent (2010-2014) aerial photography was used to examine the land cover types traversed by the survey transects. We digitized potential Karner blue habitat proximate to the distance sampling sites by identifying areas with approximately $\leq 60\%$ tree/shrub canopy cover. Transects were then modified to remove those portions of transects crossing cover types unsuitable for Karner blue. Transects were also expanded or added to cover areas of apparent suitable habitat currently excluded from surveys. We created new shapefiles for DNR review and modification prior to 2016 surveys.

RESULTS AND DISCUSSION

Karner Blue Surveys

We conducted at least one survey at all 134 areas created by merging priorities 1 – 3 and any connected sites within priorities 5 – 9. Forty areas lacking Karner observations during the first visit were not surveyed a second time because they contained marginal habitat. The 134 sites surveyed encompassed an estimated 470 hectares (1,156 acres) of potential Karner blue habitat. The average size of the sites was 3.8 hectares (9.4 acres). Approximately 462 person-hours were spent surveying these sites, with observers spending on average about 0.5 hours surveying per hectare of habitat.

We detected 876 Karner blues across the two surveys. When taking the maximum number observed between the two surveys at each site, we observed a maximum second-flight count of 658 individuals across all sites surveyed. We found 24 (17.9%) of the 134 sites surveyed to be occupied by Karners (Figures 3 and 4), with an average maximum count of 27.4 for the occupied sites. However, half of the occupied sites had maximum counts ≤ 5 (Figures 3 and 4) and 76% of the total maximum count (502 individuals) was observed at two sites. The greatest number of Karners observed during a single visit to a site was 403, which occurred during the first survey of the A094 site in Allegan State Game Area.

As part of our survey methodology, we collected geospatial information for survey transects and Karner blue locations (Figure 5). Transect locations were recorded as GPS tracks during the first survey and then followed during the second visit. Collecting transect locations is valuable because the GPS tracks provide a record of where surveys occurred and can be used to refine survey area boundaries by indicating where potential habitat was located. Observers can follow the same transects during future surveys to provide consistency in survey methodology between visits and among years. We gathered GPS waypoints at the locations of Karner blue detections. These points provide information on Karner blue distributions within survey areas and would facilitate tracking of distributions over time as habitat conditions and management actions change both within and among sites. We recommend future Karner blue surveys continue recording these geospatial data.

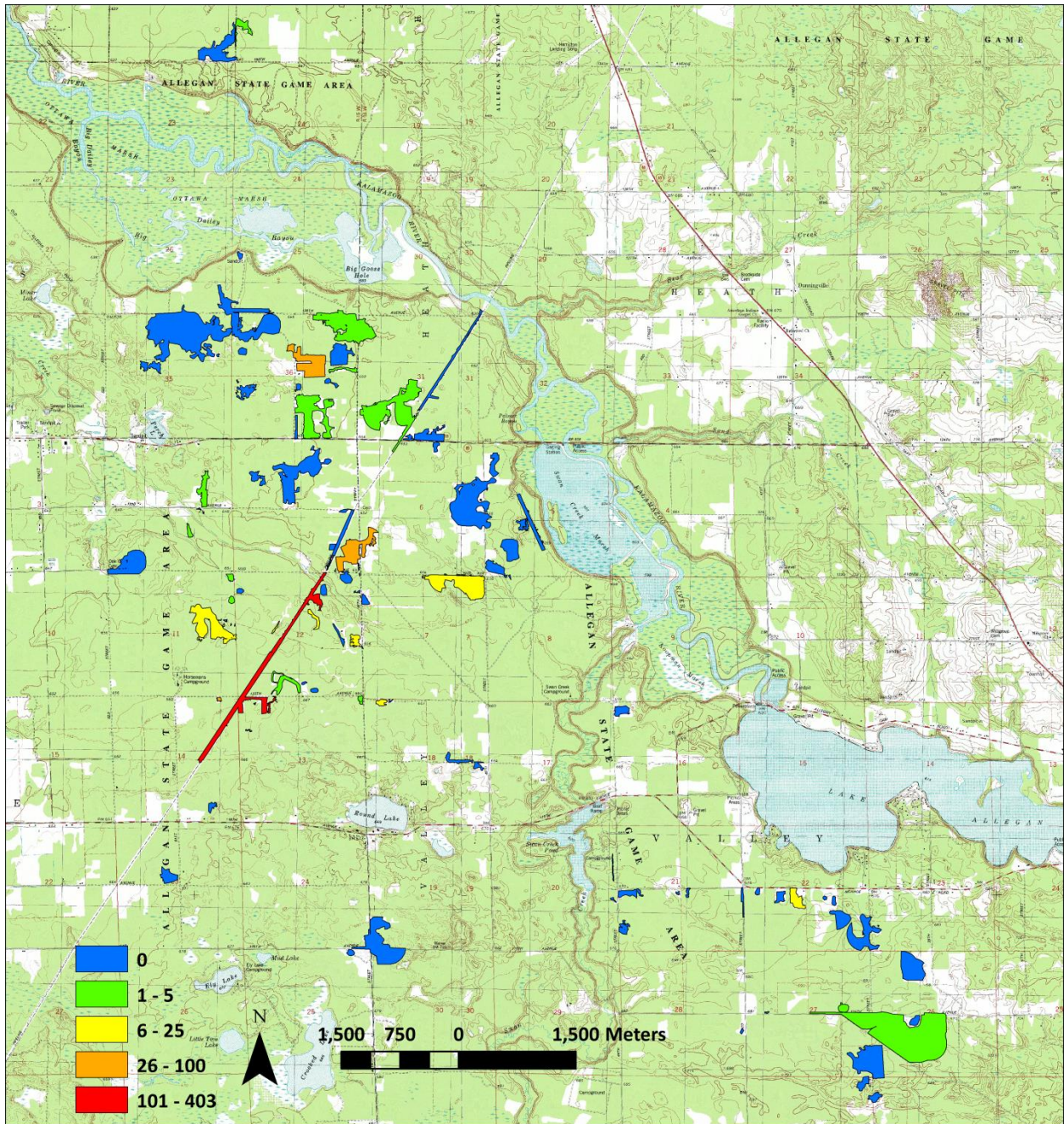


Figure 3. Number of Karner blue butterflies detected by survey area during pilot surveys conducted by the Michigan Natural Features Inventory during 2015 at Alleghen State Game Area.

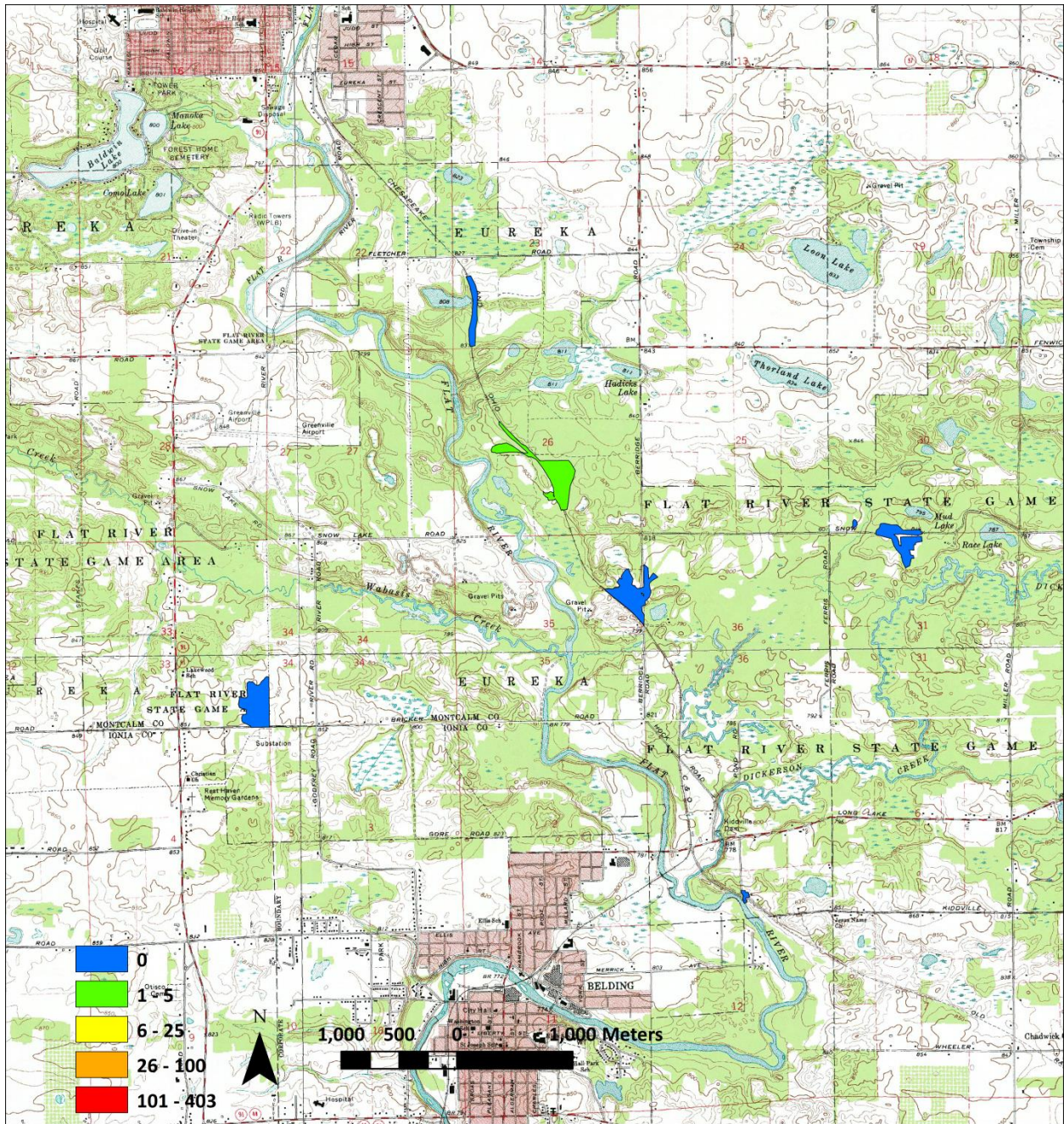


Figure 4. Number of Karner blue butterflies detected by survey area during pilot surveys conducted by the Michigan Natural Features Inventory during 2015 at Flat River State Game Area.



Figure 5. Results of surveys conducted at site A086 in Allegan State Game Area by the Michigan Natural Features Inventory during 2015. Red lines indicate the survey transects and Karner blue locations are displayed as red points.

Future Occupancy Survey Options and Cost Estimates

To characterize the many possible options for conducting future Karner blue surveys, we developed cost estimates for three sample frames and several survey design options (Table 2). The three sample frames were selected to represent low, medium, and high levels of survey effort with regard to the total area and number of sites covered. We used several survey designs as examples of the many options available, including surveys that are not conducted every year and panel designs in which only a portion of the available habitat is surveyed in a given year. In the options presented, we focused survey effort on sites within priorities 1 – 3, which contain most of the extant Karner blue populations and nearby areas with suitable habitat.

Each sample frame and survey design has its benefits and limitations with regard to the area covered, frequency of surveys, and costs. Ideally, we would like to be able to survey all potential habitats every year, but such a design is unlikely to be feasible based on our estimated costs (Table 2). The second sample frame, which is the same set of sites used during 2015 pilot surveys, seems to be a reasonable balance between focusing just on those areas with high probability of occurrence and exploring additional sites less likely to support Karner blue. Survey designs with periodic surveys (i.e., biennial, every 5 years) are more economical compared to other options, but are less useful in tracking trends because they would require longer periods of time to detect changes in relative abundance. We examined hybrid designs in which sites within priorities 1 – 3 are surveyed annually and a portion of the remaining sites from sample frames are surveyed annually on a rotating basis (i.e., 50% or 20% of the lower priority sites annually). These are attractive designs because they ensure core areas (priorities 1 – 3) and a portion of the other sites are covered every year, thus allowing better tracking of population trends. These designs also appear relatively cost effective. For example, the total costs for surveying the hybrid designs for medium-sized sample frame are not much higher than the costs for annual surveys of just priorities 1 – 3 (Table 2). We recommend that annual surveys at a set of core areas (e.g., extant, recently occupied, and adjacent/nearby sites with suitable habitat) be a component of the final sample frame and survey design.

Table 2. Estimated costs by year to conduct surveys for Karner blue butterflies using various sample frames and survey designs at Allegan and Flat River State Game Areas.

Sample Frame	Survey Design	Area (ha)	Field Staff	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Priorities 1-3 only	All sites annually	253	2	\$25,333	\$26,093	\$26,876	\$27,682	\$28,512	\$29,368	\$30,249	\$31,156	\$32,091	\$33,054	\$290,414
	All sites biennially	253	2	\$25,333	---	\$26,876	---	\$28,512	---	\$30,249	---	\$32,091	---	\$143,061
	All sites every 5 years	253	2	\$25,333	---	---	---	---	\$29,368	---	---	---	---	\$54,701
Priorities 1-3 plus connected areas	All sites annually	470	4	\$35,929	\$37,006	\$38,117	\$39,260	\$40,438	\$41,651	\$42,901	\$44,188	\$45,513	\$46,879	\$411,881
	All sites biennially	470	4	\$35,929	---	\$38,117	---	\$40,438	---	\$42,901	---	\$45,513	---	\$202,897
	All sites every 5 years	470	4	\$35,929	---	---	---	---	\$41,651	---	---	---	---	\$77,580
	Priorities 1-3 annually, biennial panel for remainder	362	3	\$28,998	\$29,868	\$30,764	\$31,687	\$32,637	\$33,616	\$34,625	\$35,664	\$36,734	\$37,836	\$332,427
	Priorities 1-3 annually, 5-year panel for remainder	296	2	\$26,686	\$27,486	\$28,311	\$29,160	\$30,035	\$30,936	\$31,864	\$32,820	\$33,805	\$34,819	\$305,921
Priorities 1-9	All sites annually	738	6	\$49,238	\$50,715	\$52,237	\$53,804	\$55,418	\$57,080	\$58,793	\$60,556	\$62,373	\$64,244	\$564,458
	All sites biennially	738	6	\$49,238	---	\$52,237	---	\$55,418	---	\$58,793	---	\$62,373	---	\$278,058
	All sites every 5 years	738	6	\$49,238	---	---	---	---	\$57,080	---	---	---	---	\$106,318
	Priorities 1-3 annually, biennial panel for remainder	496	4	\$36,731	\$37,833	\$38,968	\$40,137	\$41,341	\$42,581	\$43,858	\$45,174	\$46,529	\$47,925	\$421,076
	Priorities 1-3 annually, 5-year panel for remainder	350	3	\$28,620	\$29,479	\$30,363	\$31,274	\$32,212	\$33,179	\$34,174	\$35,199	\$36,255	\$37,343	\$328,100

Distance Sampling Transects

We modified the transects used for Karner blue distance sampling at Allegan (Figures 6 and 7) and Flat River (Figures 8 and 9) State Game Areas to better match potential habitats currently available at each location. Portions of transects crossing unsuitable areas, as indicated by dense canopy cover, were removed. We lengthened some existing transects and added new transects to survey potential habitats adjacent to the survey sites that were not being covered. Our modifications resulted in 86 transects across the four sites totaling approximately 19.9 km (12.4 miles) in length. Prior to making the proposed changes, DNR was surveying 84 transects at the four sites with a total length of approximately 23.7 km (14.7 miles). We believe the modified transects will make more efficient use of field time and provide better parameter estimates. We also recommend that GPS locations of Karner detections be collected when conducting distance sampling surveys. Biologists could examine Karner distributions at these sites when making decisions about management plans or potential changes to transect locations. Shapefiles for the adjusted transects will be provided to DNR staff for review and modification. Once the final set of transects is completed, MNFI will ground truth and mark the transects in the field prior to the second Karner blue flight of 2016.

ACKNOWLEDGEMENTS

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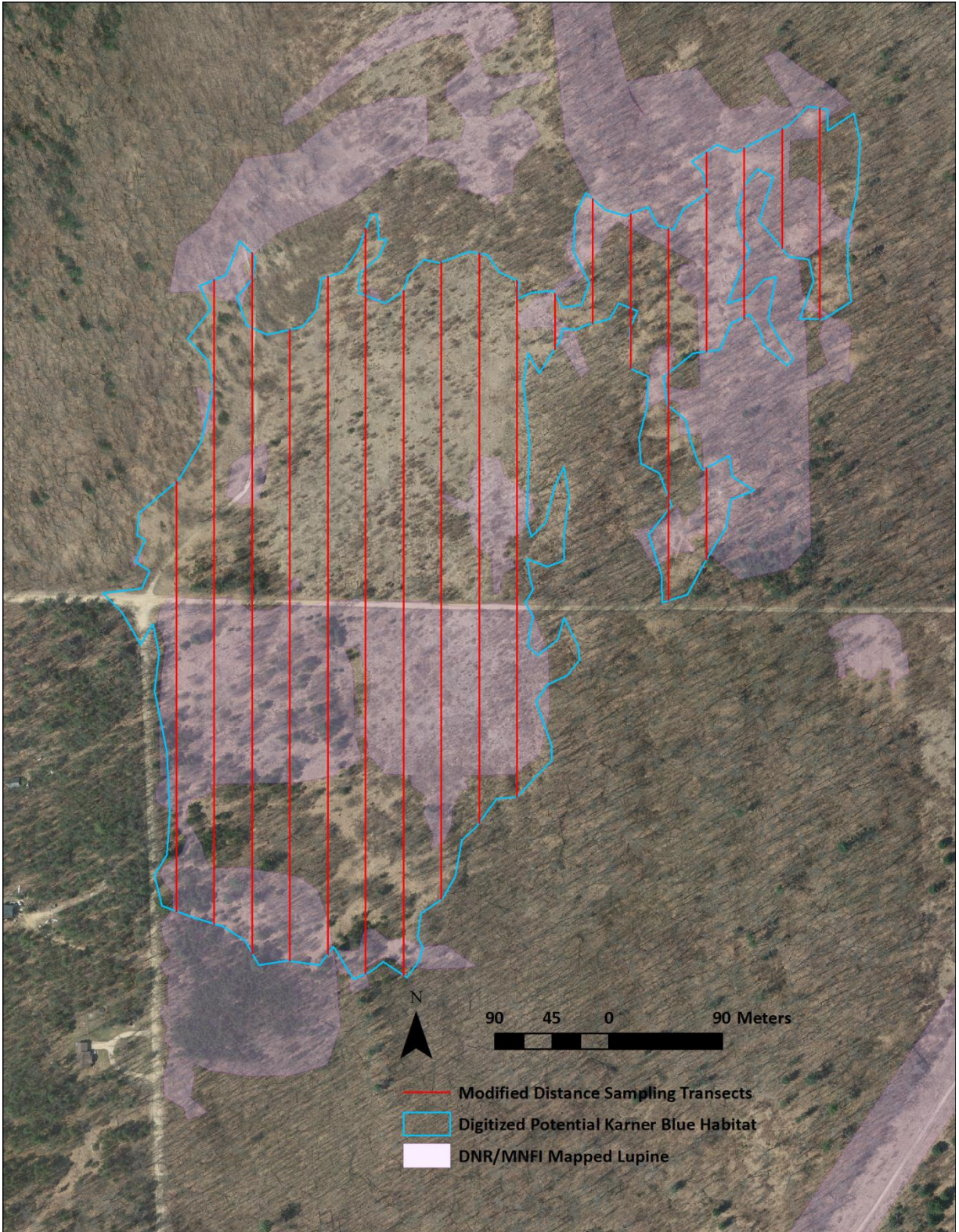


Figure 6. Modified distance sampling transects proposed by the Michigan Natural Features Inventory for the Horseman's Campground site located in Allegan State Game Area.

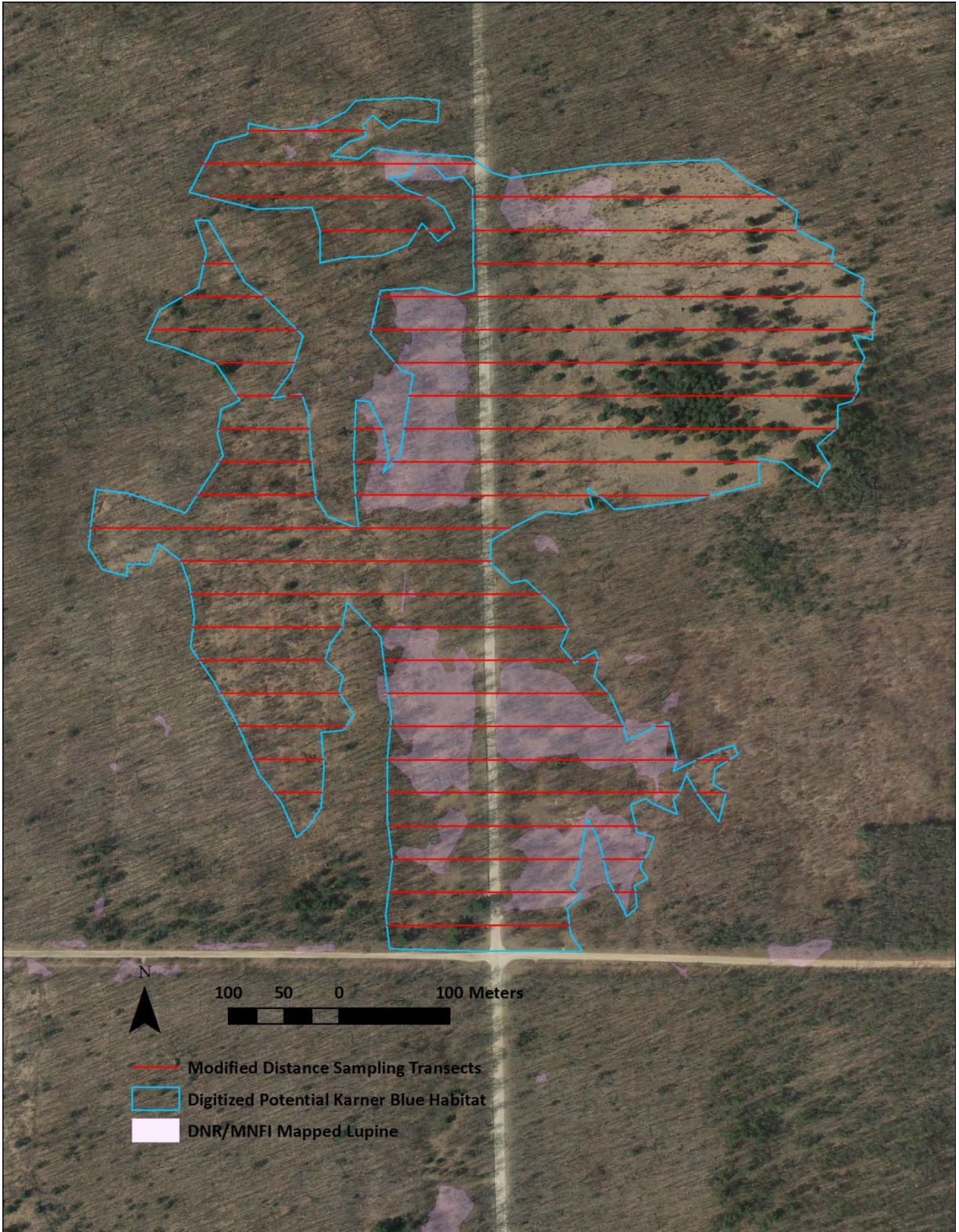


Figure 7. Modified distance sampling transects proposed by the Michigan Natural Features Inventory for the 42nd Street site located in Allegan State Game Area.

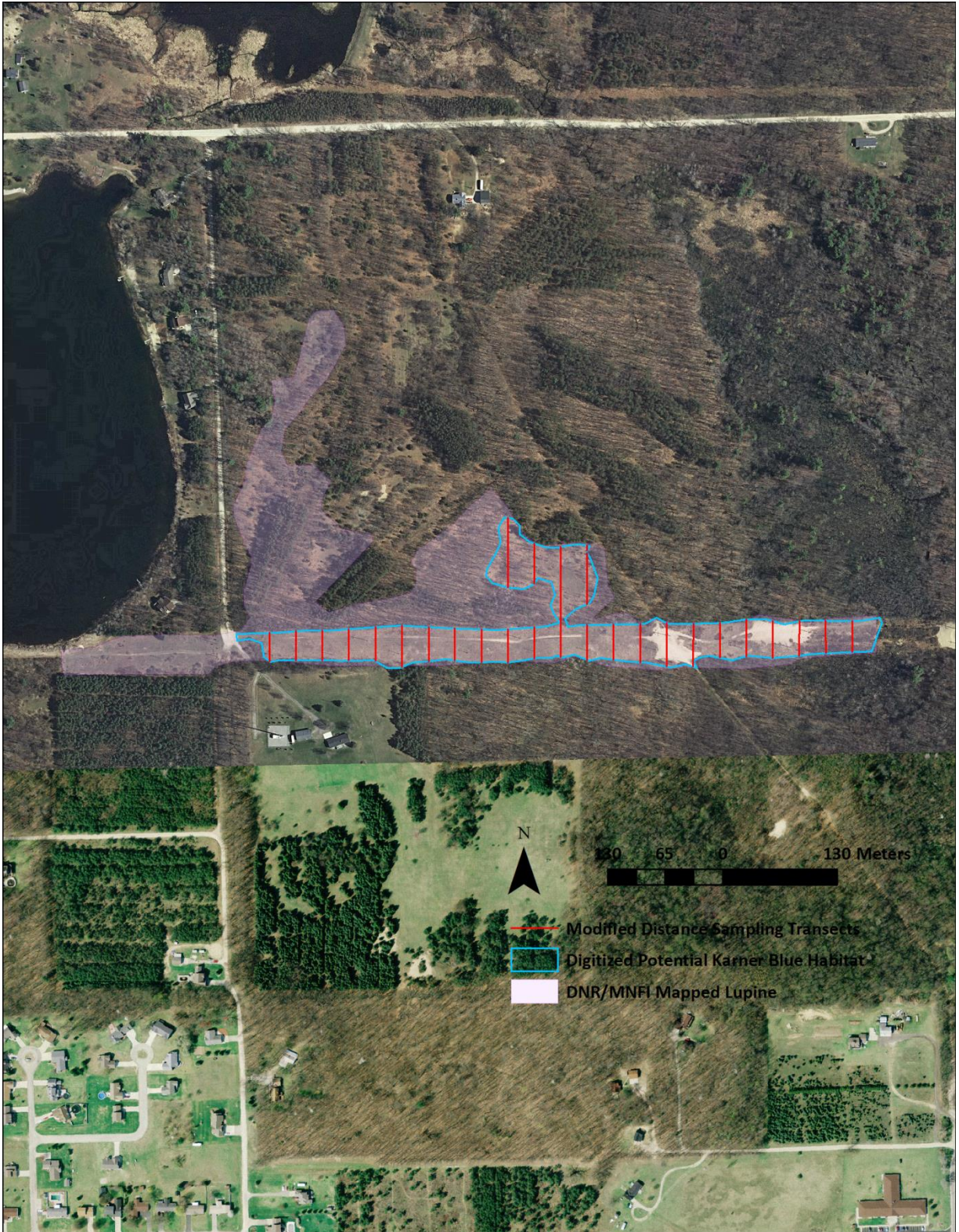


Figure 8. Modified distance sampling transects proposed by the Michigan Natural Features Inventory for the Mega-site located in Flat River State Game Area.

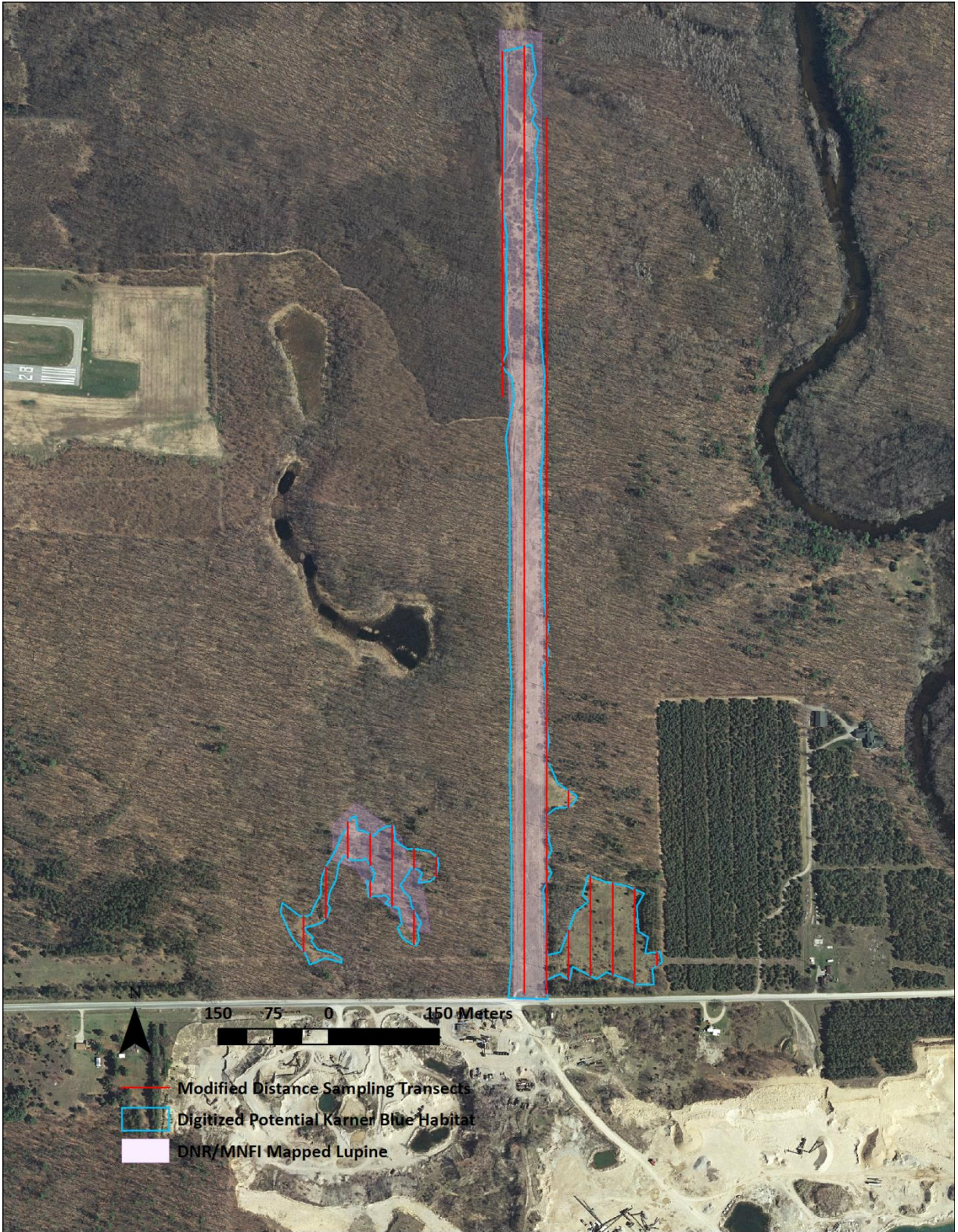


Figure 9. Modified distance sampling transects proposed by the Michigan Natural Features Inventory for the Karner Trail site located in Flat River State Game Area.

APPENDIX A

Karner Blue Survey Methodology and Data Form

MICHIGAN NATURAL FEATURES INVENTORY

KARNER BLUE (*LYCAEIDES MELISSA SAMUELIS*) SURVEY PROTOCOL

Acceptable Survey Conditions

Surveys should not be conducted when the temperature is below 15° C (60° F), during rain, or when winds exceed 25 km/h (15 mph). When temperatures are 15 - 21° C (60 - 70° F), cloud cover should be ≤50% of the sky. There is no cloud cover restriction if the temperature is above 21° C (70° F). If weather conditions deteriorate during a survey, observers should terminate the survey and resurvey the entire site on a suitable day. Be sure to note that the survey was ended on the data form and record the final weather conditions.

Survey Area

We identified preliminary survey areas using ArcMap and data layers of known Karner blue element occurrences, mapped lupine patches, and non-forested openings digitized using 2014 NAIP aerial imagery. Surveys were focused at portions of Karner blue element occurrences having (1) mapped lupine and digitized openings; (2) mapped lupine; and (3) digitized openings. All locations having these conditions were merged to create our preliminary survey polygons. We then expanded our survey areas to include digitized openings and mapped lupine patches that were within 200 m of known Karner blue occurrences. These final survey polygons will be used to target on-the-ground Karner blue surveys. Although we are targeting surveys at these polygons, we are using a flexible survey approach to allow final survey routes to be modified as needed in the field. When in the field, areas within the polygons having one or more of the following conditions can be excluded from the survey: (1) >60% tree canopy cover; (2) >75% bare soil and no lupine; (3) planted crops or ground cover (e.g., grassland, lawn) lacking lupine and nectar sources; and/or (4) located on private land. Conversely, areas of potential habitat (i.e., ≤60% canopy cover with lupine/nectar sources) located on public land immediately outside of the polygon should be added to the survey.

Timing

Surveys can be conducted between 9 AM and 6 PM (EDT). Two surveys of each site should be conducted during the second Karner blue flight (approximately early July to early August).

Survey Methodology

Visual survey. The survey will consist of a series of transects paralleling the outer boundary of the identified habitat patch. The first transect will begin 5 m inward from the outer edge of the potential habitat patch (e.g., savanna, opening). One surveyor will slowly walk along the first transect until the entire periphery of the site has been surveyed. The second transect will be located 10 m inward from the first transect and will be surveyed in the same manner. Additional transects are added until the entire patch has been surveyed. When possible, additional surveyors can be used to cover large sites or smaller sites more quickly, as long as all transects are separated by 10 m. Each surveyor will look for and count butterflies within area 5 m to either side of the transect, 5 m forward along the transect, and 5 m above the transect (imagine a 10 m x 5 m x 5 m, box-shaped, survey area). Surveyors should walk at a steady, slow speed of approximately 35 m/min. When Karner blues fly ahead of the observer, they can be ignored if the surveyor is certain that the individual was already counted. If the observer is uncertain as to whether or not the individual was counted, it should be counted and considered a new individual. When more than one individual is surveying a site, it will be important that team members communicate about butterflies moving between transects (e.g., individual counted by one team member that flies into the area being surveyed by the other team member).

To facilitate an accurate count of Karner blues and collection of geospatial information, a waypoint should be collected for each individual Karner observed. For example, if five butterflies were seen on one nectar source, five waypoints should be collected at the same location. Surveyors may need to move off of transects slightly to record waypoints. If you walk off of a transect to collect a waypoint, be sure to move back to the point where you left off before continuing on with the survey. As much as possible, avoid flushing butterflies when collecting waypoints. The number observed should also be recorded on the data form under the “total number detected” box. You should also record the number of Karners detected by activity classification and condition ranking (i.e., wing wear). The number of Karner blues exhibiting particular behaviors or activities (e.g., perched, nectaring, flying, chasing, ovipositing) should be recorded on the data form. We will rank the condition of Karners according to the following 1 – 5 numeric scale presented by Watt et al. (1977): (1) freshly emerged, wings still damp; (2) wings and other cuticle dry and hard, no visible damage; (3) noticeable wear of scales from wings or body; (4) wings showing fraying or tearing in their cuticle; and (5) wings with extensive scale wear and cuticle damage. If no Karner blues are observed during the survey of a site, write “None” in the box provided on the data form for “Total Number Detected.” A separate data form should be completed for each survey polygon.

Each surveyor should have a GPS unit (or tablet computer/smartphone) and should record their survey route or transects using the tracking function. Set the GPS unit to collect your location along the track at 30-sec intervals. Once your track has been recorded during the first visit to a particular site, the tracking function can be turned off during the second visit and the same tracks can be followed during the second survey. It will be critical that each surveyor download their survey tracks at the end of the season as an ArcMap shapefile to facilitate surveying the same routes in future years. Use the following naming format when saving your survey tracks: year_observer last name_kbb_tracks (e.g., 2015_smith_kbb_tracks). Waypoints collected for Karner blue locations should also be downloaded at the end of the season as a shapefile and named using a similar format: year_observer last name_kbb_locations (e.g., 2015_smith_kbb_locations).

Overall butterfly diversity: All butterfly species seen during Karner blue surveys should be recorded on the data form used for each site (polygon) in the space provided. Because estimating relative abundance would be difficult for multiple species and likely to distract observers from surveying for Karners, observers should only note the species of butterflies seen and should not attempt to count species other than Karner blue.

Weather: At the start and end of the survey, record the temperature (°C), percent relative humidity, cloud cover (expressed as the % of sky occluded), and maximum wind speed (km/h). If a survey needs to be terminated because of poor weather conditions, collect that same weather information at the time the survey is ended.

Site characterization: Observers will collect general information about survey sites during each visit, such as potential threats, presence of lupine, and nectar sources. At least one representative photograph should be taken of each survey site. Record file identifiers of the photographs on the data form. Several potential threats to Karner blue and its habitats are listed on the data form. Place a check mark next to all those that apply to the survey site. Potential threats not listed can be added to the form under “Other” in the space provided. For invasive plant species, rank the abundance of those species observed as dominant (D), abundant (A), frequent (F), occasional (O), or rare (R) on the data form. Invasive species not listed can be added to the form under “Other.” Below is more specific guidance on using the DAFOR scale.

Dominant (D): In practice, the dominant ranking is rarely, if ever used. To be scored as D, a species would have to be the most common plant by far, covering over 75% of the wetland. If you are not sure if a species should be scored as D, then assign it a score of A.

Abundant (A): Only use A if the species is common in many parts of the wetland. For most species, this would mean that there are thousands of individual plants present. At most sites, few species will be ranked as A. If you are unsure if a species should be scored as A or F, then give it a ranking of F.

Frequent (F): Use F if you find a species at several places within the survey area and more than just a few individuals are present at each location. You could also use F if a plant species only occurs at one part of the site but is common at that location, with many individuals observed and a substantial area covered (e.g., between one eighth and one quarter of the site). If you are not sure if a species should be scored as F or O, then assign it a score of O.

Occasional (O): Use O for species that occur in several places in the wetland, but whose populations are small at those locations. You could also use O for species that are common at one location but occupy a small area (e.g., less than one eighth of the site). If you are not sure if a species should be ranked as O or R, then give it a score of R.

Rare (R): Use R for species that occur as a small number of individuals within the site. These individuals may be located in one place, or scattered over several locations within the wetland. If you are unsure if a species should be scored O or R, then assign it a score of R.

A list of possible nectar plant species for Karner blue is provided on the data form. Rank the abundance of each available (i.e., flowering) nectar species observed at the site using the same DAFOR scale described above for invasive plant species. Nectar sources not on the list can be added in the blank boxes provided on the form.

Because lupine is the larval host plant and a potential nectar source for Karner blue, we will rank its relative abundance in two ways on the data form using the DAFOR scale. First, the relative abundance of flowering lupine can be ranked under the nectar source section of the data form. Second, you should rank the overall abundance of lupine (both flowering and non-flowering plants) on the separate line of the data form.

MICHIGAN NATURAL FEATURES INVENTORY – KARNER BLUE SURVEY

POTENTIAL THREATS (check all that apply)			
SHRUB ENCROACHMENT		INVASIVE PLANT SPECIES	
LIVESTOCK GRAZING		(rank abundance using DAFOR scale – see below)	
ORV DAMAGE		<i>Carex pennsylvanicus</i> (Pennsylvania sedge)	
HUMAN DEVELOPMENT		<i>Centaurea stoebe</i> (spotted knapweed)	
ADJACENT AGRICULTURE		<i>Coronilla varia</i> (crown vetch)	
OTHER		<i>Euphorbia esula</i> (leafy spurge)	
		<i>Heracium aurantiacum</i> (orange hawkweed)	
		<i>Melilotus alba</i> (white sweet clover)	
		Other	
NECTAR SOURCES (rank abundance using DAFOR scale – see below)			
<i>Achillea millefolium</i> (common yarrow)		<i>Hieracium</i> sp. (hawkweed)	
<i>Asclepias syriaca</i> (common milkweed)		<i>Hypericum perforatum</i> (common St. John's wort)	
<i>Asclepias tuberosa</i> (butterfly weed)		<i>Liatris aspera</i> (tall blazing star)	
<i>Asclepias verticillata</i> (whorled milkweed)		<i>Liatris cylindracea</i> (Ontario blazing star)	
<i>Centaurea stoebe</i> (spotted knapweed)		<i>Lotus corniculatus</i> (bird's-foot trefoil)	
<i>Coreopsis lanceolata</i> (lanceleaf tickseed)		<i>Lupinus perennis</i> (wild lupine)	
<i>Dianthus armeria</i> (Deptford pink)		<i>Monarda punctata</i> (horse mint)	
<i>Erigeron</i> sp. (fleabane)		<i>Polygala polygama</i> (racemed milkwort)	
<i>Euphorbia corollata</i> (flowering spurge)		<i>Rudbeckia hirta</i> (black-eyed Susan)	
<i>Helianthus</i> sp. (sunflower)		<i>Tradescantia virginiana</i> (Virginia spiderwort)	
TOTAL LUPINE COVER (flowering and non-flowering combined)			

Butterfly Condition Ranking:

- 1: Freshly emerged, wings still damp.
- 2: Wings and other cuticle dry and hard, no visible damage.
- 3: Noticeable wear of scales from wings or body.
- 4: Wings showing fraying or tearing in their cuticle.
- 5: Wings with extensive scale wear and cuticle damage.

DAFOR Scale Descriptions:

Dominant (D): In practice, the dominant ranking is rarely, if ever used. To be scored as D, a species would have to be the most common plant by far, covering over 75% of the wetland.

Abundant (A): Only use A if the species is common in many parts of the wetland. For most species, this would mean that there are thousands of individual plants present. At most sites, few species will be ranked as A.

Frequent (F): Use F if you find a species at several places within the survey area and more than just a few individuals are present at each location. You could also use F if a plant species only occurs at one part of the site but is common at that location, with many individuals observed and a substantial area covered (e.g., between one eighth and one quarter of the site).

Occasional (O): Use O for species that occur in several places in the wetland, but whose populations are small at those locations. You could also use O for species that are common at one location but occupy a small area (e.g., less than one eighth of the site).

Rare (R): Use R for species that occur as a small number of individuals within the site. These individuals may be located in one place, or scattered over several locations within the wetland.