

# Surveys for Blazing Star Borer Moth and Secretive Locust in Michigan



## Prepared By:

Logan Rowe, David Cuthrell, and Daniel Earl  
Michigan Natural Features Inventory  
Michigan State University Extension  
P.O. Box 30444  
Lansing, MI 48909-7944

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Michigan Department of Natural Resources, Wildlife Division

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We collectively acknowledge that Michigan State University occupies the ancestral, traditional, and contemporary Lands of the Anishinaabeg – Three Fires Confederacy of Ojibwe, Odawa, and Potawatomi peoples. In particular, the University resides on Land ceded in the 1819 Treaty of Saginaw. We recognize, support, and advocate for the sovereignty of Michigan’s twelve federally recognized Indian nations, for historic Indigenous communities in Michigan, for Indigenous individuals and communities who live here now, and for those who were forcibly removed from their Homelands. By offering this Land Acknowledgement, we affirm Indigenous sovereignty and will work to hold Michigan State University more accountable to the needs of American Indian and Indigenous peoples.

Cover: Jack pine sphagnum bog characteristic of secretive locust habitat (left) and blazing star borer moth blacklight setup with blazing star in the foreground (right). Photos by Logan Rowe.

## Executive Summary

Michigan Natural Features Inventory (MNFI) received funding from the Michigan Department of Natural Resources (MDNR) through a State Wildlife Grant (SWG) to re-evaluate Element Occurrences (EOs) of blazing star borer moth (*Papaipema beeriana*, State Special Concern) and secretive locust (*Appalachia arcana*, State Special Concern) in Michigan. The primary objectives of this project were to 1) Develop a monitoring framework to assess the state-wide distribution of the blazing star borer moth and secretive locust in Michigan, 2) Determine the population trends, site-level relative abundance, and conservation status of the blazing star borer moth and secretive locust in Michigan, and 3) Describe best habitat management activities for both species to ensure their continued population health. This report details the methods and results of blazing star borer moth and secretive locust surveys in Michigan from 2022-2023. Habitat management recommendations for each species are provided in the discussion section.

Blazing star borer moth and secretive locust surveys were conducted within suitable habitats documented in the Natural Heritage Database and at additional locations with suitable habitats following standardized monitoring protocols (Cuthrell and Rowe, 2021, Cuthrell et al. 2021). Element Occurrences were assessed prior to surveys for their likelihood of containing target species using the Element Occurrence rank and the date of last survey. Selected sites included both EOs with historical data only (lacking documented occurrence within the past 20 years) and sites that have been surveyed more recently. In 2022, a total of 23 surveys were conducted for blazing star borer moth and 24 surveys were conducted for secretive locust. In 2023, a total of 25 surveys were conducted for blazing star borer moths and 28 surveys were conducted for secretive locust.

The surveys in 2022-2023 represent a resurvey of 24 blazing star borer moth EOs and 47 secretive locust EOs in the Michigan Natural Heritage Database. We documented blazing star borer moth at 10 (43%) survey locations in 2022 and 12 (48%) survey locations in 2023. Through these surveys, 3 new EOs for blazing star borer moth were documented. We were unable to document blazing star borer moth at 11 previous EOs, 3 of which are now considered Historic. We documented secretive locust at 8 (33%) survey locations in 2022 and 10 (36%) survey locations in 2023. We failed to document secretive locust at 26 EOs in the Natural Heritage Database, 20 of which are now considered historic. Subnational conservation status assessments were completed for each species (blazing star borer moth: previous = S2, current = S1S2; secretive locust: previous = S2, current = S1S2). The results of these survey efforts document a considerable decline in the number of secretive Locust EOs in the Michigan Natural Heritage Database and low population numbers of both species at extant sites.

Additional surveys for blazing star borer moth and secretive locust are warranted in the state to continue documenting each species' persistence in occupied habitats. Continued habitat management is required to promote host plant populations for blazing star borer moth, and to maintain high quality jack pine bog structure for secretive locust. To aid land managers, we developed preliminary habitat management recommendations for sites occupied by blazing star borer moth and secretive locust.

## Acknowledgements

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Blacklight survey for blazing star borer moth at Gourneck State Game Area in 2022. Photo by Logan Rowe.

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## Introduction

Blazing star borer moth (*Papaipema beeriana*, BSBM) and secretive locust (*Appalachia arcana*) are both listed as State Special Concern species in Michigan and are considered Species of Greatest Conservation Need (SGCN) in the Michigan Wildlife Action Plan (Derosier et al. 2015). Globally, the BSBM is ranked G3G2 (Vulnerable-Imperiled), and secretive locust is ranked G2 (Imperiled). Both species are considered Imperiled in Michigan. Blazing star borer moth is found sparsely throughout the midwestern region of the United States within the Tallgrass Prairie Region and is closely associated with larval host plants in the genus *Liatis* (i.e. blazing stars), typically found within high quality, native grasslands (Bess 2005). In Michigan, all documented occurrences are in the lower peninsula. The natural communities where BSBM can occur in Michigan include Dry Sand Prairie, Dry-Mesic Prairie, Lakeplain Wet Prairie, Lakeplain Oak Openings, Lakeplain Wet-mesic Prairie, Mesic Prairie, Mesic Sand Prairie, Oak Barrens, Oak-Pine Barrens, Prairie Fen, Southern Wet Meadow, Wet Prairie, and Wet-Mesic Prairie. Secretive locust is a species endemic to Michigan, with most occurrences isolated in 13 counties within the Grayling Outwash Plains ecoregion, and is closely associated with Bog, Oak-Pine Barrens, and Pine Barrens natural communities. Due to its rarity, the biology and life history of secretive locust is poorly understood, but it primarily occurs in leatherleaf (*Chamaedaphne calyculata*) and sphagnum moss dominated bogs with stands of jack pine (*Pinus banksiana*). In drier areas where secretive locust is found, it is likely that populations extend beyond the bog edges and into upland jack pine dominated landscapes.

Since being listed as State Special Concern species, Michigan Natural Features Inventory (MNFI) has been tracking occurrences of BSBM and secretive locust within the Michigan Natural Heritage Database (MNHD), which contains the most authoritative, comprehensive, and up-to-date scientific information available to guide conservation of Michigan's biodiversity. The MNHD contains a total of 41 Element Occurrences (EOs) of BSBM and 49 EOs of secretive locust. Element occurrence records within the database date back to 1951 and 1932 for BSBM and secretive locust, respectively. Until recently, it was presumed that populations of BSBM and secretive locust remained relatively stable in Michigan, albeit in low numbers. However, many of the EOs for these species have not been visited recently, and some are considered historic (last observed prior to 2003). Furthermore, due to the declining persistence of their preferred high-quality habitats (BSBM: wet to mesic prairie and prairie fen, secretive locust: jack pine dominated bogs), there is an immediate need to conduct population and habitat surveys to determine the status of remnant populations and provide management recommendations to land managers.

In 2022, MNFI initiated a review of EOs within the MNHD, with the goal of selecting priority sites to conduct population level surveys for BSBM and secretive locust. Sites were selected based on the available population data, and included EO Rank (species viability i.e., the probability of persistence) and the first and last observation dates. We aimed to select a range of sites that included both sites with recent documentation of species occurrence and sites with historic documentation only. We also identified sites with suitable habitat and included them in 2022 and 2023 surveys for BSBM and secretive locust. Once sites were selected, our primary objectives were to 1) Establish a standardized monitoring framework to evaluate EO conditions and assess the distribution of blazing star borer moth and secretive locust in Michigan, 2) Determine the population trends, relative abundance, and conservation status of the blazing star borer moth and secretive locust in Michigan, and 3) provide best management practices for both species to the relative land managers to ensure continued population health.



Examples of high-quality blazing star borer moth (top) and secretive locust (bottom) habitats found in Michigan. BSMB site: ORV Prairie, secretive locust site: Higgins Lake Road.

## Methods

### Evaluation of Element Occurrences to Inform Site Selection

Prior to surveys, MNFI compiled blazing star borer moth and secretive locust occurrence data housed in the Michigan Natural Heritage Database. A total of 41 EOs for blazing star borer moth and 49 EOs for secretive locust were evaluated for inclusion in 2022-2023 survey efforts. Element occurrences were assessed based on multiple factors: 1) EO Rank, 2) date of last observation, 3) spatial representation of the species' distribution in Michigan. Since the primary goal was to assess the current status of BSBM and secretive locust in Michigan, we aimed to select a set of survey sites for each species that varied in their EO rank, date of last observation, and distribution across the state. A total of 24 BSBM EOs and 47 secretive locust EOs were selected for surveys in 2022-2023. In addition to surveying known EOs for each species, we surveyed potential habitats deemed capable of supporting target species' due to presence of host plant (BSBM: *Liatris* sp.) or appropriate habitat structure (secretive locust: jack pine bog). We surveyed a total of 19 additional locations for BSBM and 1 for secretive locust.

### Blazing Star Borer Moth Surveys

Surveys for BSBM were completed between September 8<sup>th</sup> and October 11<sup>th</sup> in 2022 and August 28<sup>th</sup> and October 4<sup>th</sup>, in 2023. Surveys were conducted using standardized methodology developed by MNFI to document the *Papaipema* moth community at a local site. During each BSBM survey event in 2022-2023, abundance data was collected for each species of *Papaipema* encountered and *Papaipema* species richness at each survey site was determined. Associated environmental and weather data was also collected (See Appendix C). Moth surveys utilized the technique of blacklighting, which consists of standard mercury-vapor and UV lights powered by a portable generator. A large white sheet was used as a collecting surface. This frame was placed in a central location with larval host plants on all sides to maximize the likelihood of collecting adults. Surveys were generally conducted between the hours of 8:00pm and 12:00am. Data was collected in the field using Survey 123 and translated to paper forms during the final species identification process.



Blazing star borer moth blacklight survey set up from the Lovells Road survey site on 8/28/2023.

## Secretive Locust Surveys

Surveys for secretive locust were completed between August 22<sup>nd</sup> and September 2<sup>nd</sup> in 2022 and August 18<sup>th</sup> and August 28<sup>th</sup> in 2023. To survey for this species, we conducted visual meander surveys through suitable habitats associated with known EOs. Rather than walking transects, meander surveys for secretive locust consisted of scanning the bases of jack pine (*Pinus banksiana*) above the vegetation line, which is usually dominated by leatherleaf (*Chamaedaphne calyculata*) and/or black huckleberry (*Gaylussacia baccata*). Using binoculars, surveyors would start at the base of jack pine and slowly scan upwards until the entire base of tree was thoroughly surveyed. Because adults use the thermoregulatory behavior of sunbathing on the trunks of suitable trees, we focused our surveys on the sunny side of each suitable tree. In addition to presence/absence data, we collected additional data on individual sex, height about vegetation line (inches), species of tree the individual was observed on, and the species of dominant vegetation below individual occurrence. As much as possible, we limited surveys to periods when the temperature was above 15° C (60° F), there was no rain, skies were mostly clear, and when winds were ≤ 25 km/h (15 mph). We used Survey 123 to collect secretive locust occurrence data and to record habitat management recommendations.



Surveying for secretive locust in a high-quality bog near Grayling, Michigan.

## Data Summary and Analysis

Element occurrences within the Michigan Natural Heritage Database were updated for each relevant BSBM and secretive locust survey location. New EOs were created for 3 locations where BSBM was previously undocumented. We provide site level summaries of the data so that land managers can access the information for habitat management decisions. In addition to BSBM, we report all *Papaipema* spp. documented during blacklight surveys at each site (See Appendix B). At a few sites, we also documented occurrences of royal fern borer moth (*P. speciosissima*; State Special Concern) or Culver's root borer moth (*P. sciata*; State Threatened) and updated their EOs. Species distribution maps were created based on 2022-2023 survey efforts.

We used NatureServe's Conservation Rank Calculator to update the subnational (state level) conservation rank for each BSBM and secretive locust in Michigan (NatureServe 2020). This tool determines species status ranks and assesses the extinction risk of species by requiring knowledge of the distribution, population size and trends, and critical threats for a species of concern. The calculator was built to accommodate missing data and to accept a great deal of uncertainty, which is important when assessing groups such as invertebrates that may have low survey effort and/or a shortage of occurrence data historically. The strengths of the calculator are that it standardizes the assessment process, is easily replicated, and records all the assessment fields (including author and date). For a more detailed description of the process and metrics please refer to Master et al. (2012) and Faber-Langendoen et al. (2012). Each species receives an S-rank as follows: S1- Critically Imperiled, S2- Imperiled, S3- Vulnerable, S4- Apparently Secure, S5- Secure, SX- Presumed Extirpated, SH- Possibly Extirpated, and SU- Status Unknow. We used the updated information on the spatial occupancy and relative abundance trends for each species in Michigan to inform the model. Critical threats were determined using available information in the database regarding species life history and biology, specific habitat needs, and rarity.

## Data Contribution to the Michigan Natural Heritage Database

Blazing star borer moth and secretive locust records were added to Michigan's Natural Heritage Database in October 2023. Independent species occurrences, or occurrence clusters of the same species, were added to the database as source features (SF). Depending on the proximity of SFs to adjacent SFs of the same species, naturally occurring populations occupying the landscapes were described in the database as EOs. Each species was assessed independently, creating species specific spatial datasets for BSBM and Secretive locust.

## Results

In 2022-2023, we completed a total of 48 blazing star borer moth surveys at 43 sites and 52 secretive locust surveys at 52 sites (Table 1) Five BSMB sites were surveyed twice between 2022-2023. A total of 24 BSMB EOs and 47 secretive locust EOs were resurveyed during this project.

Table 1. Summary for blazing star borer moth and secretive locust surveys in Michigan from 2022-2023, including number of sites surveyed, number of occupied sites, and species detection rates.

Target Species	Common Name	Survey Year	Number of Sites Surveyed	Number of Survey Sites Occupied by Target Species	Species Detection Rate
<i>Papaipema beeriana</i>	Blazing star borer moth	2022	23	10	0.43
		2023	25	12	0.48
<i>Appalachia arcana</i>	Secretive locust	2022	24	8	0.33
		2023	28	10	0.36

### Blazing Star Borer Moth Surveys

Blazing star borer moth was documented at 21 survey locations during 2022-2023 surveys. At one site, Mt. Hope Road Fen, we documented BSMB in both 2022 and 2023. We were able to reconfirm species presence at 14 (54%) previously described EOs. We were unable to detect BSMB at 11 previously described EOs, 3 of which are now considered ‘Historic’ in the Natural Heritage Database (Table 3, Figures 1, 2, 3). However, through survey efforts in 2022-2023, we were able to document and describe 3 new EOs for BSMB. In addition to BSMB, we documented all species of *Papaipema* present at each site during surveys (Appendix B). Two sites contained *P. speciosissima* (royal fern borer moth, State Special Concern) and 3 sites contained *P. sciata* (Culver’s root borer moth, State Threatened). Blazing star borer moth was generally observed on cool nights with high humidity and low winds (Table 2). Based on a subnational conservation status assessment of BSMB, the species requires an updated rank of S1S2 (Critically Imperiled – Imperiled).

Table 2. Environmental variables associated with blazing star borer moth collections at survey sites in Michigan from 2022-2023.

Variable	Temperature (F)	Relative Humidity (%)	Average Wind Speed (mph)	Cloud Cover (%)
Mean	56.93	77.36	0.94	62.10
Standard Deviation	6.09	10.54	1.27	40.80
Standard Error	0.87	1.51	0.18	5.83
95% CI	1.74	3.01	0.37	11.66

Table 3. Summary of blazing star borer moth site level survey data for surveys in Michigan from 2022-2023, including species presence, Source Feature, Element Occurrence ID and current Element Occurrence status for each survey site.

Site Name	Survey Date	Lat	Long	Number of <i>P. beeriana</i> documented	SF ID	EO ID	EO Status
Vanderbilt Fen	09/08/2022	42.182	-85.630	0	NA	NA	Not an EO
Liberty Fen- Site 2	09/12/2022	42.092	-84.456	3	73082	7973	EO update
Liberty Fen-Connin Tract	09/12/2022	42.085	-84.461	5	73083	7973	EO update
Route 509 Middle	09/13/2022	45.982	-86.889	0	NA	NA	Not an EO
Route 509 South	09/13/2022	45.977	-86.892	0	NA	NA	Not an EO
Route 509 North	09/13/2022	45.990	-86.882	0	NA	NA	Not an EO
Crapo Lake Road Powerline Middle	09/14/2022	44.894	-84.455	0	NA	10956	Failed to find/ Historic
Crapo Lake Road Powerline East	09/14/2022	44.880	-84.432	0	NA	10956	Failed to find/ Historic
Crapo Lake Road Powerline West	09/14/2022	44.895	-84.457	0	NA	10956	Failed to find/ Historic
Fred-Meyer Trail Pewamo	09/19/2022	42.999	-84.877	0	NA	NA	Not an EO
Springfield - Long Lake East	09/21/2022	42.757	-83.547	1	73079	26242	New EO
Springfield - Long Lake Middle	09/21/2022	42.756	-83.550	1	73080	26242	New EO
Springfield - Long Lake West	09/21/2022	42.763	-83.559	4	73081	26242	New EO
Comstock Park - White Pine Trail	09/22/2022	43.054	-85.647	0	NA	NA	Not an EO
Crosswinds Marsh	09/27/2022	42.105	-83.454	0	NA	NA	Not an EO
West Prairie	09/27/2022	42.140	-83.291	6	73098	23892	EO update
Petersburg SGA - Teal Rd SW	09/28/2022	41.875	-83.695	3	65359	12949	EO update
Petersburg SGA - Teal Rd West	10/05/2022	41.878	-83.697	1	65357	12949	EO update
Lovells Road	08/28/2023	44.897	-84.538	0	NA	22188	Failed to find
Miller Road	08/29/2023	44.725	-84.291	0	NA	NA	Not an EO
Huron River Barrens	09/07/2023	42.504	-83.703	0	NA	19007	Failed to find
Huron River Barrens West	09/07/2023	42.504	-83.751	0	NA	658	Failed to find
Teahen Road Prairie	09/08/2023	42.484	-83.823	0	NA	19001	Failed to find
Algonac State Park -Blazing Star Prairie	09/11/2023	42.654	-82.519	1	76949	10633	EO update

<b>Site Name</b>	<b>Survey Date</b>	<b>Lat</b>	<b>Long</b>	<b>Number of <i>P. beeriana</i> documented</b>	<b>SF ID</b>	<b>EO ID</b>	<b>EO Status</b>
Algonac State Park - Ernie Prairie	09/11/2023	42.641	-82.518	0	NA	19006	Failed to find
King Road Prairie (Fish Point SWA)	09/12/2023	43.627	-83.615	1	76976	22147	EO update
Fish Point SWA - Dickerson Road	09/13/2023	43.610	-83.634	2	76948	22146	EO update
Knight Road	09/14/2023	43.631	-83.795	0	NA	NA	Not an EO
ORV Prairie	09/16/2023	43.317	-85.977	0	NA	23674	Failed to find
Pinckney Prairie	09/18/2023	42.407	-84.060	2	76978	6071	EO update
Allegan SGA -36th Street	09/18/2023	42.643	-85.895	0	NA	5902	Failed to find/ Historic
Geiger Road Prairie	09/19/2023	43.798	-83.412	1	76973	19003	EO update
Rudy Road Fen	09/20/2023	41.999	-86.090	0	NA	18999	Failed to find/ Historic
Paw Paw Prairie Fen	09/24/2023	42.173	-85.769	1	48499	19005	EO update
Watkins Lake State Park - Fay Lake Rd	09/25/2023	42.125	-84.162	0	NA	21329	Failed to find
Calla Burr	09/25/2023	42.771	-83.579	0	NA	NA	Not an EO
Buckhorn Lake Fen	09/26/2023	42.717	-83.620	0	NA	17193	Failed to find
King Road-Danou	09/28/2023	42.152	-83.275	1	76975	20090	EO update
Watkins Lake State Park	10/02/2023	42.126	-84.159	1	76974	21329	EO update
Allegan State Game Area - 41st Street	10/04/2023	42.653	-85.946	2	76943	26991	New EO
Mt. Hope Road Fen	09/07/2022, 09/07/2023	42.311	-84.208	2	76980	13430	EO update
Hill Creek Fen	09/07/2022, 09/27/2023	42.666	-85.454	1	24668	15659	EO update

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<b>Site Name</b>	<b>Survey Date</b>	<b>Lat</b>	<b>Long</b>	<b>Number of <i>P. beeriana</i> documented</b>	<b>SF ID</b>	<b>EO ID</b>	<b>EO Status</b>
Algonac State Park - Roberts Road West/ Marine Drain	09/11/2023, 10/03/2023	42.664	-82.532	4	76947	26992	New EO
Gourdneck SGA ROW	09/27/2022, 10/5/2022	42.197	-85.640	0	NA	NA	Not an EO
Fisher Road Fen	10/11/2022, 09/19/2023	42.706	-83.919	3	76972	13431	EO update

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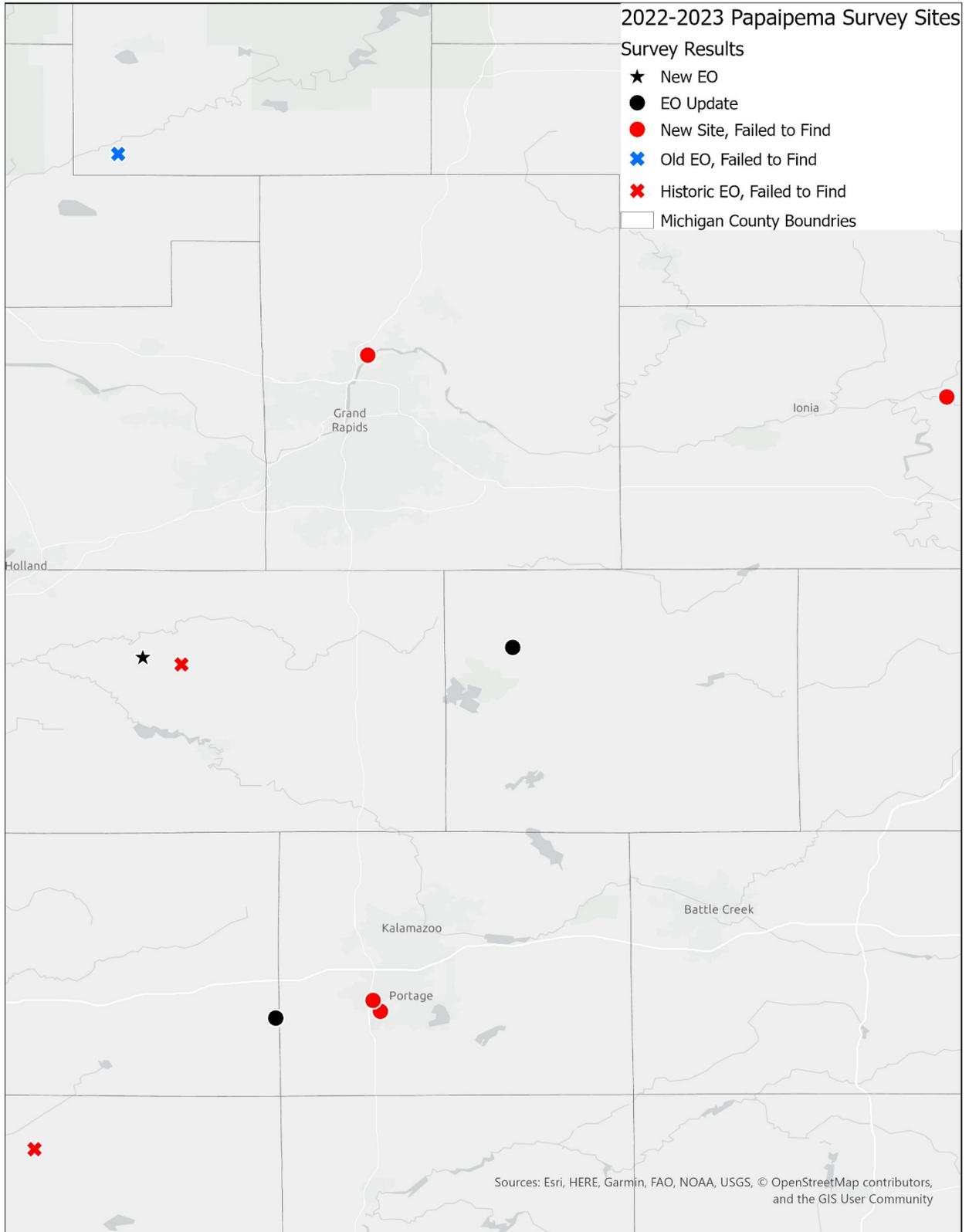


Figure 1. Southwest Michigan blazing star borer moth survey locations from 2022-2023. Map includes the results from Natural Heritage Database updates for each survey site.

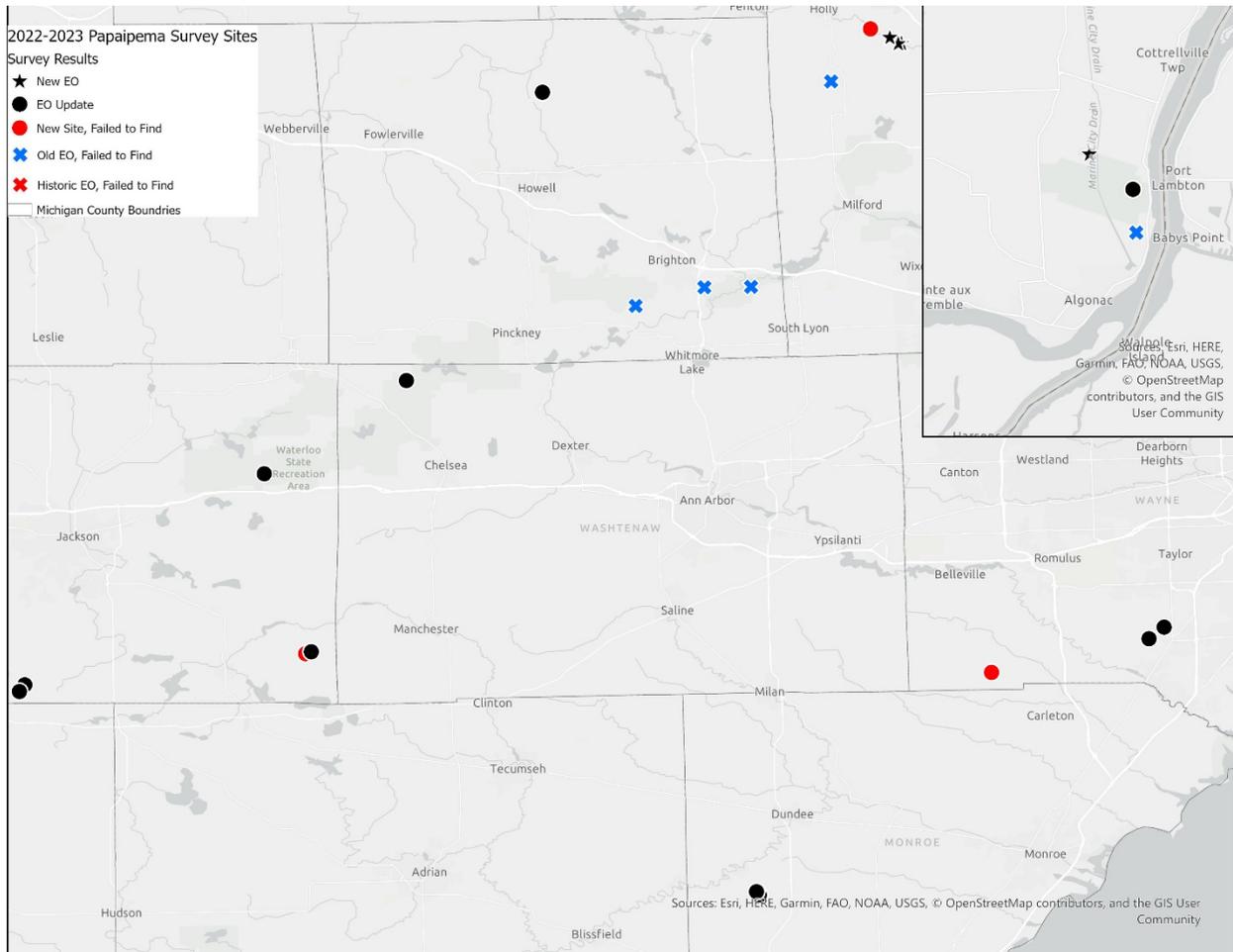


Figure 2. Southeast Michigan blazing star borer moth survey locations from 2022-2023. Map includes the results from Natural Heritage Database updates for each survey site.

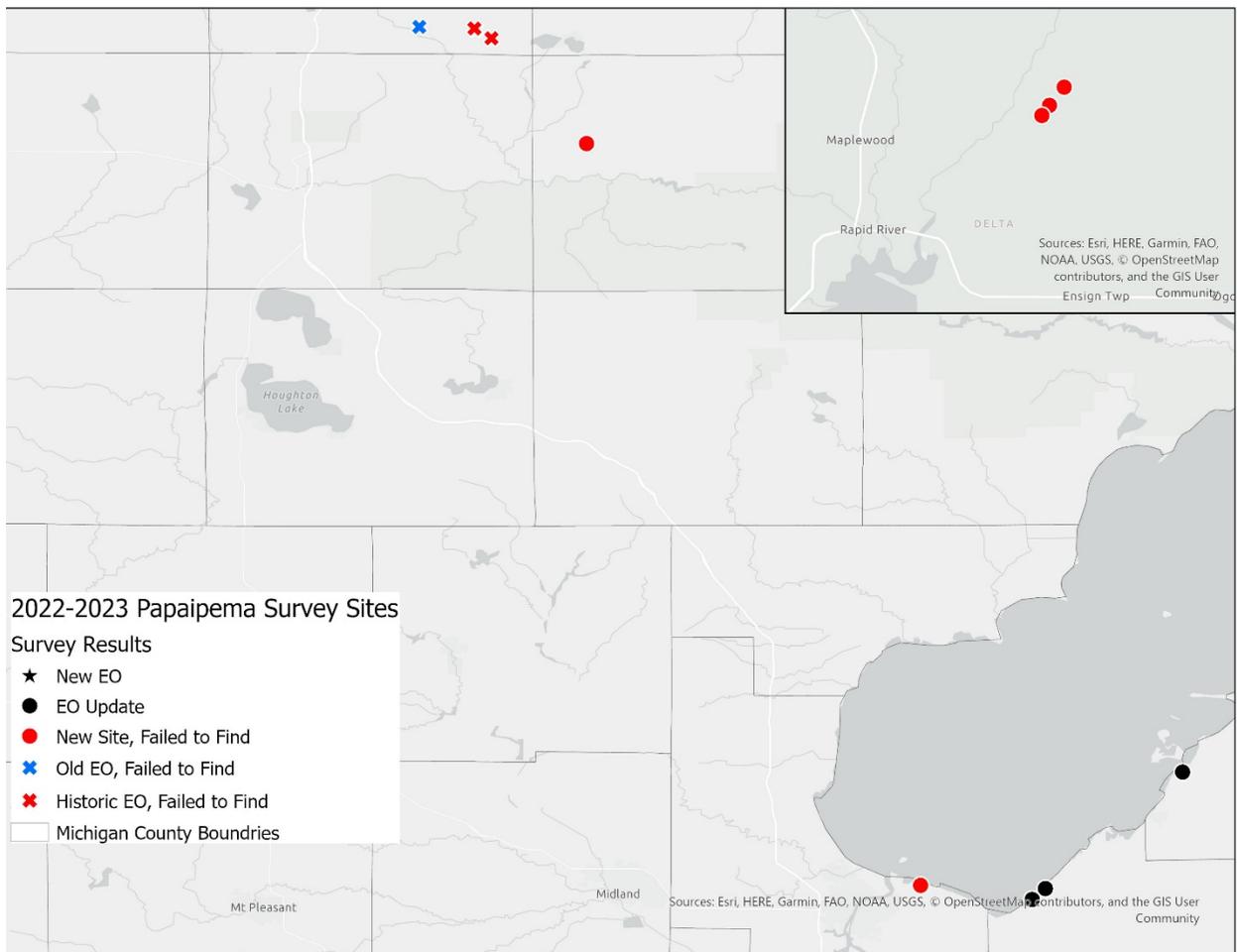


Figure 3. Northern Michigan (including the upper peninsula) blazing star borer moth survey locations from 2022-2023. Map includes the results from Natural Heritage Database updates for each survey site.

## Secretive Locust Surveys

Secretive locust was documented at 18 (35%) survey locations during 2022-2023 surveys. We were unable to locate secretive locust at 26 previously described EOs, 20 of which are now considered 'Historic' in the Natural Heritage Database (Table 5, Figure 4). For sites that were occupied, we documented an average of  $3.4 \pm .74$  secretive locust per survey event. We did not document any new EOs for secretive locust during 2022-2023 population surveys. Secretive locust was generally observed sunning on jack pine (n = 22 observations) but was also observed directly on leatherleaf (n = 19 observations) as well as sphagnum moss (n = 2 observations), eastern white pine (*Pinus strobus*, n = 2 observations), tamarack (*Larix laricina*, n = 1 observation), and spruce (*Picea* sp., n = 1 observation). The mean height at which observations occurred was  $10.59 \pm 2.6$  cm. Observations tended to occur on warm days with medium humidity and low cloud cover (Table 4). Based on a subnational conservation status assessment of secretive locust, the species rank remains as an S1S2 (Critically Imperiled – Imperiled).

Table 4. Environmental variables associated with secretive locust observations at survey sites in Michigan from 2022-2023.

Variable	Shaded Temperature (F)	Relative Humidity (%)	Wind Speed (mph)	Cloud Cover (%)
Mean	72.64	52.75	4.93	31.10
Standard Deviation	7.23	13.37	4.28	31.59
Standard Error	1.00	1.85	0.59	4.38
95% CI	2.01	3.71	1.19	8.76



Secretive locust male sunning on the base of a jack pine near Grayling, Michigan.

Table 5. Summary of secretive locust site level survey data for surveys in Michigan from 2022-2023, including species presence, Source Feature, Element Occurrence ID and current Element Occurrence status for each survey site.

Site Name	Survey Date	Lat	Long	Number of <i>A. arcana</i> documented	SF ID	EO ID	EO status
Arrowhead Road	08/22/2022	44.685	-84.837	0	NA	24432	Failed to find
Arrowhead Road - Unnamed Two Track	08/22/2022	44.672	-84.838	12	73274	24432	EO update
Dollar Lake Road	08/22/2022	44.682	-84.776	3	73275	7641	EO update
Hartwick Pines - Scenic Trail	08/23/2022	44.743	-84.633	0	NA	305	Failed to find/ Historic
Tow Line Road Bog	08/23/2022	44.765	-84.406	1	NA	306	EO update
Best Bog	08/23/2022	44.704	-84.473	3	NA	20093	EO update
Shupac Lake – Site A	08/30/2022	44.844	-84.472	0	NA, 3273	11120	Failed to find/ Historic
Grass Lake Bog	08/31/2022	45.188	-84.463	0	NA	887	Failed to find/ Historic
Hardwood Lake Bog	08/31/2022	45.171	-84.406	0	NA	7098	Failed to find/ Historic
Black River Barrens	08/31/2022	45.143	-84.290	0	NA	2739	Failed to find/ Historic
East Caulkin Lake Barrens - Site 1	09/01/2022	44.908	-84.394	0	NA	4832	Failed to find/ Historic
East Caulkin Lake Barrens – Site 2	09/01/2022	44.903	-84.389	0	NA	4832	Failed to find/ Historic
East Caulkin Lake Barrens – Site 3	09/01/2022	44.896	-84.399	0	NA	4832	Failed to find/ Historic
Shupac Lake - Site B	09/01/2022	44.842	-84.453	0	NA	11120	Failed to find/ Historic
Shupac Lake – Site C	09/01/2022	44.842	-84.456	0	NA	11120	Failed to find/ Historic
Grass Lake Bog	08/30/2022	44.189	-84.777	1	73276	23851	EO update
Big Creek Well	08/30/2022	44.566	-84.209	0	NA	14043	Failed to find
Mack Lake	08/30/2022	44.566	-84.148	0	NA	18522	Failed to find
Meridian Road	08/31/2022	44.611	-84.372	0	NA	18517	Failed to find
Roscommon Forest Area - Compartment 47	08/31/2022	44.455	-84.372	3	NA	3563	EO update
Third Lake Road Bog	08/31/2022	44.391	-84.526	3	NA	5052	EO update
Bertha's Heaven – Site A	09/02/2022	44.402	-83.705	0	NA	13984	Failed to find
Bertha's Heaven – Site B	09/02/2022	44.396	-83.726	0	NA	13984	Failed to find
M-55 Bog	09/02/2022	44.305	-84.580	9	73277	12581	EO update
Wells Road	08/16/2023	44.414	-83.477	1	76568	8366	EO update

Site Name	Survey			Number of <i>A. arcana</i> documented	SF ID	EO ID	EO status
	Date	Lat	Long				
Grass Lake Road	08/16/2023	44.411	-83.361	0	NA	13987	Failed to find/ Historic
Foote Dam Pond	08/16/2023	44.475	-83.434	0	NA	10650	Failed to find/ Historic
Poor Farm Road	08/16/2023	44.529	-83.366	0	NA	NA	Not an EO
Bucks Truck Trail Barrens	08/18/2023	44.752	-84.550	2	76920	4145	EO update
Wakeley Bridge Road West	08/18/2023	44.733	-84.526	0	NA	9373	Failed to find
Wakeley Lake	08/18/2023	44.605	-84.532	1	76940	14114	EO update
Howes Lake/ The Doughnut					76942,	12654,	
	08/18/2023	44.689	-84.818	6	76944	11655	EO update
Lake Margrethe East	08/18/2023	44.662	-84.767	0	NA	7357	Failed to find
Rice Pond	08/18/2023	42.798	-84.458	3	76964	20092	EO update
Cranberry Creek Barrens	08/19/2023	44.122	-84.948	0	NA	3170	Failed to find/ Historic
Floodwood Creek Barrens	08/19/2023	44.113	-84.929	1	76957	4619	EO update
Roscommon Forest Area - Compartment 160					76958, 76959, 76960, 76961, 76962,		
	08/19/2023	44.190	-84.730	7	76963	5851	EO update
St. Helen SE Bog	08/18/2023	44.314	-84.392	0	NA	6696	Failed to find/ Historic
Bear Lake Chain	08/18/2023	44.453	-84.395	1	76967	12583	EO update
Six Mile Hill	08/18/2023	44.435	-84.603	0	NA	3304	Failed to find/ Historic
Higgins Lake Road	08/28/2023	44.433	-84.765	0	NA	11551	Failed to find/ Historic
Rollway Road Bog					76983,		
	08/28/2023	44.215	-84.738	2	76984	2691	EO update
Hunt Creek Fisheries Research Center	08/30/2023	44.875	-84.152	0	NA	5503	Failed to find/ Historic
Lyon Manor	08/30/2023	44.465	-84.727	0	NA	10326	Failed to find/ Historic
Grayling Forest Unit - Compartment 218	08/28/2023	44.683	-84.457	0	NA	11046	Failed to find/ Historic
Big Frost Pocket South	08/21/2023	44.797	-84.132	0	NA	464	Failed to find
Sucker Lake Bog	08/21/2023	45.050	-83.970	0	NA	3012	Failed to find/ Historic

<b>Site Name</b>	<b>Survey Date</b>	<b>Lat</b>	<b>Long</b>	<b>Number of <i>A. arcana</i> documented</b>	<b>SF ID</b>	<b>EO ID</b>	<b>EO status</b>
Pelts Road South	08/21/2023	45.346	-83.976	0	NA	8845	Failed to find/ Historic
Peltz Road North	08/21/2023	45.354	-83.975	0	NA	8844	Failed to find/ Historic
Ruth Road Bog					76995,		
	08/27/2023	44.745	-84.272	2	76996	12402	EO update
Blue Lakes	08/27/2023	45.148	-84.348	0	NA	9413	Failed to find/ Historic
McGlowerd Road	08/28/2023	45.327	-83.948	0	NA	20094	Failed to find

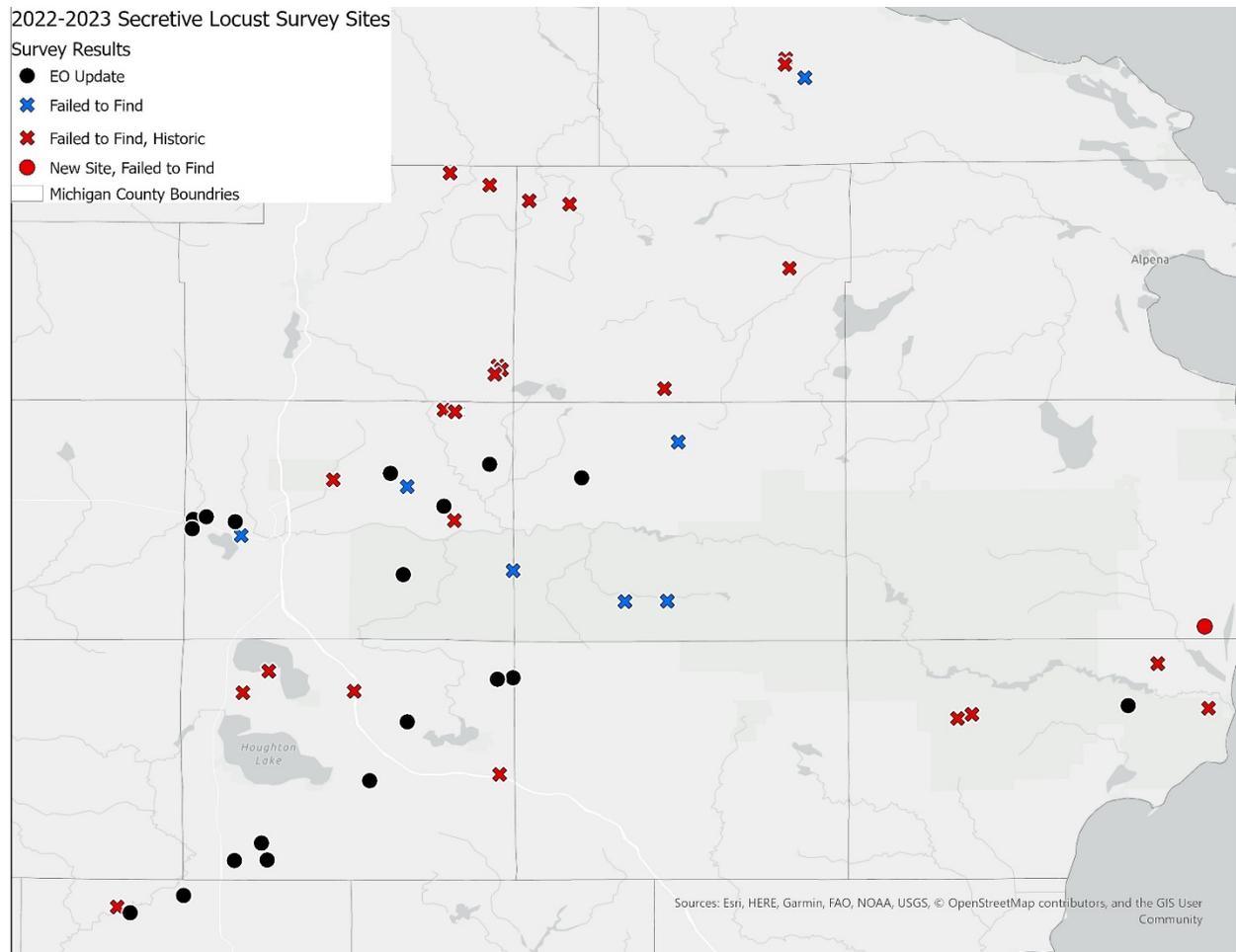


Figure 4. Secretive locust survey locations from 2022-2023 in northern Michigan. Map includes the results from Natural Heritage Database updates for each survey site. Map represents the entire global distribution of the species.

## Management Recommendations

### Blazing Star Borer Moth

The blazing star borer moth is currently a focal species for Prairies & Savannas in the Michigan Wildlife Action Plan (WAP) (Derosier et al. 2015). It is considered rare and local, range-wide, always in close association with its primary larval host plants, blazing stars. This moth produces a single brood per year, with the adults appearing in late summer/early fall. The BSBM preferred host plant, marsh blazing-star (*Liatris spicata*) occurs in the more mesic of sites, including moist sandy plains, wet lakeplain prairies, prairie fens and only rarely in drier oak, or jack pine savanna (Reznicek et al. 2021). The other species of blazing stars which have been utilized by BSBM in Michigan (Cuthrell unpublished data) include both the rough blazing star (*Liatris aspera*) and the northern blazing star (*Liatris scariosa*) both of which can occur in dry sand prairie remnants, savannas, and barrens. At known sites associated prairie plants typically include big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), common mountain mint (*Pycnanthemum virginianum*), tall coreopsis (*Coreopsis tripteris*), Ohio goldenrod (*Solidago ohioensis*), Culver's root (*Veronicastrum virginicum*), and switch grass (*Panicum virgatum*). There is an urgent and immediate need to control invasive species as almost every extant EO for BSBM contains one or more invasive species (See Appendix A for site level management needs). The most aggressive non-native invasive species that seem to impact habitat for both the moth and the larval food plant, include common reed (*Phragmites australis*), glossy buckthorn (*Rhamnus frangula*), cattail (*Typha angustifolia*, *T. x glauca*), and reed canary grass (*Phalaris arundinacea*). Some sites have two or more of these invasives present.

### Prescribed Fire Considerations

Almost all major workers on the genus have commented on the fire sensitivity of *Papaipema* eggs and Decker (1930) highly recommends use of fire to control the pest species *P. nebris*. Land managers should always assume high mortality of BSBM eggs in fall, winter, or spring burn units. To protect *Papaipema* populations retaining an adequate amount of the host plant and to divide habitat into smaller burn units is recommended. No BSBM site should ever be entirely burned in a single year. Keep in mind that distribution of the BSBM population among the various burn units will likely vary from year to year, so current information is needed. Generally, decisions will be made on adult observations from the previous growing season, since this is the best approximation on the distribution of BSBM eggs within a site. To preserve the rarer *Papaipema* populations, Schweitzer (1999) recommends protecting an adequate amount of the host plant by dividing their habitat into smaller burn units. These smaller units, once they reach maintenance levels, can be burned in rotation with 3-5 years between burns of a single unit, and adjacent units should not be burned in consecutive years.

Host plants spread over a large area, or in several discrete patches, reduce the risk from predators/parasitoids and random catastrophic events (i.e., flooding, pesticide drift), as compared to a comparable number of plants in a single dense patch. All known sites of BSBM on managed lands should be monitored periodically and over the long term (5-15 years or more) to adequately ascertain true population trends.



MNFI Zoologist, Dan Earl, waiting to survey for blazing star borer moth at Mt. Hope Road Fen on 09/07/2022.

## Secretive Locust

Developing habitat requirements for secretive locust is more challenging because so little is known about the life history and oviposition habit of the species. We do know that adults occupy habitat ranging from the dry end including the edges of dry sand prairie, pine barrens, dry northern forest; to the wet end of the continuum including northern wet prairies, intermittent wetlands, and bogs (Rabe et al. 1996). Secretive locust also could be affected by development, road construction, and logging at occupied sites. Uncut buffer areas around bogs/wetlands may be necessary to protect oviposition sites. Because habitat needs are unclear, the maintenance of a mosaic of suitable upland and wetland habitats in their natural state is prudent, until further research more clearly defines specific habitat requirements.

The secretive locust is best known from bogs where leatherleaf and Labrador tea (*Ledum groenlandicum*) typically occur in dense stands underlain by deep, hummocky sphagnum (see photo below). These bogs often are surrounded by stands of jack pine and some tamarack which may encroach along the margins of the bog.



Typical secretive locust habitat on the wet end of the spectrum (Bog) in Camp Grayling, Michigan.

The primary mechanism for preserving bogs is to maintain their hydrology. Reducing access to peatland systems will help decrease detrimental impacts caused by off-road vehicles. Minimizing impacts to hydrologic regimes can be accomplished by avoiding surface water inputs from drainage ditches, agricultural fields, road construction, and logging in the adjacent uplands, and maintaining native vegetation types in the uplands around the community. In forested landscapes, establishing no-cut buffers around bogs and avoiding road construction and complete canopy removal in stands immediately adjacent to wetlands can help protect the hydrologic regime. In fire-prone landscapes, where shrub and tree encroachment threaten to convert open wetlands to shrub-dominated systems or forested swamps, prescribed fire or selective cutting can be employed to maintain open conditions. Ideally, prescribed fires conducted in adjacent fire-dependent upland communities would be allowed to carry into open wetlands such as bogs when safety permits.



Typical secretive locust habitat on the dry end of the spectrum (Pine barrens) in Camp Grayling, Michigan. Photo from Arrowhead Road site surveyed on 08/22/2022.



Logging adjacent to secretive locust habitat can negatively influence population structure and associated plant species by altering hydrology, increasing presence of invasive species, removing potentially critical upland habitats for the species.

## Conclusion

In 2022-2023, we resurveyed 24 blazing star borer moth EOs and 47 secretive locust EOs in the Michigan Natural Heritage Database, documenting a slight decline in occupancy for BSBM and a larger decline for secretive locust. The results of this study provide current knowledge on BSBM and secretive locust distributions across Michigan and a status of management needs at BSBM EO locations. Many of the EOs that were visited were under pressure from invasive species, which should be managed immediately to improve population health and associated habitat quality. Based on completed subnational rankings for BSBM and secretive locust, we've concluded that these warrant rankings of S1S2 and S1S2, respectively. For both species, this represents a change from S2 to S1S2 due to a fragmented population structure across Michigan, low abundance at occupied sites, and a decrease in overall occupancy across Michigan. Additional surveys for BSBM and secretive locust are warranted in the state to continue documenting each species' persistence in occupied habitats. Continued habitat management is required to promote host plant populations for BSBM, and to maintain high quality jack pine bog structure for secretive locust.

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Appendix A: Site recommendations for blazing star borer moth survey sites in Michigan from 2022-2023.

Site Name	EO ID	Dave Recommendations
Vanderbilt Fen	NA	Manage for <i>Liatris</i> and possibly resurvey
Liberty Fen- Site 2	7973	Site is being managed for Poweshiek skipperling and eastern massassauga rattlesnake and this should be compatible with the needs of BSBM.
Liberty Fen-Connin Tract	7973	Site is being managed for Poweshiek skipperling and eastern massassauga rattlesnake and this should be compatible with the needs of BSBM.
Route 509 Middle	NA	Manage for <i>Liatris</i> and possibly resurvey
Route 509 South	NA	Manage for <i>Liatris</i> and possibly resurvey
Route 509 North	NA	Manage for <i>Liatris</i> and possibly resurvey
Crapo Lake Road Powerline Middle	10956	Manage for <i>Liatris</i> and resurvey
Crapo Lake Road Powerline East	10956	Manage for <i>Liatris</i> and resurvey
Crapo Lake Road Powerline West	10956	Manage for <i>Liatris</i> and resurvey
Fred-Meyer Trail Pewamo	NA	Manage for <i>Liatris</i> and possibly resurvey
Springfield - Long Lake East	26242	Site is being managed for Poweshiek skipperling and eastern massassauga rattlesnake and this should be compatible with the needs of BSBM.
Springfield - Long Lake Middle	26242	Site is being managed for Poweshiek skipperling and eastern massassauga rattlesnake and this should be compatible with the needs of BSBM.
Springfield - Long Lake West	26242	Site is being managed for Poweshiek skipperling and eastern massassauga rattlesnake and this should be compatible with the needs of BSBM.
Comstock Park - White Pine Trail	NA	Manage for <i>Liatris</i> and possibly resurvey
Crosswinds Marsh	NA	Manage for <i>Liatris</i> and resurvey
West Prairie	23892	Continue with lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i> (marsh blazingstar) and other prairie plants

Petersburg SGA - Teal Rd SW	12949	Continue with lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i> (marsh blazingstar) and other prairie plants
Petersburg SGA - Teal Rd West	12949	Continue with lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i> (marsh blazingstar) and other prairie plants
Lovells Road	22188	Manage for <i>Liatris</i> and resurvey
Miller Road	NA	Manage for <i>Liatris</i> and resurvey
Huron River Barrens	19007	Highest priority is to resurvey at this site because there is an abundance of <i>Liatris</i> and management has been ongoing
Huron River Barrens West	658	Highest priority is to resurvey at this site because there is an abundance of <i>Liatris</i> and management has been ongoing
Teahen Road Prairie	19001	Highest priority is to resurvey at this site because there is an abundance of <i>Liatris</i> and management has been ongoing
Algonac State Park -Blazing Star Prairie	10633	Continue with lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i> (marsh blazingstar) and <i>Veronicastrum virginicum</i> (Culver's root).
Algonac State Park - Ernie Prairie	19006	Continue with lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i> (marsh blazingstar) and <i>Veronicastrum virginicum</i> (Culver's root).
King Road Prairie (Fish Point SWA)	22147	Continue with lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i> (marsh blazingstar) and other prairie plants
Fish Point SWA - Dickerson Road	22146	Continue with lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i> (marsh blazingstar) and other prairie plants
Knight Road	NA	Continue with lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i>

ORV Prairie	23674	Continue with lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i> (marsh blazingstar) and other prairie plants
Pinckney Prairie	6071	Continue with prairie management here especially in relation to widespread buckthorn and other shrubby encroachment. Also control reed canary grass and other NNIS.
Allegan SGA -36th Street	5902	Continue with lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i> (marsh blazingstar) and other prairie plants
Geiger Road Prairie	19003	Continue with lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i> (marsh blazingstar) and other prairie plants
Rudy Road Fen	18999	Highest priority is for resurvey within this prairie fen. Continue management for buckthorn and other NNIS control
Paw Paw Prairie Fen	19005	Continue prairie fen management particularly in response to widespread invasion of narrow-leaved and hybrid cattail and buckthorn. Resurvey to determine persistence of the population at this site.
Watkins Lake State Park - Fay Lake Rd	21329	Management at this site is needed, particularly in response to the widespread invasion of glossy buckthorn. In addition, local infestations of narrow-leaved or hybrid cattail and phragmites also occur in the fen.
Calla Burr	NA	Manage for <i>Liatris spicata</i> and other open prairie fen plant species and continue with buckthorn control.
Buckhorn Lake Fen	17193	Site is being managed for Poweshiek skipperling and eastern massasauga rattlesnake and this should be compatible with the needs of BSBM.
King Road-Danou	20090	Management at this site is urgent, particularly the invasion of phragmites into patches of <i>Liatris spicata</i> and throughout the prairie itself. The site may be lost if phragmites is not controlled.

Watkins Lake State Park	21329	Management at this site is needed, particularly in response to the widespread invasion of glossy buckthorn. In addition, local infestations of narrow-leaved or hybrid cattail and phragmites also occur in the fen.
Allegheny State Game Area - 41st Street	26991	Continue with lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i> (marsh blazingstar) and other prairie plants
Mt. Hope Road Fen	13430	Management at this site is urgent, particularly the invasion of glossy buckthorn into patches of <i>Liatris spicata</i> and throughout the fen itself. The site may be lost if the buckthorn is not controlled.
Hill Creek Fen	15659	Management at this site is needed, particularly in response to the widespread invasion of glossy buckthorn. In addition, local infestations of narrow-leaved or hybrid cattail and phragmites also occur in the fen.
Algonac State Park - Roberts Road West/ Marine Drain	26992	Continue with Lakeplain prairie management here and maintain openings with an abundance of <i>Liatris spicata</i> (marsh blazingstar) and <i>Veronicastrum virginicum</i> (Culver's root).
Gourdneck SGA ROW	NA	Manage for <i>Liatris</i> and possibly resurvey
Fisher Road Fen	13431	Management at this site is urgent (see Figure X), particularly the invasion of <i>Phragmites</i> into patches of <i>Liatris spicata</i> and throughout the fen itself. The east side of the road is already in very bad shape (Figure X) and the most urgent need is now along the western edge of the road. The site may be lost within 5 years if the phragmites is not controlled. Glossy buckthorn is also a real threat/issue here and needs to be addressed as well. Prescribed fire could be a tool to help the west side of the road but the fen includes private parcels

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Appendix B: Full summary of *Papaipema* borer moths collected during survey events in Michigan from 2022-2023.

Site Name	Survey Date	<i>arctivorans</i>	<i>baptisea</i>	<i>beeriana</i>	<i>birdii</i>	<i>cataphracta</i>	<i>cerussata</i>	<i>eupatorii</i>	<i>furcata</i>	<i>impecuniosa</i>	<i>inquesiata</i>	<i>insulidens</i>	<i>limpida</i>	<i>marginidens</i>	<i>nebris</i>	<i>necopina</i>	<i>nepheleptena</i>	<i>pterisii</i>	<i>ptresii</i>	<i>rigida</i>	<i>sciata</i>	<i>speciosissima</i>	<i>unimoda</i>
Vanderbilt Fen	09/08/2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Liberty Fen 2	09/12/2022	2	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0
Liberty Fen-Connin Tract	09/12/2022	6	0	5	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
Route 509 Middle	09/13/2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Route 509 South	09/13/2022	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	7	0	0	0	0
Route 509 North	09/13/2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grayling ROW Middle	09/14/2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Big Creek Site A	09/14/2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerline Rd West	09/14/2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FMT Pewamo	09/19/2022	0	0	0	1	2	0	0	4	1	1	0	0	0	1	0	0	0	0	0	0	0	0
Springfield - Long Lake East	09/21/2022	2	0	1	1	1	0	15	0	11	3	0	0	0	0	0	2	0	0	4	0	0	9
Springfield - Long Lake Middle	09/21/2022	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	5	0	0	0
Springfield West - Long Lake West	09/21/2022	0	0	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Comstock Park - White Pine Trail	09/22/2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crosswinds Marsh	09/27/2022	0	1	0	0	2	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West Prairie	09/27/2022	0	0	6	7	1	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
Teal Rd SW	09/28/2022	0	1	3	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
Teal Rd West	10/05/2022	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Lovells Rd	08/28/2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miller Rd	08/29/2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Huron River Barrens	09/07/2023	4	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Huron River Barrens west	09/07/2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site Name	Survey Date	<i>arctivorans</i>	<i>baptisea</i>	<i>beeriana</i>	<i>birdii</i>	<i>cataphracta</i>	<i>cerussata</i>	<i>eupatorii</i>	<i>furcata</i>	<i>impecuniosa</i>	<i>inquesiata</i>	<i>insulidens</i>	<i>limpida</i>	<i>marginidens</i>	<i>nebris</i>	<i>necopina</i>	<i>nepheleptena</i>	<i>pterisii</i>	<i>ptresii</i>	<i>rigida</i>	<i>sciata</i>	<i>speciosissima</i>	<i>unimoda</i>
Teahen Road Prairie - Brighton SRA	09/08/2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Algonac State Park Blazing Star Prairie	09/11/2023	2	0	1	0	0	1	0	1	0	1	0	3	0	0	0	0	0	0	0	0	0	0
Ernie Prairie - Algonac King Road Prairie (Fish Point SWA)	09/11/2023	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Fish Point SWA	09/12/2023	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Knight Road	09/13/2023	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
ORV Prairie	09/16/2023	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Pinckney Prairie	09/18/2023	1	0	2	0	0	1	0	2	1	6	0	0	1	0	0	0	0	0	3	1	0	0
Allegan SGA 36th Street	09/18/2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saginaw Wetlands	09/19/2023	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Dowagiac Fen	09/20/2023	2	0	0	0	2	2	0	0	0	15	0	0	0	0	0	1	0	0	0	0	0	0
Paw Paw Prairie Fen	09/24/2023	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Watkins Lake State Park - Fay Lake Rd	09/25/2023	0	0	0	0	0	0	6	0	1	13	0	0	0	0	0	1	0	0	0	0	0	0
Calla Burr	09/25/2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Big Valley	09/26/2023	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
King Road Prairie (SE MI)	09/28/2023	1	0	1	0	1	0	1	0	1	5	0	0	0	0	0	0	0	0	0	0	1	0
Watkins Lake State Park 134th & 41st Street (Allegan State Game Area)	10/02/2023	0	0	1	0	0	0	6	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
	10/04/2023	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	09/07/2022																						
Mt Hope Fen	09/07/2023	7	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	7	0	0	0

Site Name	Survey Date	<i>arctivorans</i>	<i>baptisea</i>	<i>beeriana</i>	<i>birdii</i>	<i>cataphracta</i>	<i>cerussata</i>	<i>eupatorii</i>	<i>furcata</i>	<i>impecuniosa</i>	<i>inquesiata</i>	<i>insulidens</i>	<i>limpida</i>	<i>marginidens</i>	<i>nebris</i>	<i>necopina</i>	<i>nepheleptena</i>	<i>pterisii</i>	<i>ptresii</i>	<i>rigida</i>	<i>sciata</i>	<i>speciosissima</i>	<i>unimoda</i>
Hill Creek Fen	09/07/2022 , 09/27/2023	0	0	1	1	0	0	12	0	0	1	0	0	0	0	0	0	0	1	0	0	0	7
Algonac State Park Roberts Road	09/11/2023 , 10/3/2023	3	0	4	0	1	0	1	0	0	1	0	1	2	0	0	0	0	0	0	0	0	1
Gourdneck SGA ROW	09/27/2022 , 10/05,2022	0	0	0	0	0	0	0	0	2	5	0	0	0	0	0	0	0	0	0	0	1	0
Fisher Rd Fen	10/11/2022 , 09/19/2023	0	0	3	0	20	0	1	0	8	3	0	0	0	0	0	1	0	0	0	0	0	37

Appendix C: Blazing star borer moth survey form completed during specimen processing.

Survey Site:				Date ____ - ____ - ____				Managed Area:								
Surveyors:				overall start time :												
				overall end time :												
GPS coordinates of blacklight setup								Waypoint or file name:								
	Scientific Name								Environmental Data							
									temperature [C ] [F]	relative humidity - %	wind speed - max [km/h] [mph]	wind speed - avg [km/h] [mph]	cloud cover - %	precipitation level	moon visibility	barometric pressure [kPa] [inHg]
Start time of the period								<b>TOTALS</b>								
1st hour :																
2nd hour :																
3rd hour :																
4th hour :																
5th hour :																
6th hour :																
7th hour :																
<b>TOTALS</b>																
Dominant Plant Species								Notes/Comments/Diagrams								

## Instructions

- 1) **Survey Site:** the name of the specific location (e.g. Brandt Rd fen)
- 2) **Managed Area:** the name of the state game area, rec area, or nature preserve (e.g. Holly SRA)
- 3) Please write times using the **24 hr clock**
- 4) Please use **decimal degrees** or **degrees/minutes/seconds**
- 5) Check the box to indicate what **units** were used for the **temperature** and **wind speed** data.
- 6) **Cloud cover** should be estimated to the nearest 10%.
- 7) **Precipitation level:** **0** = none **T** = trace **1** = light **2** = moderate **3** = heavy
- 8) **Moon visibility:** **0** = not visible at all - obscured by clouds, other features, or below the horizon  
**1** = partially obscured by clouds or other features (e.g. trees, buildings)  
**2** = completely visible
- 9) **Barometric pressure:** The barometric pressure may be recorded at the same time as other env. data, if possible, but at a minimum it should be looked up later for either the beginning or end of the overall sampling period and noted whether the pressure was rising, stable, or falling.
- 10) You may begin the survey at any time but begin the "2nd hour" interval when the next full hour starts (e.g. you begin the 1st hour at 20:30 but the "2nd hour" begins at 21:00 and every hour thereafter is on the hour). Next to each hour designation write in the start time of that period. **Note that the first and last 1hour periods may be partial hours so be sure to record the start and end times.**
- 11) You may place a small tick or question mark in the appropriate box when a known or suspect moth is collected or observed (e.g. a possible silphim borer is collected during the "3rd hour" so a "?" is marked under P. silphii next to "3rd hour"). Specimens collected within the same 1 hour period may be kept in the same kill jar and transferred later to reclosable storage bags with a slip indicating date, location, sampling period/time, and collector(s). Specimens will be ID'd later in the lab and the total number of each species will be written in the appropriate sampling hour row/column.

**Papaipema spp. in Michigan** in order by Hodges Number (special concern, threatened, or endangered are in bold):

<b>(SC)</b> <i>cerina</i> (Grt., 1874)	<i>lysimachiae</i> Bird, 1914	<i>appassionata</i> (Harv., 1876)	<b>(SC)</b> <i>aweme</i> (Lyman, 1908)
<i>cataphracta</i> (Grt., 1864)	<i>pterisii</i> Bird, 1907	<i>furcata</i> (Sm., 1899)	<i>cerussata</i> (Grt., 1864)
<i>aerata</i> (Lyman, 1901)	<b>(SC)</b> <i>speciosissima</i> (G. & R., 1868)	<i>nebris</i> (Gn., 1852)	<b>(SC)</b> <i>sciata</i> Bird, 1908
<i>arctivorens</i> Hamp., 1910	<i>inquaesita</i> (G. & R., 1868)	<i>necopina</i> (Grt., 1876)	<i>limpida</i> (Gn., 1852)
<i>harrisii</i> (Grt., 1881)	<i>rutila</i> (Gn., 1852)	<b>(T)</b> <i>silphii</i> Bird, 1915	<b>(SC)</b> <i>beeriana</i> Bird, 1923
<i>impecuniosa</i> (Grt., 1881)	<i>baptisiae</i> (Bird, 1902)	<b>(SC)</b> <i>maritima</i> Bird, 1909	<i>unimoda</i> (Sm., 1894)
<i>verona</i> (Sm., 1899)	nr. <i>Birdi</i> (Dyar, 1908)	<i>eupatorii</i> (Lyman, 1905)	
<i>astuta</i> Bird, 1907	<i>nepheleptena</i> (Dyar, 1908)	<i>nelita</i> (Stkr., 1898)	
<i>leucostigma</i> (Harr., 1841)	<i>circumlucens</i> (Sm., 1899)	<i>rigida</i> (Grt., 1877)	