# Michigan Bat Monitoring Program—2017 Acoustic Report

A Report Submitted to the
Michigan Department of Natural Resources
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## Summary


- The Organization for Bat Conservation (OBC) and the Michigan Department of Natural Resources (MDNR) have partnered to continue stewardship of the Michigan Bat Monitoring Program (MBMP). This was the second year of the program, which is a citizen-science based effort to monitor the state's bats via bio-acoustic monitoring.
- The MBMP surveyed 19 locations in 2017. Fifteen new routes (Route 11–25) were created, in addition to one point survey area (designated Route 10). In addition to these, three routes from 2016 (01, 07, and 08) were repeated. Two of the newly designated routes (13 and 15) were surveyed last year but yielded no data due to error, which has now been resolved.
- Six routes from 2016 were not repeated. Two of these (5 and 6) were attempted but failed due to equipment error. Routes 02, 04, and 09 are expected to be permanently decommissioned, but all have new routes located nearby. Route 03 was not run due to constraints on partner time, but is expected to be run in 2018.
- Eleven regional partner organizations participated in surveys in 2017, involving at least 50 participants from the public.
- Surveys were conducted on 31 nights, with a total of over 53 survey hours. One survey occurred in May, 7 in June, 14 in July, and 9 in August.
- We recorded a total 1,248 bat passes, 1,002 of which were attributable to specific species or species groups. These included calls of 764 (76.2%) big brown/silver-haired bats, 85 (8.5%) eastern red bats, 122 (12.2%) hoary bats, 25 (2.5%) little brown bats, 4 (0.4%) tri-colored bats, 1 (<0.01%) evening bat, and 1 (<0.01%) Indiana bat. The remaining 246 calls were categorized as unidentifiable bats. These call identifications were assigned based on agreement of at least two of three methods (Kaleidoscope, EchoClass, and a manual vetter).
- One call was identified as belonging to an Indiana bat (Route 19 near Oscoda), although in many cases this species' call is indistinguishable from that of the little brown bat. Two automated identification methods (Kaleidoscope and Echoclass) labeled the call as such. However, the manual vetter deemed it as an unidentifiable call.
- Several other rare or uncommon species were recorded. We provide evidence of tri-colored bats in Washtenaw County (Route 12) during the summer. This species is more commonly encountered during winter hibernation, and its summer distribution in the state is not well understood. The single evening bat call was recorded along Route 01, where the species was also detected in 2016. For little brown bats, 92% of calls were collected from the point-survey site (Route 10), indicating the potential presence of a maternity colony. Only two other sites recorded the species.


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# Introduction

## *Bats in Michigan*

Understanding distribution and abundance of bats in Michigan can help quantify benefits and services like pest control, as well as inform conservation decisions. Tracking populations over time and across a broad geographic areas can identify new threats, quantify ongoing ones, and identify key areas for habitat protection. There are nine species of bat in Michigan (Kurta, 2008). These consist of the big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), Indiana bat (*Myotis sodalis*), little brown bat (*Myotis lucifugus*), northern long-eared bat (*Myotis septentrionalis*), evening bat (*Nycticeius humeralis*), and tri-colored bat (*Perimyotis subflavus*).

Populations of bats in the wild are not well understood. Unlike many other vertebrates, they are difficult to observe and identify, especially by members of the general public. As nocturnal animals who are not readily seen or heard, it is nearly impossible to accrue data on bats via casual observation. Insect-eating bats emit sounds that are mostly above the range of human hearing, and are also not easily captured or safely handled. Recently, technology has helped reduce this barrier by allowing us to "hear" bats. Acoustic recorders that can detect high-frequency sounds are becoming increasingly cheap and accessible, creating the potential for widespread data collection on bats.

These enhanced data collection capabilities may be just in time—bats are facing devastating novel threats. The most prominent and imminent of these is the invasive fungus *Pseudogymnoascus destructans*, which is the causative agent of white-nose syndrome (WNS). Because of this disease, several species in Michigan have declined in recent years. While some species were already endangered (the Indiana bat; USFWS, 2007), others that were previously common were now rare—particularly the northern long-eared bat and little brown bat. Other species, like the evening bat and hoary bat, are historically uncommon in Michigan and elsewhere for other reasons. Understanding aspects of natural history for rare species, as well as declining ones, will benefit from continuous and widespread monitoring efforts (USFWS, 2011).

The Michigan Bat Monitoring Program (MBMP) was created to monitor the statewide distribution and relative abundance of bats in their summer range using bio-acoustics. By engaging multiple partner organizations, we hope to create a stable framework for continuous, annual monitoring. Participants in the program collect data on bats by recording their echolocation calls. These calls help bats maneuver through their environment and detect prey. While these calls are often species-specific, they are primarily functional in a context which is not species-specific (O'Farrell et al., 1999). This means that, unlike birds or frogs which often sending messages to members of the same species, calls of bats are more generalized among species. This can make definitive species identification difficult. In some cases, follow-up catch-and-release surveys of bats may be informative. Regardless, widespread acoustic data collection plays an important first step in identifying spatial and temporal species distributions, and citizen scientists now have a powerful ability to inform science, policy, and conservation efforts by collecting data on a scale that was not possible before.

### *Objectives*

- Foster awareness and appreciation of Michigan's bats by increasing the visibility of these difficult-to-observe animals to the public.
- Increase our knowledge of Michigan's bats by documenting activity levels, relative abundance of species within communities, and locations of species within the state.

### Principle investigators

Giorgia Auteri, is the citizen-science coordinator for OBC and a PhD student in the Department of Ecology and Evolutionary Biology at University of Michigan. She is a bat biologist and educator. She has over seven years of experience working with bats, including various acoustic and live-capture methods. Giorgia conducted research for her master's thesis regarding bat behavior and ecology at Eastern Michigan University, and is currently a doctoral student at the University of Michigan, where she is pursuing research on evolutionary ecology of bats. Giorgia is active in the North American Society for Bat Research, American Institute of Biological Sciences, American Society of Mammalogists, Citizen Science Association, National Speleological Society, and Michigan Academy of Sciences. Her

experience working with bats spans the private and public sectors, including work for state, tribal, academic, non-profit, and environmental consulting organizations.

Rob Mies, Executive Director and co-founder of OBC, is a bat ecologist, author, and conservation spokesperson. Over the past 25 years, Rob has appeared on many television shows promoting awareness of bat conservation. These shows include The Doctors, The Tonight Show, The Ellen DeGeneres Show, The Today Show, Live with Regis and Kelly, Late Night with Conan O'Brien, Fox & Friends, CBS Early Show, and Martha Stewart. Rob is the Chairman of the Michigan Bat Working Group, President of the Midwest Bat Working Group, and Coordinator of the North American Bat Conservation Alliance. He is an advisor and member of the American Zoological Association Bat Taxon Advisory Group, North American Society of Bat Researchers, Association of Nature Center Administrators, Michigan Wind and Wildlife Advisory Group, and the white-nose syndrome Communications Working Group.

## Methods

### Volunteer coordination

To facilitate selection of safe, effective routes for driving acoustic surveys, OBC relied on coordinators at Regional Partner Organizations (RPOs). Preference was given to RPOs which participated in 2016 and were interested in participating again. Additional partner organizations were contacted based on availability of equipment. Monitoring packages were mailed to partners in May. These regional leaders were able to identify transects which could safely be driven at reduced speeds, and were also adeptly suited to coordinate community volunteer efforts. When possible, routes that were previously surveyed in 2016 were re-surveyed.

After partners were identified, OBC provided RPO colleagues with training on equipment use and survey protocols, and provided guidance on route development. Instructional materials included documents providing an equipment overview, safety suggestions for volunteers, a list of survey steps, and datasheets to be filled out with each survey. OBC also developed and shared an online video tutorial (http://go.savebats.org/2abRJG8). More details on these materials can be found in the

MBMP report from 2016 (Auteri and Mies, 2016), located at https://batconservation.org/learn/michigan-bat-monitoring-program/.

This year, OBC implemented two additional instructional methods to facilitate coordination with RPOs. We conducted two webinar training events, which we asked first-time RPOs to attend, and also created a Facebook group for all participants of the MBMP. Both were sources for volunteers and cooperating staff to engage more fully and to learn not just about survey protocols, but also about Michigan's bats in general.

After completing surveys, RPOs were provided with shipping labels to return monitoring equipment and datasheets to OBC.

## Route selection and protocol

To build upon the previous year's efforts, we emphasized repetition of previous routes. New routes were created in instances where new partners were identified. Ultimately, survey locations were determined by MBMP RPOs, with some guidance from OBC's citizen-science coordinator. Routes in a variety of land cover/use categories were developed, in an effort to sample a variety of habitat types, levels of urbanization, and regions of the state. We did not specifically target areas of presumably high quality habitat, with the goal of increasing our understanding of bats' use of all land cover types in Michigan.

Leaders at RPOs were asked to develop a route 20–30 miles in length and which could be driven safely at a maximum speed of 20 miles per hour. PROs were asked to attempt a survey route in each of June and July, to document bats during the summer period of residency, when females are raising offspring. RPOs were also invited to conduct surveys throughout August and early September, in a bid to document activity of bats during periods of swarming and migration. Volunteers were asked to start their surveys roughly 30 minutes after sunset, as well as to avoid surveying if rain, strong winds, fog, or temperatures below 50° F. These weather parameters, in addition to an estimate of percent cloud cover, were recorded at the start and end of each survey.

## Acoustic monitoring

The OBC was provided with all materials needed to conduct acoustic surveys by the MDNR. In turn, we identified and distributed equipment to RPOs, and provided guidance on how to conduct surveys. Each monitoring package consisted of a detector to be attached to the roof of a vehicle, and which was connected to a recording/display device inside the vehicle via a cord running through the passenger window. Provided equipment consisted of:

- Echo Meter Touch (EMT; Wildlife Acoustics, Inc., Maynard, MA)
- IPad Mini 2 (Apple Inc., Cupertino, CA) with Echo Meter Touch Bat Detector App (Wildlife Acoustics, Inc., Maynard, MA)
- Protective case for IPad (Griffin Technology, Nashville, TN)
- Six-foot extension cable (to connect EMT recorder to IPad; CableJive, Malden, MA)
- Garmin Glo external GPS unit (Garmin International, Inc., Olathe, KS)
- Gaffer's tape for attaching EMT unit to roof of car, while also preventing damage to vehicles
- Styrofoam to place between EMT unit and roof of car (assists with reduction of noise from vibration)

EMT units are often used by hobbyist bat enthusiasts because the detectors are cost-effective, compact, and provide an attractive visual display of calls. However, there is no means to standardize the units via calibration. In lieu of being able to formally tune recorders, OBC staff performed simultaneous testing of units prior to sending out equipment, similar to the previous year. All units were set up in a stationary fashion, with microphones attached adjacently along a horizontal clothesline. Units recorded simultaneously for ~ 2 hours after sunset.

Volunteers conducted mobile surveys, with the exception of one point count survey. The microphone of the detector was placed on a piece of Styrofoam before being mounted on the vehicle roof, which helped to both reduce noise from vibrations of the vehicle, and minimize the recording of reflected echolocation pulses from the roof of the vehicle. Gaffer's tape was used to attach the microphone, Styrofoam, and the extension cable to the vehicle roof. An extension cable ran through the open passenger window of the vehicle, to the IPad Mini 2

inside the vehicle, which stored the tablet. The IPad allowed non-driving volunteers to view echolocation calls of bats and monitor equipment. One survey was conducted in a similar fashion, via bicycle. The Garmin Glo GPS unit was paired with the rest of the equipment, and allowed each recorded call to be tagged with its corresponding coordinates.

## Acoustic analyses

While conducting bio-acoustic surveys, sounds may also be recorded which are not issued from non-target taxa or which are not from animals at all, for example ultrasonic sounds of rustling leaves or wind. To counter this, downloaded files from each unit were first subjected to a simple, automated noise filter. This filter separates files containing structured calls of bats from those that contain miscellaneous ultrasonic sounds.

To help mitigate misidentification of calls, we used a conservative approach for attributing species to calls (as in the previous year). We required agreement of multiple identification methods before a final species designation was given. Three separate methods were used, and a final identification was assigned only if at least two agreed. Two of these were quantitative and relied exclusively on software programs developed for automated identification of calls of bats. The third method was qualitative species assignment to calls by the primary author, who has six years of experience working with calls of bats. She visually inspecting each call using AnalookW (Titley Electronics, New Ballina Australia). The two quantitative programs used are currently approved by the USFWS: Kaleidoscope (Wildlife Acoustics, Inc., Version 4.0.0) and Echoclass (Eric Britzke, ERDC, Version 3.1). All three methods use parameters such as pulse duration, minimum frequency, interpulse interval, and shape of the frequency-versus-time curve to characterize calls (Tibbels and Kurta, 2003; O'Farrell et al., 1999).

We attempted to assign a species-specific identification for almost all species. However, calls of the silver-haired bat and big brown bat are extremely similar (Betts, 1998), and no effort was made to separate these species acoustically. Similarly, files often contain sounds made by bats that are not suitable for identification. As opposed to search-phase calls, these files consist of only feeding buzzes, social calls, and calls that are fragmented or otherwise not clearly recorded. These poor quality recordings can be due to distance of the bat from the detector, the animal's orientation to the unit, or increased Doppler Effect, which

is associated with recordings obtained from driving surveys. These files, nevertheless, are useful in quantifying overall levels of bat activity, so we cataloged such calls as "unidentified."

Number of acoustic recordings can be used as an index for level of activity (e.g., Tibbels and Kurta, 2003). However, acoustic recordings cannot be used to reliably estimate population size in a specific area—there is no way to determine whether a single individual, or five different bats made the calls that were recorded. Thus, when we talk about "number of calls recorded" or proportions of species calls, it's useful to keep in mind the discrepancies that can occur from resampling the same individual multiple times.

# Results

## Volunteer coordination

OBC sent training materials and equipment to RPOs in May. These eleven RPOs included Ann Arbor Natural Area Preservation, the AuSable Valley chapter of the Audubon Society, the Children's Zoo at Celebration Square in Saginaw, Crosswinds Marsh, Grand Traverse Regional Land Conservancy, Huron County Nature Center, John Ball Zoo, Little Traverse Conservancy, Saginaw Valley State University, the Troy Nature Society's Stage Nature Center, and the Waterloo Natural History Association. OBC staff members also volunteered their time to conduct a survey. Equipment containing recordings of calls, data sheets, and information on routes were all returned to OBC by mid-October. While most recording units were returned with data on them, one unit did not have data due to an apparent equipment malfunction. All RPOs from 2016 opted to participate again, with the exception of the Dahlem Conservancy, which is no longer operational.

## Survey routes

Nineteen survey routes were sampled (Routes 1, 7, 8, and 11–25), in addition to one point count survey (which was designated Route 10). These were located throughout the southern and central Lower Michigan, with the exception of one route in the Eastern Upper Peninsula (Map 1). Routes 1, 7, and 8 were repeated from the previous year, and all other routes were newly created. Routes 13 and 15 had been attempted the previous year, but did

not collect data due to user error, which was resolved in 2017. Several RPOs conducted multiple survey routes with a single detector (Table 1). "Route 10" was a walking/point-count survey, which we chose to include it in this report. Maps 02–17 depict survey routes.

These routes were sampled during 31 total survey events, although only seven routes were resampled multiple times, and only two routes were sampled in both June and July. However, multiple routes established by the same RPO were often near each other—often overlapping. We attribute this, in part, to first-time RPOs modifying newly established routes.

Timing, frequency, and duration of each survey route are summarized in Table 1. Total hours surveyed were 53 hours and 25 minutes, and ranged from 1.0 to 3.25 hours with a mean survey length of 2.1 hours (± 0.5 hours). Surveys occurred between May 24th and August 30th of 2017, with routes driven one to four times. One survey occurred in May, seven surveys in June, fourteen in July, and nine in August. Temperatures remained above 50 F except at the end of one survey (in May). No rain, fog, or wind greater than a gentle breeze was reported during any of the surveys, although some surveys concluded with rain. Cloud cover ranged from 0–100%.

Six routes which were surveyed in the previous year were not resamples in 2017—Routes 02, 03, 05, 06, 08, and 09. The reasons for this were various. One unit was returned without data due to equipment malfunction. This RPO had previously conducted two routes with a single unit, thus Routes 05 and 06 were not resampled. Route 02 was not resampled because the RPO which initially developed it closed. However, a two new routes (24 and 25) is extremely close to it. Similarly, routes 04 and 09, which were near each other and managed by OBC, were located near OBC's previous headquarters, which recently moved. A new route (14) is nearby and will likely replace these in future years as the driving route in the area.

## Acoustic recordings

1,248 files included calls apparently made by bats. Our three identification methods—Kaleidoscope, Echoclass, and manual vetting—yielded differing results (Table 2). A final call identification was assigned only if at least two methods agreed (post- grouping of calls across big brown and silver-haired bats). There was no agreement between any two of the methods for an additional 205 files. There was consensus that 246 calls (20%) were

issued by bats but were not identifiable to species ("unidentified"), and we excluded these from future analyses. After removing these calls, we were left with 1,002 calls attributable to a specific species or species group of bats. Of these, Kaleidoscope and EchocClass agreed 54% of the time, Kaleidoscope and manual vetting agreed 81% of the time, and EchoClass and manual vetting agreed 49% of the time. For agreement with the final call identification, contributions of each method were 93% with Kaleidoscope, 88% with manual vetting, and 61% with Echoclass. While 1,248 calls were identified as bat calls in the Final Identification, each of the three methods attempted to classify more calls than this, with the discrepancies attributable to calls for which no method agreed or noise files misidentified as calls. Kaleidoscope labelled 1,618 files, EchoClass 1,414, and 1,305 files were identified by the human observer. Table 2 shows calls attributed to each species via the different identification methods.

Of the 1,002 passes identified to species or species group, 764 (76.2%) were assigned to big brown/silver-haired bats, which were ubiquitous and recorded at all surveys (Table 3, Figure 1). They were followed by eastern red bats (85 calls, 8.5%) and hoary bats (122 calls, 12.2%). Twenty five (2.5%) calls of little brown bats were recorded. One call was attributed to an Indiana bat, and one to an evening bat (both <0.01%). Four calls of tri-colored bats (0.4%) were recorded. Images of calls of interest are included in Figures 2–4.

Table 3 summarizes species identified per survey, including information on route and date. Most little brown bats (23 of 25) occurred at a point-count survey (Route 10). The species was also detected along Routes 07 and 12. The supposed call of the Indiana bat was recorded near Oscoda along Route 19 (44.4943, -83.35326), at 22:15 on June 21st. The four calls attributed to tri-colored bats were all recorded at Route 12—one on July 11th (at 22:14) and three on August 8th (22:32, 23:18, and 23:18). All four were in Ann Arbor (42.2719, -83.7180). The single call of an evening bat was recorded at Route 01, where the species was also recorded in 2016.

Route 12 in Ann Arbor had the highest species richness (Figure 1), with six species detected at the site, and also had the highest absolute number of recordings in a single survey (on 08 August 2017). Routes 01, 07, and 19 also had relatively high richness compared to other sites, with four species detected at each.

# Discussion

## Michigan's citizen-scientists

In 2017, the MBMP greatly expanded sampling effort, increasing the number of partner organization and citizen-scientists involved. This additional participation translates not only to added biological data, but also to heightened engagement and awareness regarding Michigan's bats. We are excited to continue building relationships with RPOs and individual citizen scientists, many who participated in the inaugural year and are already looking forward to 2018. At least three RPOs have actively used the monitoring equipment for outreach beyond the MBMP—conducting bat walks in their area. We credit the successful completion of the 2017 survey season to the eager participation of Michigan's public, and hope that such efforts continue to reach more people.

In 2018, we will focus on connecting individuals interested in participating with RPOs. We have created a webpage for MBMP (https://batconservation.org/learn/michigan-bat-monitoring-program/), to which we will soon be adding locations and contact information of point-people at RPOs. We believe this will help connect RPOs with additional volunteers, which will facilitate repetition of routes within the survey season. We have also added a form submission to the website so that individuals can directly contact OBC's citizen science coordinator if they are interested in participating. We will also work to focus RPO efforts on repetition of routes during multiple months.

## Michigan's bats

MBMP generated a large number of georeferenced calls in 2018, including some calls with intriguing species identifications. While the most notable among these is the purported call of an Indiana bat, which both the state and federal government list as an endangered species (MDNR, 2013a; USFWS, 2007), there is often uncertainty when identifying calls of this species. Calls of little brown and Indiana bats are notoriously similar. Furthermore, the supposed call appears to actually be that of two bats calling simultaneously—a situation which automated call identification softwares are not equipped to handle. It is extremely unlikely that the call is actually that of an Indiana bat, given the geographic location of the call (Map 13).

In 2017, the MBMP also identified an area used by little brown bats in the northern Lower Peninsula (Route 10, Map 5). These calls were collected during a point-count survey, conducted by an RPO as part of a "bat walk" for the public. This highlights the use of monitoring efforts beyond the designated survey protocol for exploratory purposes, and we will be encouraging development of a driving survey for the area in 2018.

The ubiquity of big brown bats was not surprising, however we recorded many more hoary bats compared to the previous year, or to what is considered typical for the region. Eastern red bats were, surprisingly, the third instead of second most commonly recorded species. The reasons for this are unclear, as no single site appeared particularly anomalous (i.e., almost all sites seemed to have more hoary bats than would be expected).

We documented one call of an evening bat along Route 01, in Berrien County where it is known to occur. The species is considered threatened in the state (MDNR, 2013a) One evening bat was previously documented in the county in 1969 (Kurta, 1982) and in 2016 three calls of this species were identified via the MBMP, also along Route 01 (Auteri and Mies, 2016). Other occurrences in the state include an individual that was captured via mist-net in the adjacent Cass County—directly east of Berrien County (unpublished report submitted to USFWS by Environmental Solutions and Innovations, Inc.). In recent years, there have been a handful of observations which indicate this species may be becoming more common, or expanding, at the northern edge of its range (e.g. Auteri and Kurta, 2015; Minnesota DNR, 2016; Wisconsin DNR, 2016; Auteri et al., 2016). Increased monitoring along the evening bat's range in Michigan could help biologists and natural resource managers better understand whether this species is shifting its range due to climate change, and identify potential impacts of this new addition on local communities of bats.

The tri-colored bat is an uncommon species in the state, which is considered of "special concern" by the MDNR (2013b), although it may be expanding within the state (Kurta et al., 2007). We recorded four calls of this species during the 2017 survey period. Unlike the Indiana bat, this species often has a distinctive call. This, in combination with the multiple calls which were identified in the same location, is suggestive but not definitive of the species' presence in the Ann Arbor area. Summer records of the species in Michigan during are rare (Brown and Kurta, 2013), and small hibernating populations are known

(Kurta et al., 2007; Slider and Kurta, 2011). Continued survey efforts could help characterize the range of this species in in the Lower Peninsula. Because this species is slow flying and "quiet," encouraging participants to conduct informal walking or point-count surveys, in addition to driving surveys, could help facilitate obtainment of recordings from this species.

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Regional Partner organizations:

Ann Arbor Natural Area Preservation, the AuSable Valley chapter of the Audubon Society, the Children's Zoo at Celebration Square in Saginaw, Crosswinds Marsh, Grand Traverse Regional Land Conservancy, Huron County Nature Center, John Ball Zoo, Little Traverse Conservancy, Saginaw Valley State University, the Troy Nature Society's Stage Nature Center, and the Waterloo Natural History Association

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# Tables

Summary information for routes and recordings.

*Table 1. Information specific to each run of a route, including route number, survey date(s), duration of survey, start time of each survey, and partner organization.*

| Route | Date (yyyy-mm-dd) | Start (hh:mm) | Duration (hh:mm) | Organization |
|---|---|---|---|---|
| 1 | 2017-07-04 | 21:30 | 2:15 | OBC |
| 7 | 2017-06-29 | 22:38 | 1:48 | Grand Traverse Conservancy |
| | 2017-07-19 | 22:05 | 1:55 | |
| | 2017-08-01 | 22:00 | 2:15 | |
| 8 | 2017-07-25 | 21:50 | 1:55 | Little Traverse Conservancy |
| 10 | 2017-07-01 | — | — | Little Traverse Conservancy |
| 11 | 2017-07-31 | 20:35 | 1:35 | John Ball Zoo |
| | 2017-08-31 | 21:32 | 1:47 | |
| 12 | 2017-07-11 | 21:42 | 2:28 | AA Natural Area Preservation |
| | 2017-08-08 | 21:46 | 1:54 | |
| 13 | 2017-07-08 | 22:20 | 1:30 | Crosswinds Marsh |
| | 2017-08-18 | 21:15 | 1:26 | |
| 14 | 2017-07-12 | 22:00 | 2:30 | Stage Nature Center |
| | 2017-07-27 | 22:08 | 2:27 | |
| 15 | 2017-06-01 | 21:05 | 1:30 | Huron County Nature Center |
| | 2017-07-19 | — | — | |
| 16 | 2017-08-30 | 20:55 | 2:01 | Children's Zoo at Celebration Square |
| 17 | 2017-06-06 | 21:45 | 3:15 | AuSable Audubon |
| | 2017-06-16 | — | — | |
| 18 | 2017-07-18 | — | — | AuSable Audubon |
| 19 | 2017-06-21 | 22:00 | 2:29 | AuSable Audubon |
| | 2017-08-08 | — | — | |
| | 2017-08-09 | 21:40 | 3:15 | |
| | 2017-08-23 | 21:30 | 2:30 | |
| 20 | 2017-05-24 | 21:30 | 1:00 | AuSable Audubon |
| 21 | 2017-07-13 | 21:13 | 1:42 | John Ball Zoo |
| 22 | 2017-07-26 | 21:52 | 1:43 | John Ball Zoo |
| | 2017-08-24 | 21:35 | 2:10 | |
| 23 | 2017-06-29 | 23:45 | 1:22 | John Ball Zoo |
| 24 | 2017-06-27 | 21:53 | 2:33 | Waterloo Natural History Association |
| 25 | 2017-07-27 | 22:17 | 2:10 | Waterloo Natural History Association |

*Table 2. Total calls attributed to each species via each of the three identification methods—Kaleidoscope, Echoclass, and manual vetting—followed by final designations based on agreement between paired identification methods. Species codes are as follows: big brown/silver-haired (EPLA), eastern red bat (LABO), hoary bat (LACI), gray bat (MYGR), eastern small-footed bat (MYLE), little brown bat (MYLU), northern long-eared bat (MYSE), Indiana bat (MYSO), evening bat (NYHU), tri-colored bat (PESU), and unidentified (UNID). Dashes indicate identifications that were excluded as options for some methods. Discrepancies in totals among methods are indicate differences in number of calls attributed as "noise." For 173 files, no two methods agreed on a final identification.*

| ***Species*** | ***Kaleidoscope*** | ***Echoclass*** | ***Human*** | ***Final*** |
|---|---|---|---|---|
| **EPLA** | 819 | 456 | 868 | **764** |
| **LABO** | 90 | 196 | 107 | **85** |
| **LACI** | 244 | 172 | 49 | **122** |
| **MYGR** | — | 5 | — | **—** |
| **MYLE** | 0 | 2 | 0 | **0** |
| **MYLU** | 46 | 0 | 25 | **25** |
| **MYSE** | 0 | 0 | 0 | **0** |
| **MYSO** | 3 | 1 | 0 | **1** |
| **NYHU** | 41 | 2 | 3 | **1** |
| **PESU** | 17 | 2 | 2 | **4** |
| **UNID** | 358 | 578 | 251 | **246** |
| **Total** | 1618 | 1414 | 1305 | **1248** |

*Table 3.* Bat calls per survey, which is identified by route number and date. Identifications correspond to final identifications based on agreement of at least two ID methods. Unidentified calls are not shown. Species codes are big brown bat/silver-haired bat (EPLA), eastern red bat (LABO), hoary bat (LACI), evening bat (NYHU), tri-colored bat (PESU), little brown bat (MYLU), and Indiana bat (MYSO).

| | | Final species ID | | | | |
|---|---|---|---|---|---|---|
| **Route** | **Date (yyyy-mm-dd)** | **EPLA** | **LABO** | **LACI** | **Other** | **Total** |
| 1 | 2017-07-04 | 15 | 3 | 12 | 1 NYHU | **31** |
| 7 | 2017-06-29 | 20 | 2 | 1 | | **23** |
| | 2017-07-19 | 25 | 4 | 3 | 1 MYLU | **33** |
| | 2017-08-01 | 13 | 14 | 4 | | **31** |
| 8 | 2017-07-25 | 21 | 1 | 3 | | **25** |
| 10 | 2017-07-01 | 1 | | | 23 MYLU | **24** |
| 11 | 2017-07-31 | 31 | 7 | 1 | | **39** |
| | 2017-08-31 | 9 | | 1 | | **10** |
| 12 | 2017-07-11 | 65 | 8 | 2 | 1 PESU | **76** |
| | 2017-08-08 | 95 | 1 | | 1 MYLU; 3 PESU | **100** |
| 13 | 2017-07-08 | 26 | 5 | 10 | | **41** |
| | 2017-08-18 | 40 | 3 | 4 | | **47** |
| 14 | 2017-07-12 | 60 | 1 | 15 | | **76** |
| | 2017-07-27 | 69 | | 9 | | **78** |
| 15 | 2017-06-01 | 2 | 3 | 1 | | **6** |
| | 2017-07-19 | 8 | 1 | 1 | | **10** |
| 16 | 2017-08-30 | 12 | | 2 | | **14** |
| 17 | 2017-06-06 | 2 | 3 | 7 | | **12** |
| | 2017-06-16 | 5 | | 2 | | **7** |
| 18 | 2017-07-18 | 59 | 4 | 8 | | **71** |
| 19 | 2017-06-21 | 24 | 4 | 8 | 1 MYSO | **37** |
| | 2017-08-08 | 18 | 1 | 3 | | **22** |
| | 2017-08-09 | 11 | 1 | 1 | | **13** |
| | 2017-08-23 | | 1 | | | **1** |
| 20 | 2017-05-24 | 2 | | | | **2** |
| 21 | 2017-07-13 | 7 | 1 | 5 | | **13** |
| 22 | 2017-07-26 | 54 | 7 | 8 | | **69** |
| | 2017-08-24 | 3 | 1 | 4 | | **8** |
| 23 | 2017-06-29 | 18 | | 1 | | **19** |
| 24 | 2017-06-27 | 22 | 6 | 5 | | **33** |
| 25 | 2017-07-27 | 27 | 3 | 1 | | **31** |
| **Total Result** | | **764** | **85** | **122** | **30** | **1002** |

## Figures

Graphs of survey data and images of species calls.


*Figure 1. Proportions of calls attributed to different species at each survey location, separated by month. Species designations are big brown/silver-haired bat (EPLA), eastern red bat (LABO), hoary bat (LACI), little brown bat (MYLU), Indiana bat (MYSO), tri-colored bat (PESU), and evening bat (NYHU).*

*Figure 2. The single call attributed to the endangered Indiana bat (top), and the call identified as an evening bat (bottom). Both are displayed in zero-crossing, with frequency (kilohertz) is on the y-axis and time in seconds on the x-axis. Time between call pulses is compressed. To assist with call characterization, the Indiana bat call also has a plot of call slope vs time (top left). Date and coordinates are displayed under the x-axis of each call. Kaleidoscope and Echoclass agreed on the identification of the call attributed to the Indiana bat, which the manual observer determined to be an unidentified call of the genus Myotis. This file actually appears to be two overlapping calls, and is thus unreliable as a diagnostic call. The human vetter and Kaleidoscope agreed on the purported call of the evening bat.*

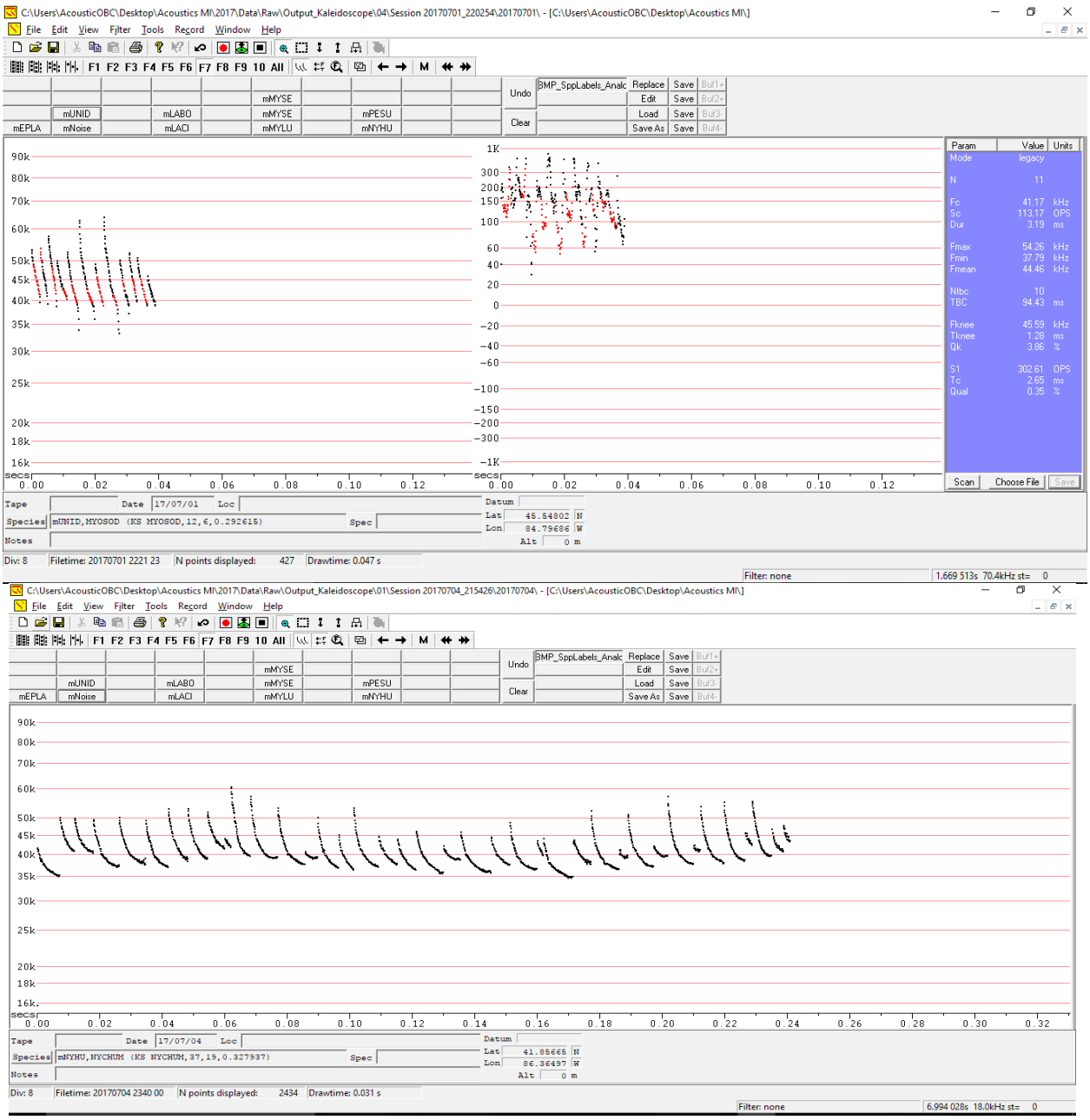


*Figure 3. A characteristic calls of the little brown bat. While 25 calls attributed to this species were recorded, this is given as a representative. Both top and bottom images represent the same file in different views. The top shows a standard frequency vs. time graph, with inter-pulse time compressed (as in both calls in Fig. 2). The bottom image shows the same call, in frequency vs. real, unaltered time.*

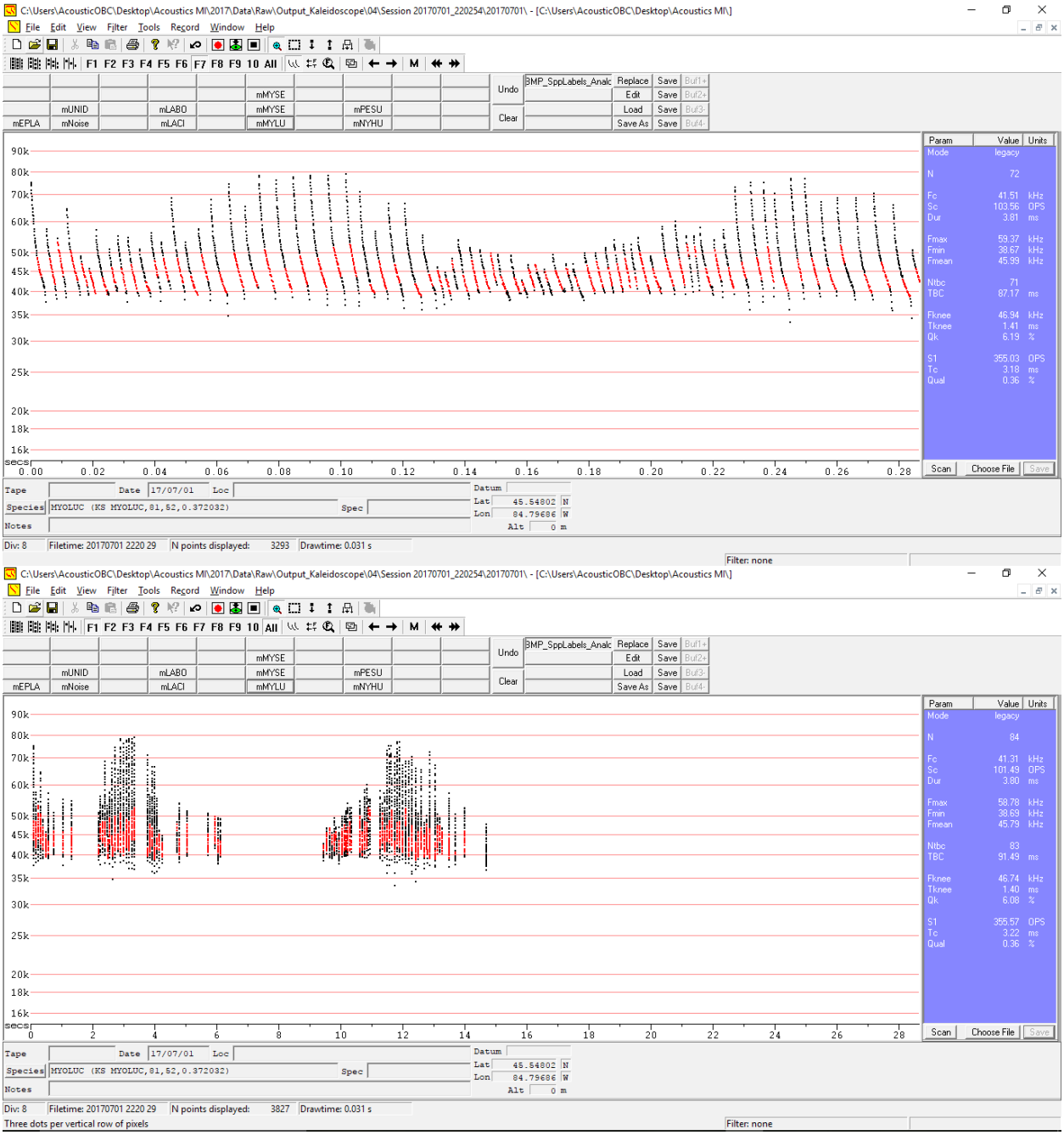
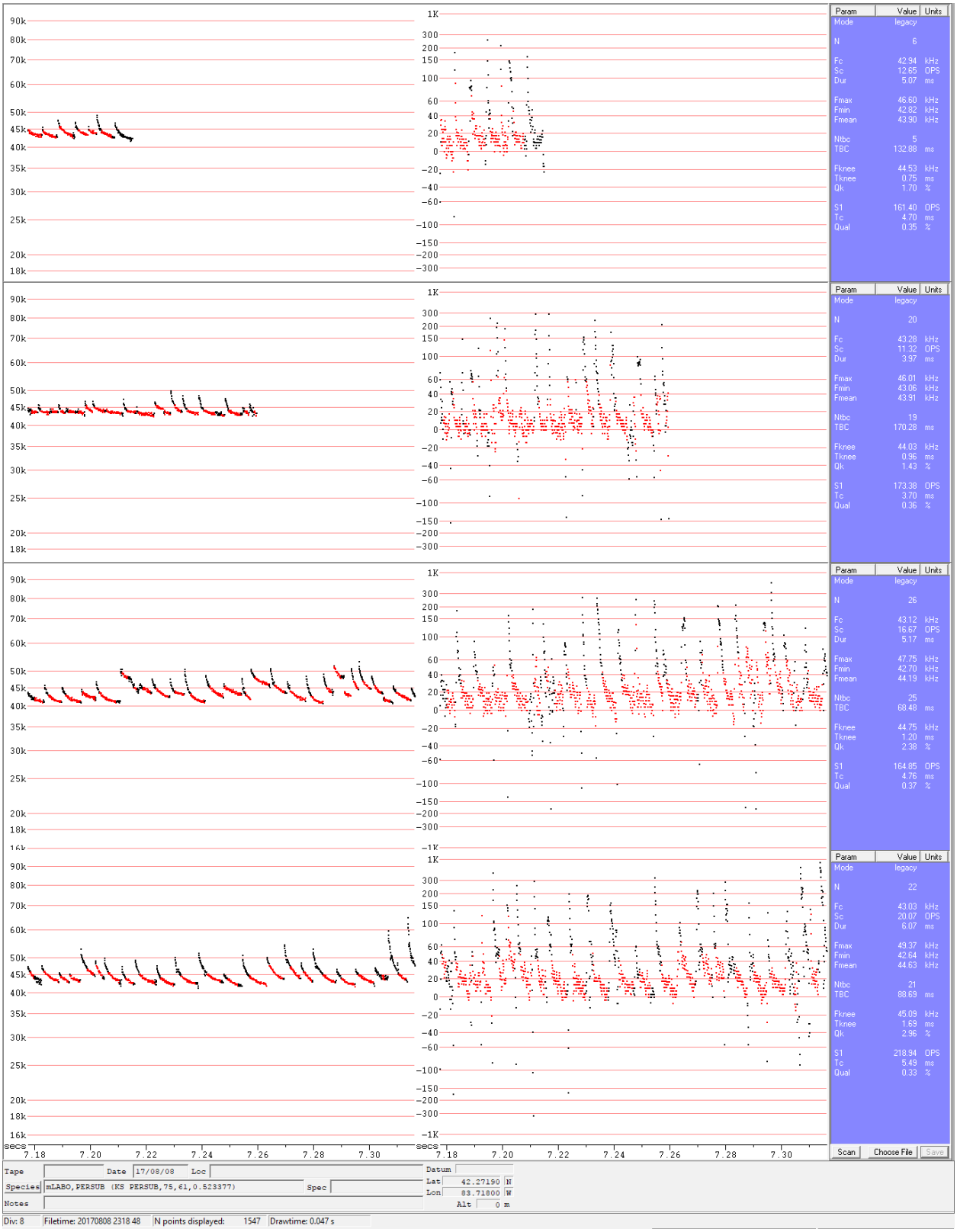
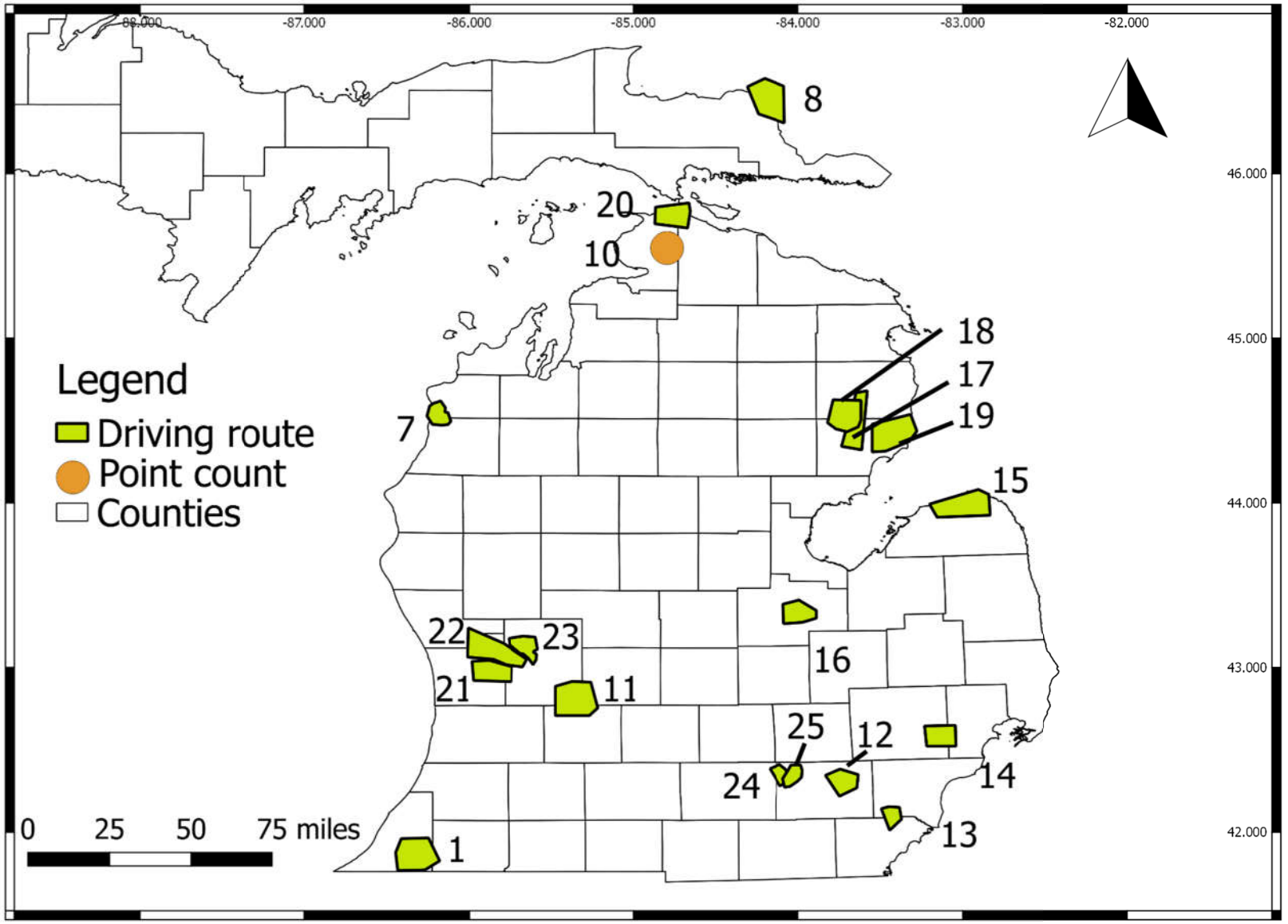


*Figure 4. The four calls identified as belonging to tri-colored bats.*

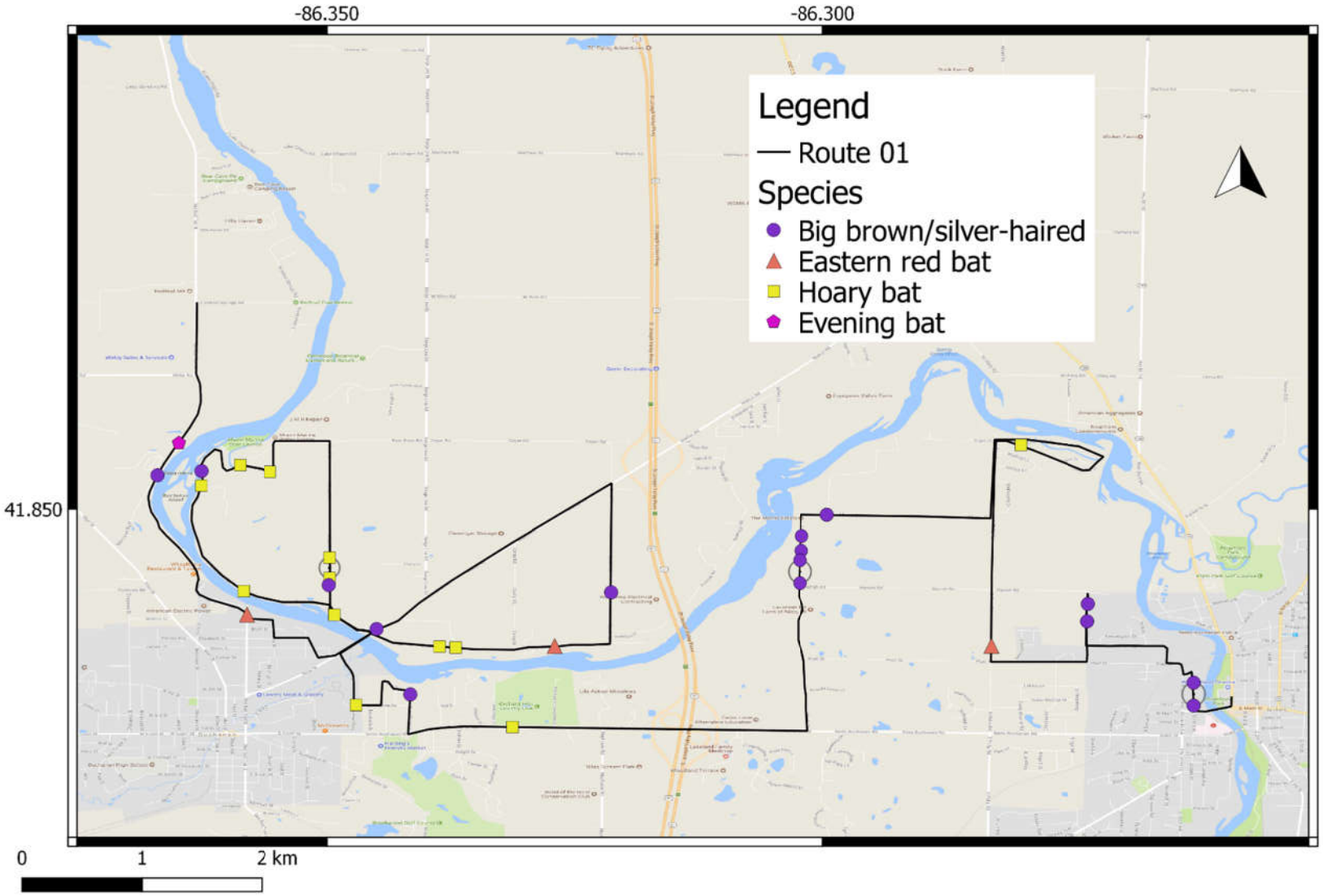


# Maps

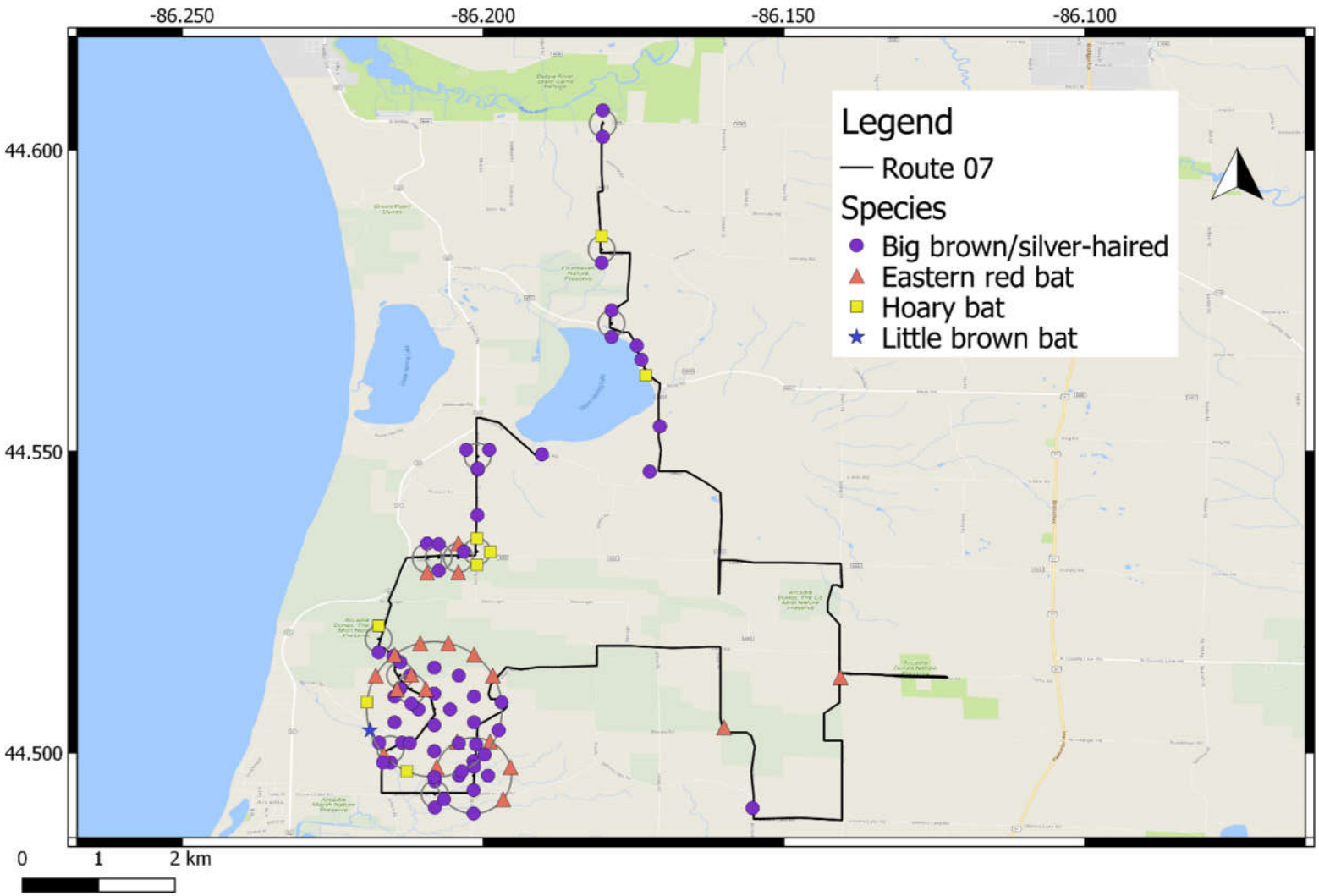
Survey locations, routes, and locations of calls.



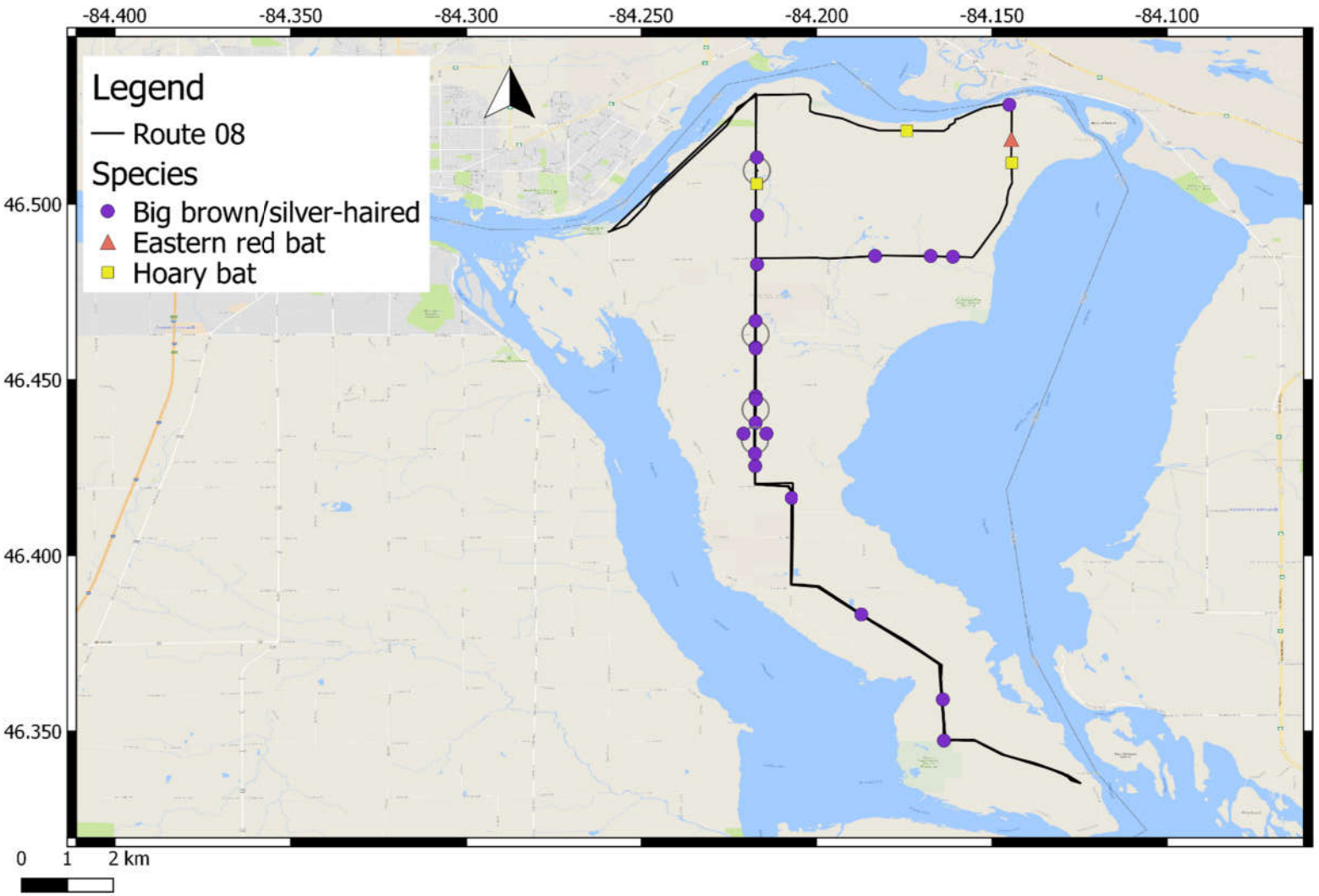

*Map 1.* General locations of acoustic survey locations in Michigan in 2017.



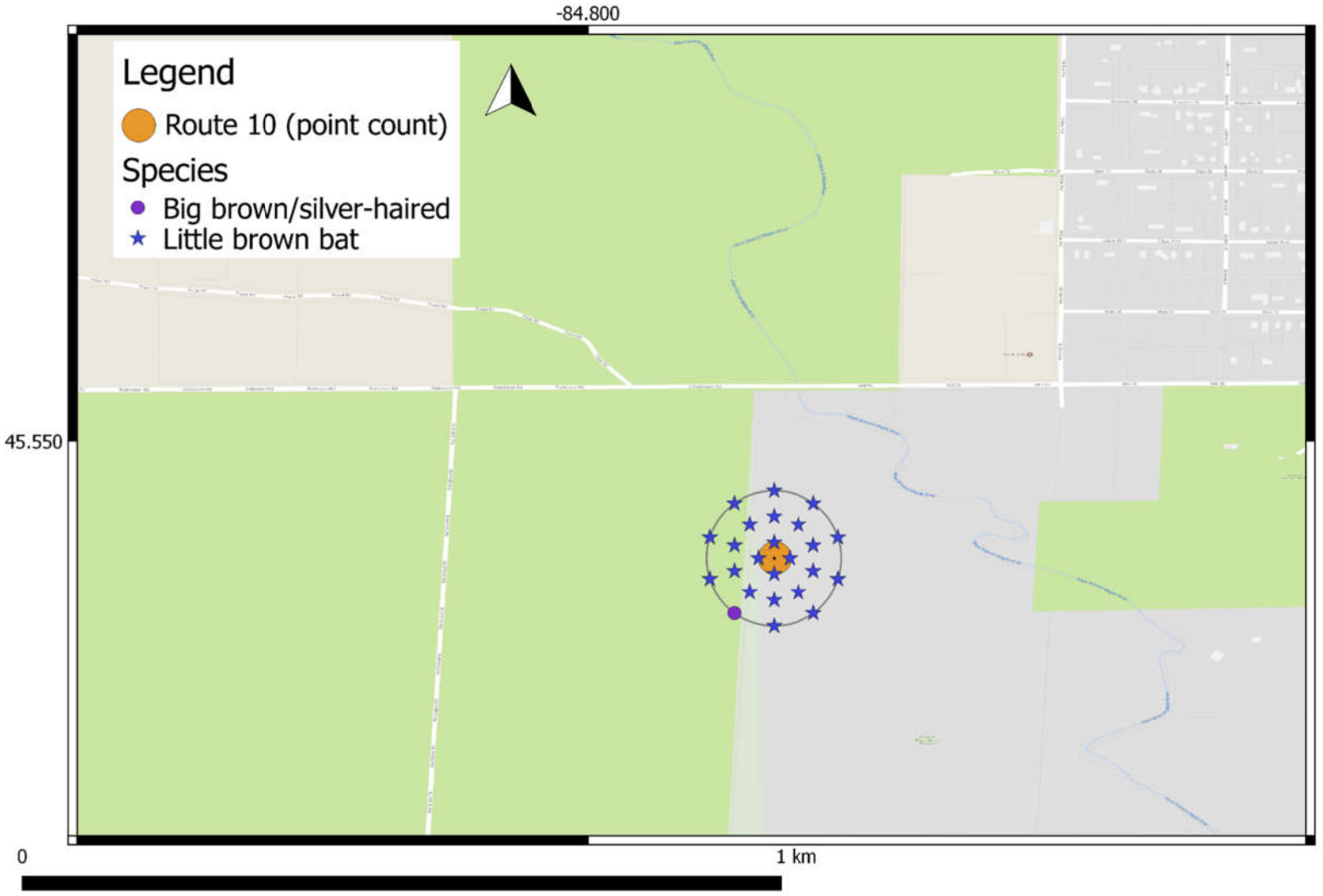

*Map 2. Route 01 path and final species designations.*



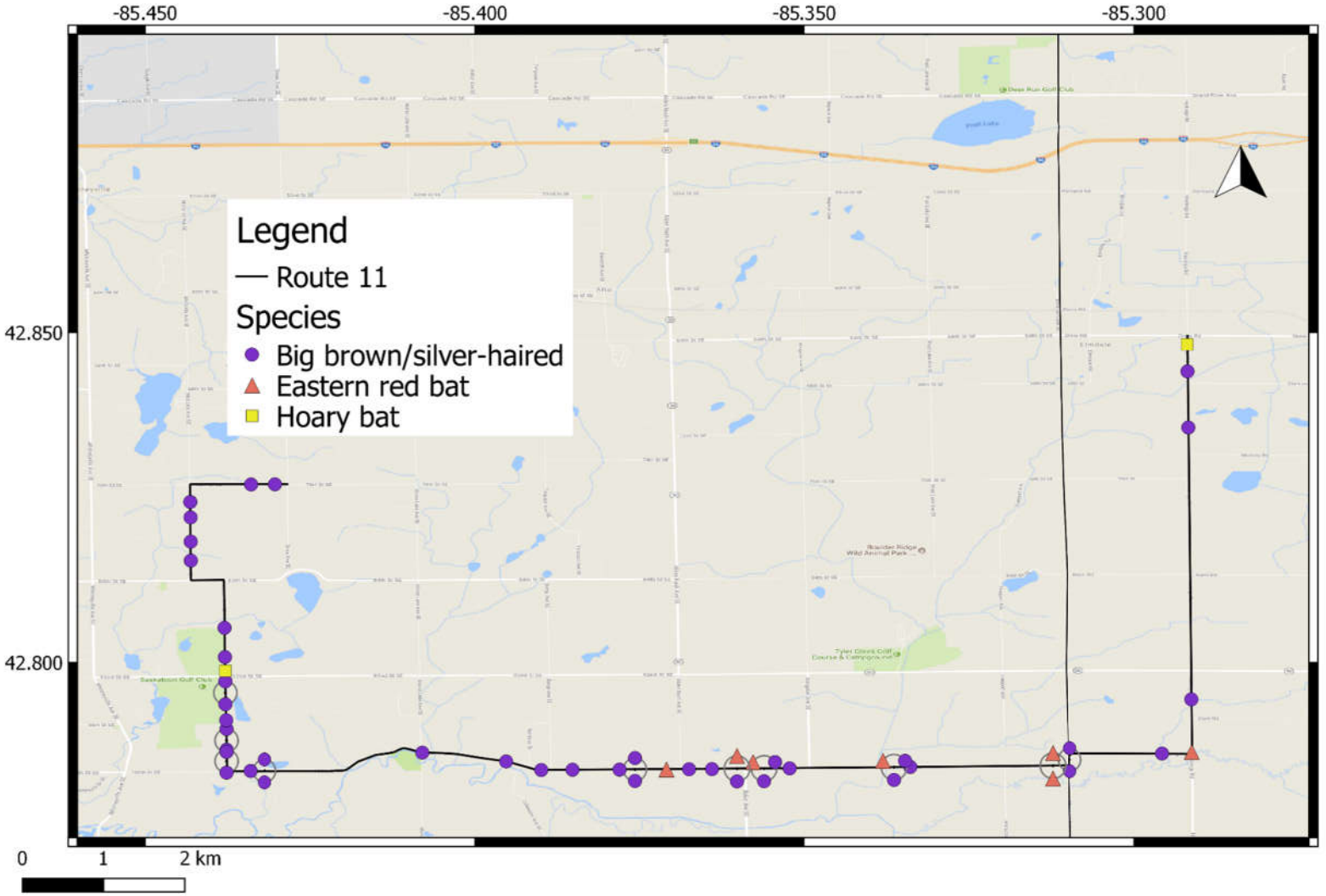

*Map 3. Route 07 path and final species designations.*



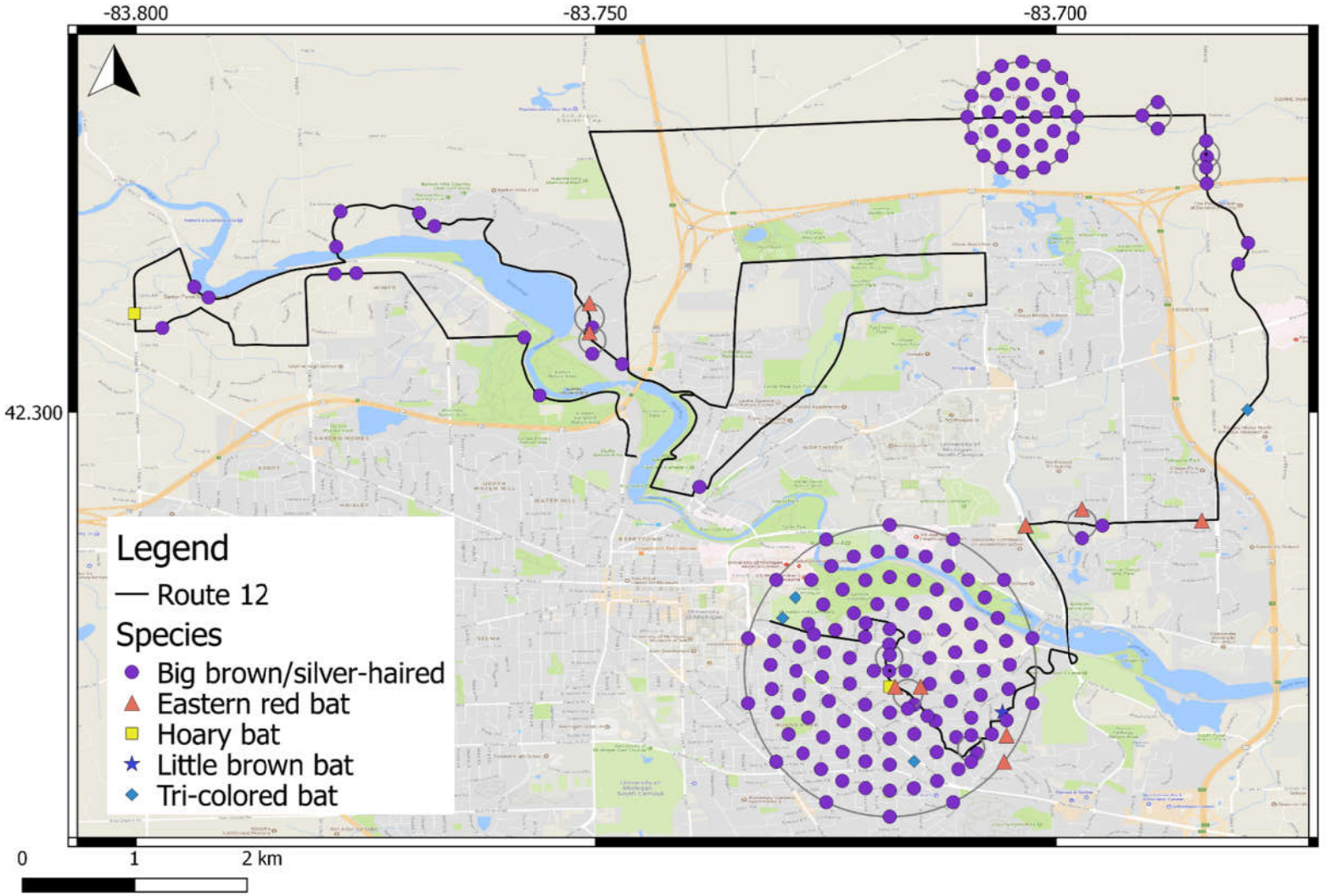

*Map 4. Route 08 path and final species designations.*



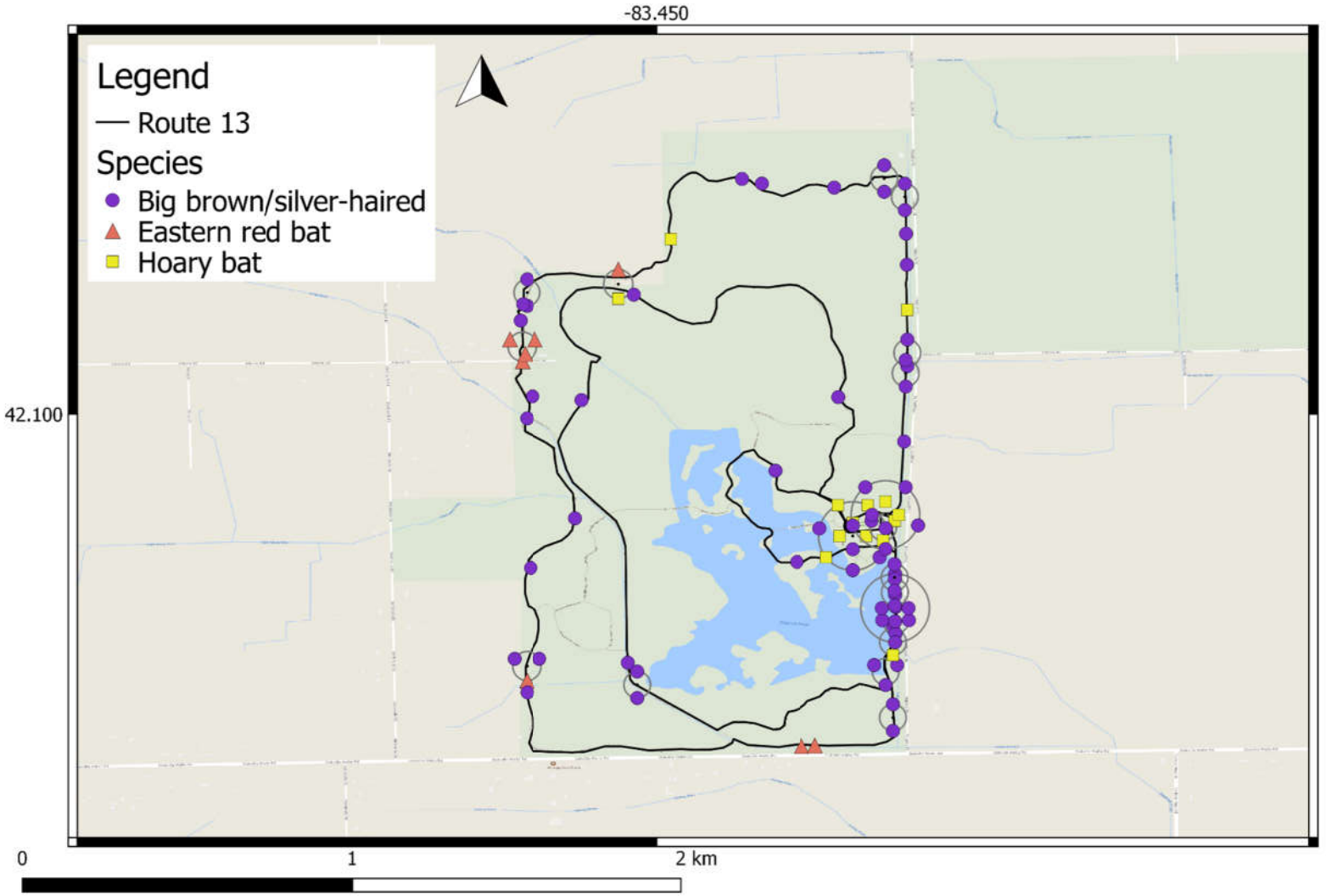

*Map 5. Route 10 point-count location and final species designations.*



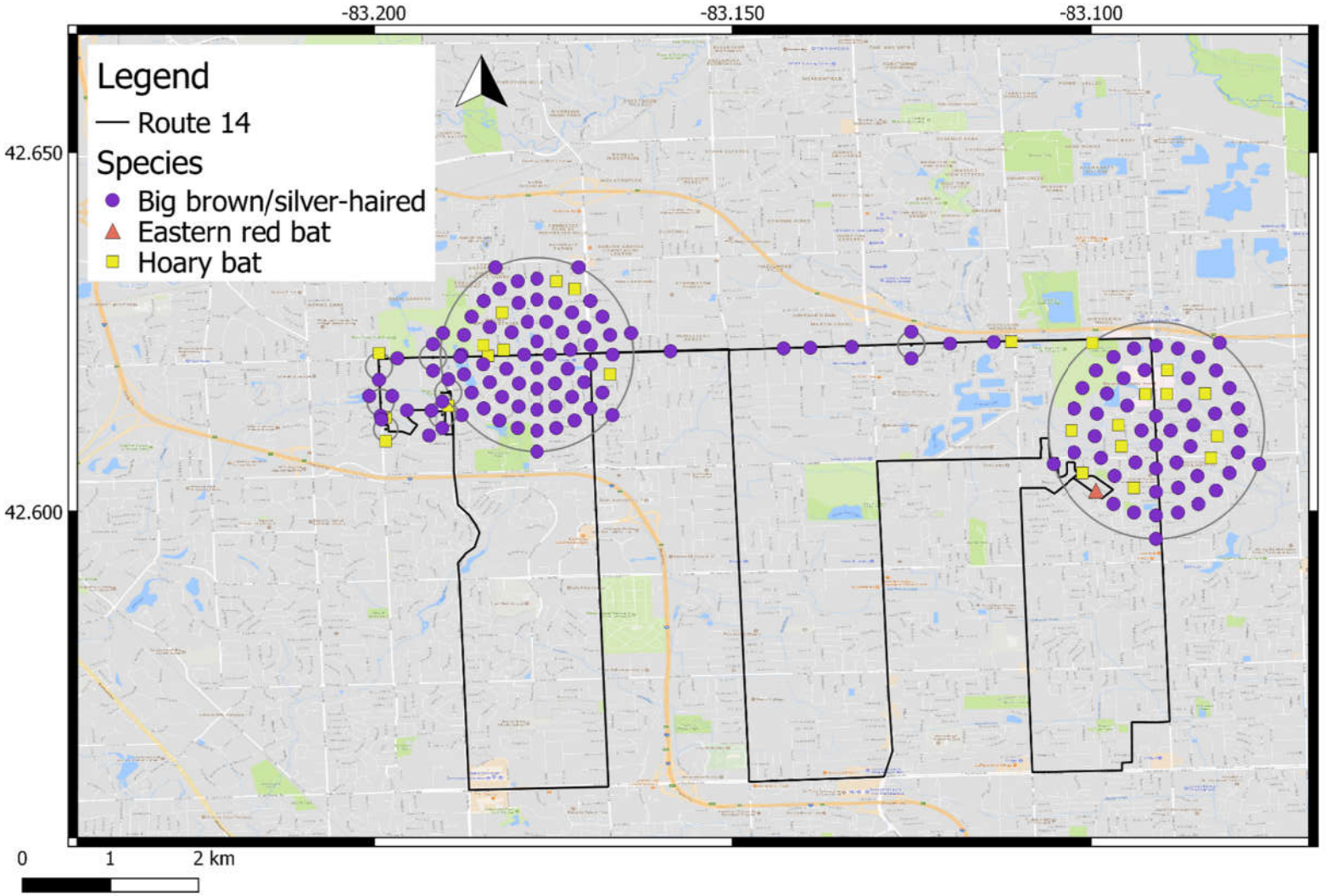

*Map 6. Route 11 path and final species designations.*



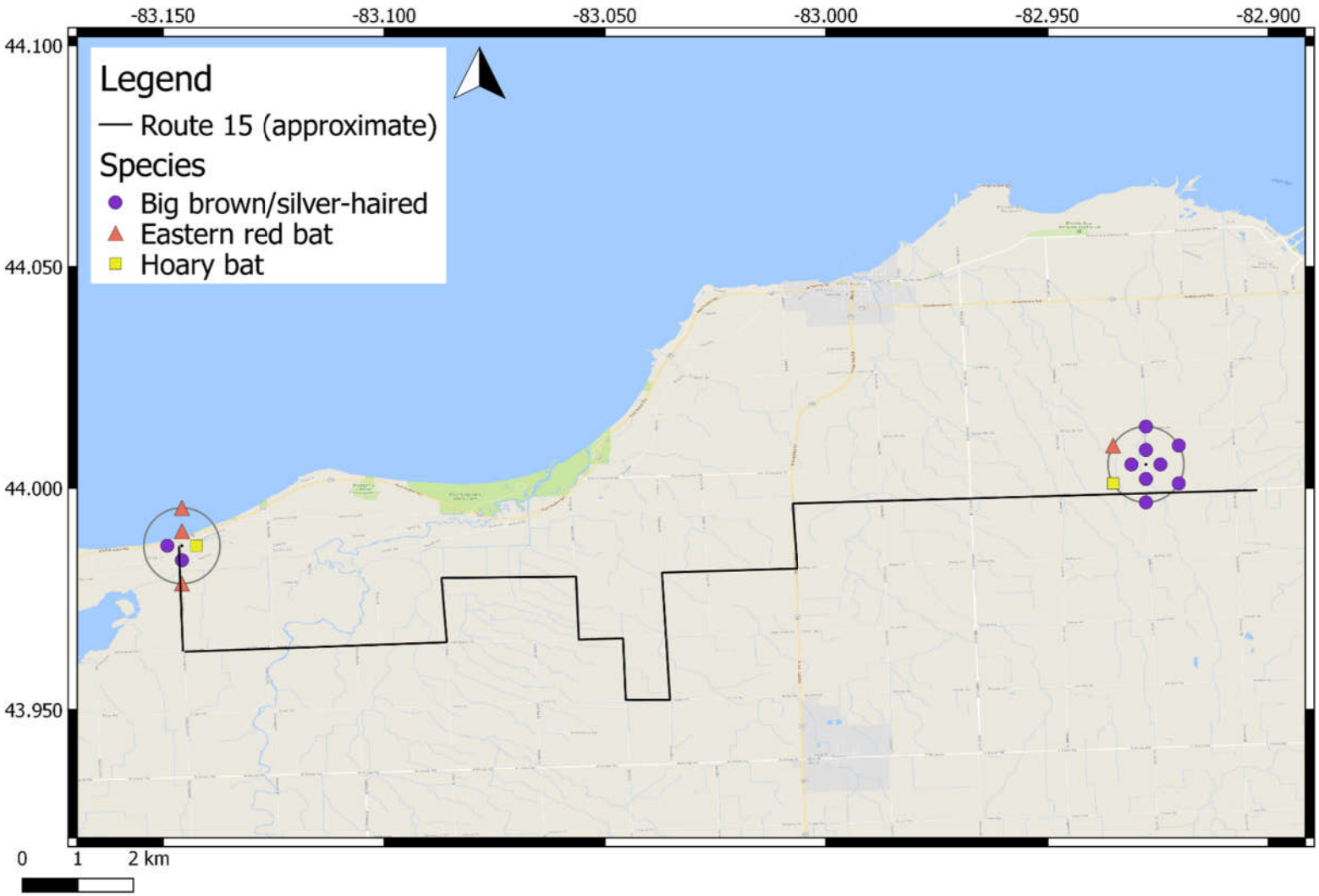

*Map 6. Route 12 path and final species designations.*



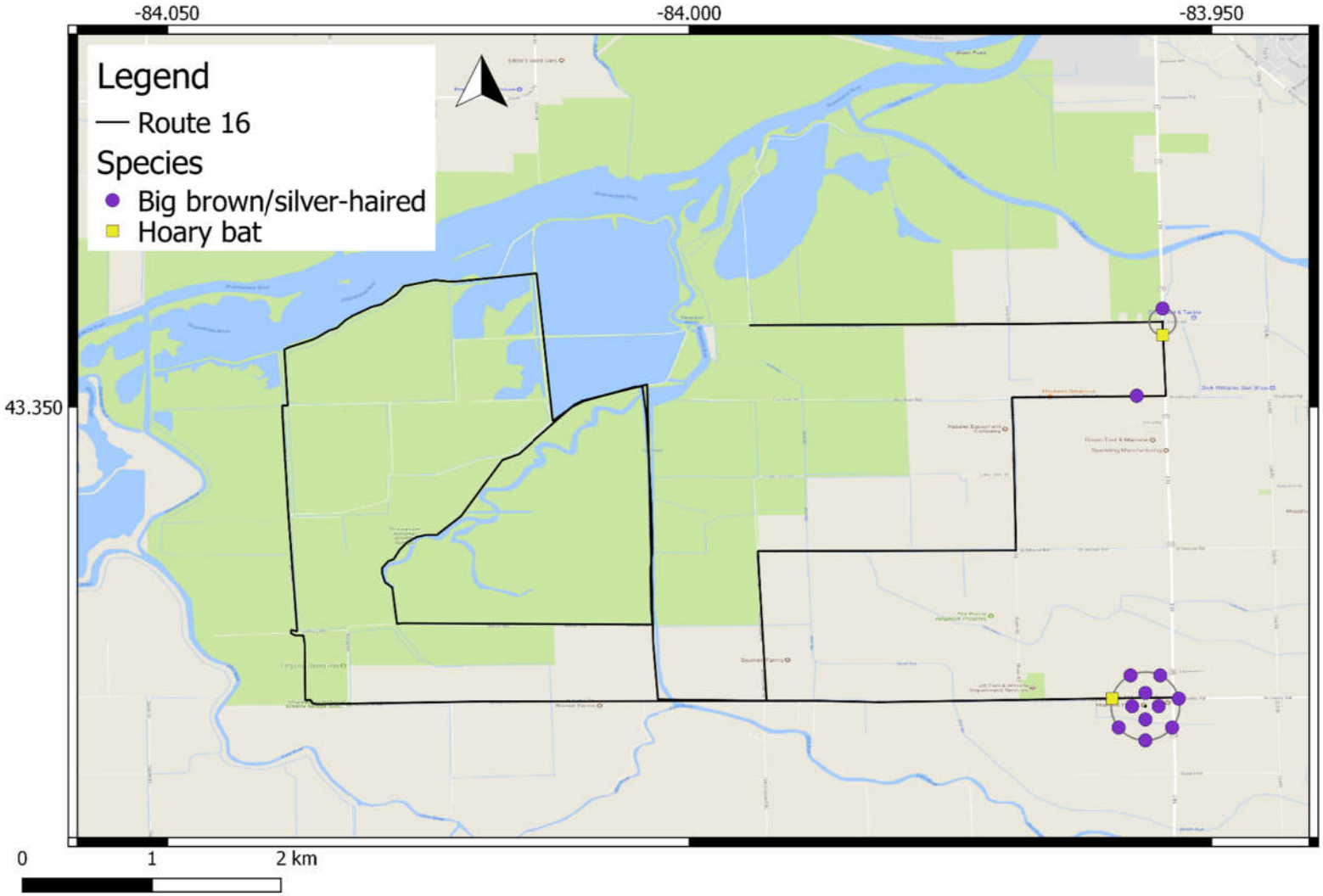

*Map 7. Route 13 path (done via bicycle) and final species designations.*



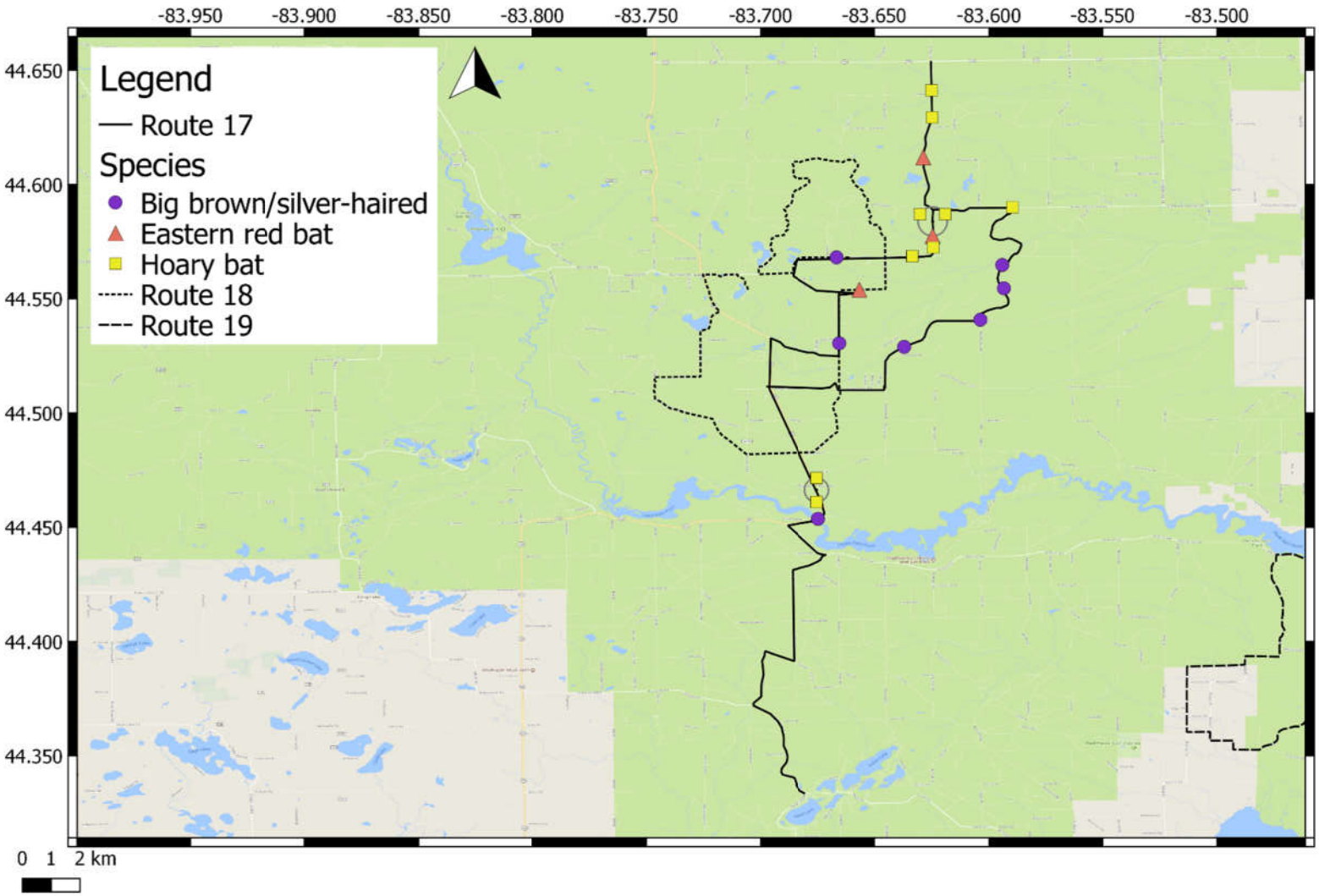

*Map 8. Route 14 path and final species designations.*



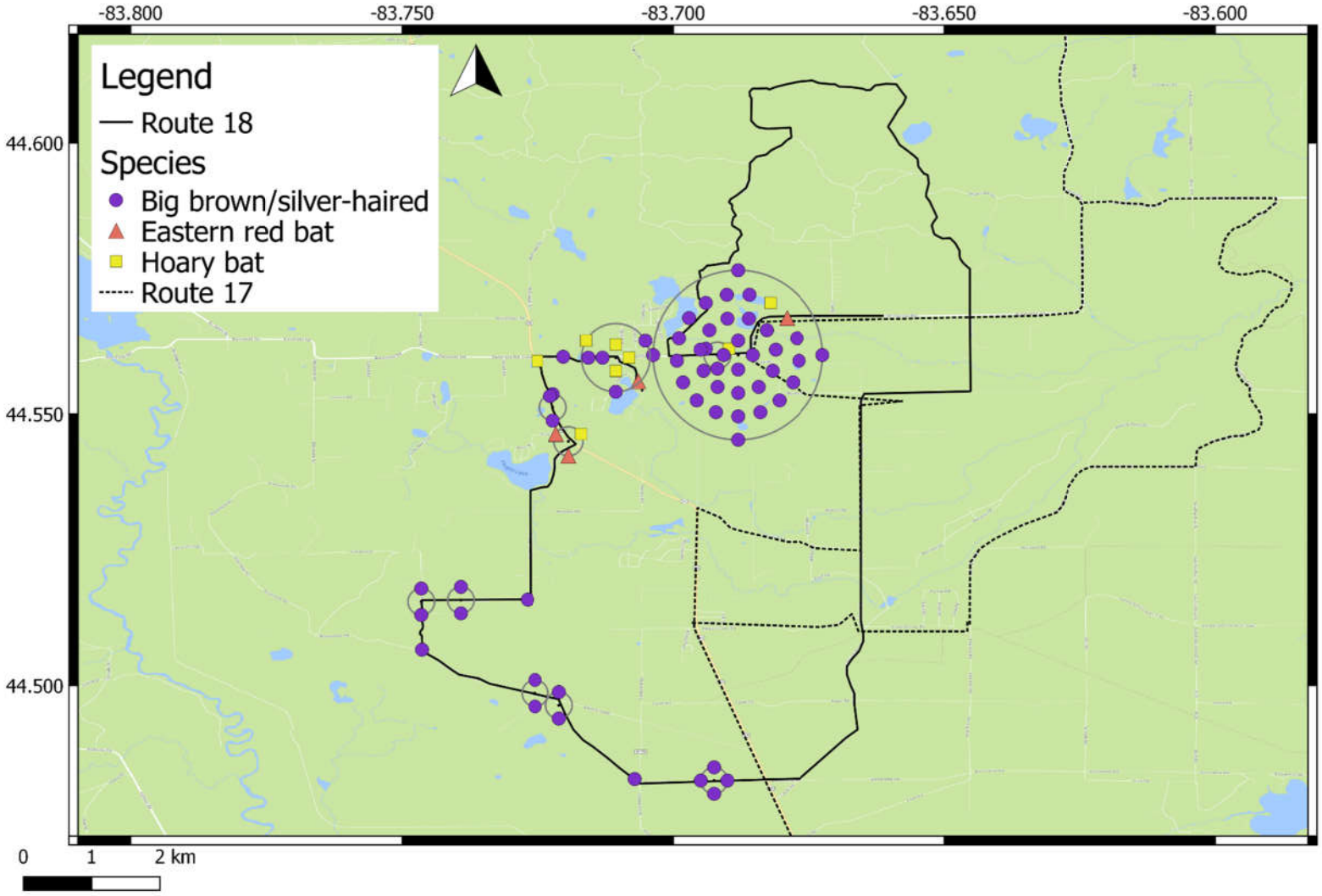

*Map 9. Route 15 path (approcimate) and final species designations.*



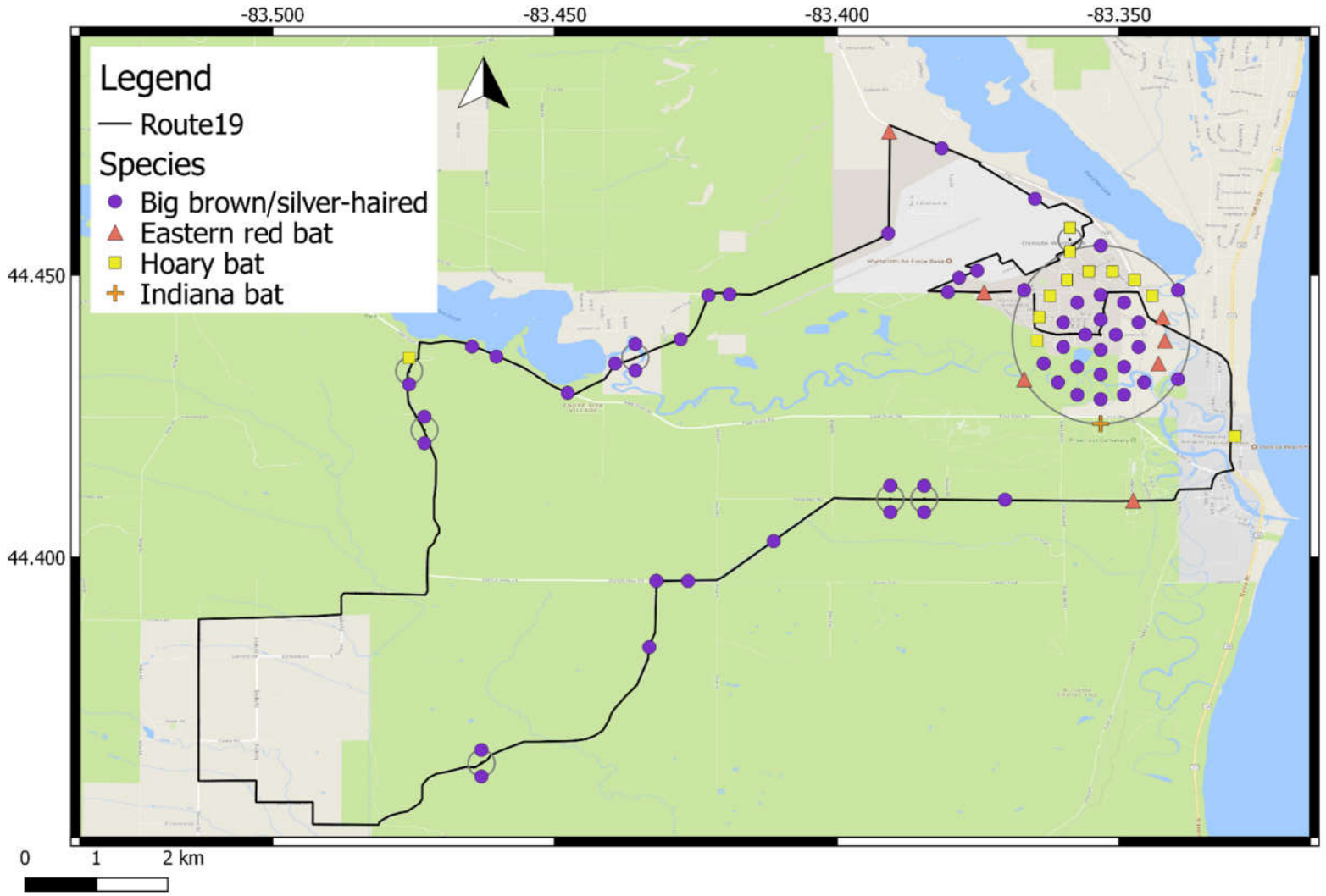

*Map 10. Route 16 path and final species designations.*




*Map 11. Route 17 path and final species designations.*

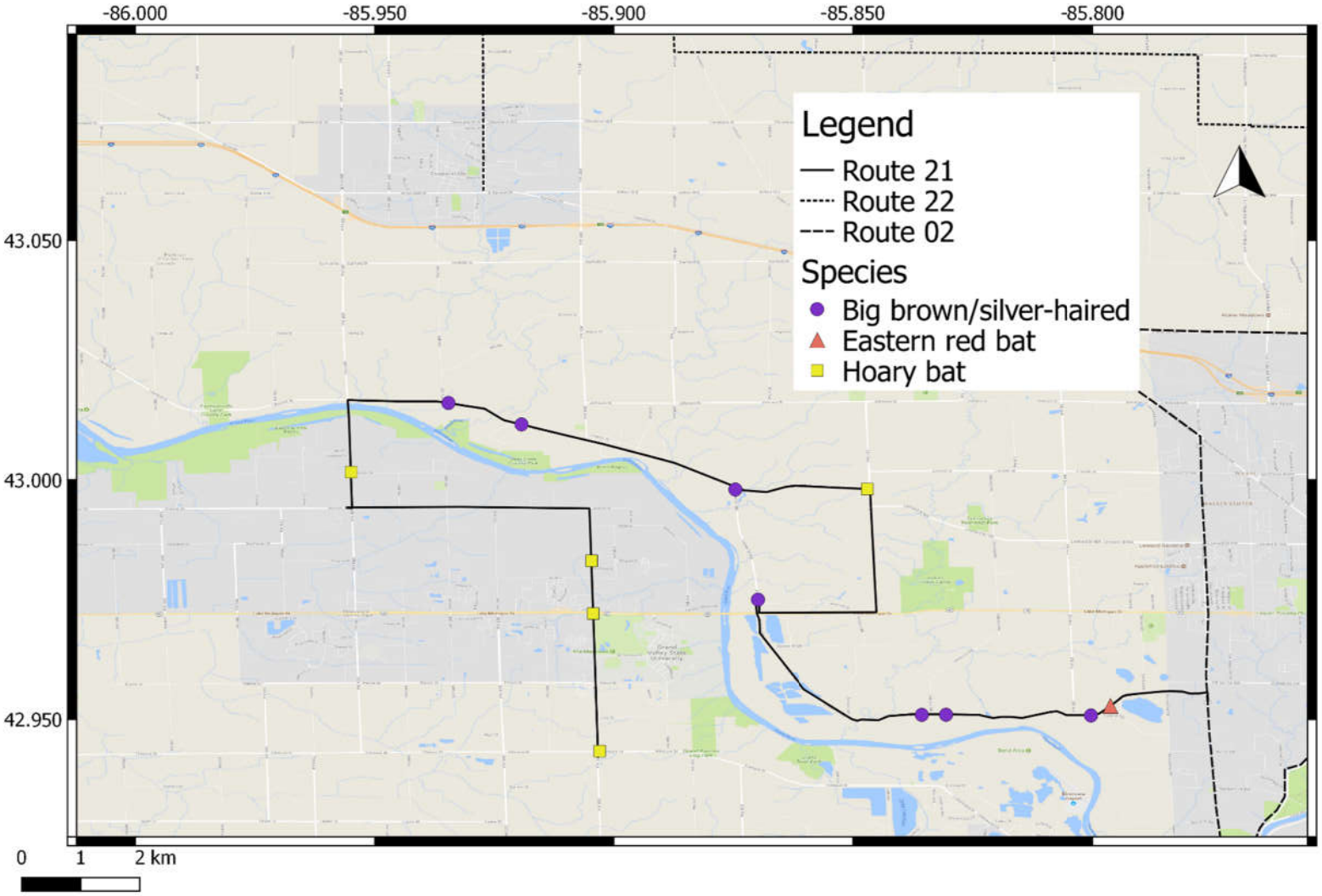



*Map 12. Route 18 path and final species designations.*

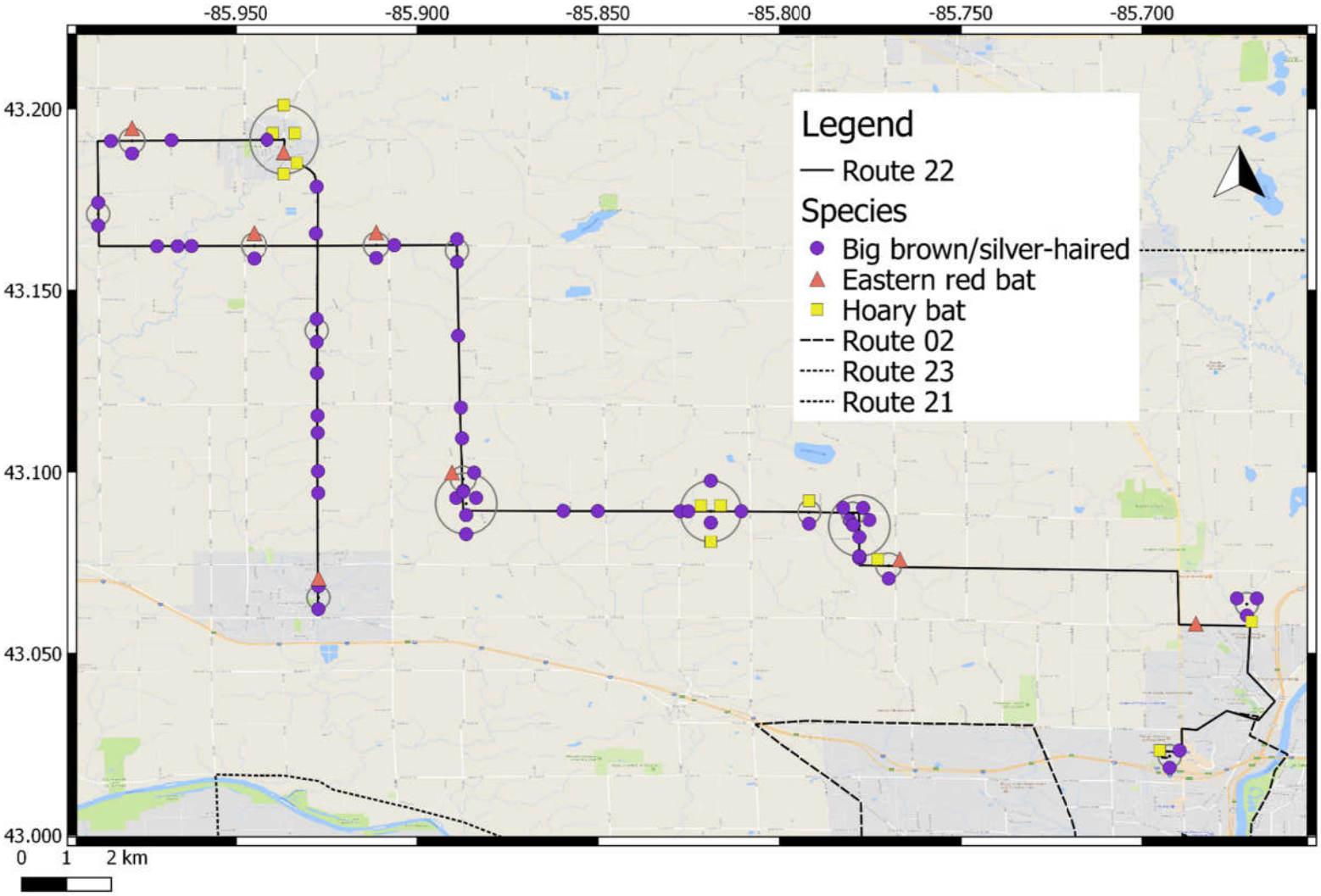



*Map 13. Route 19 path and final species designations.*

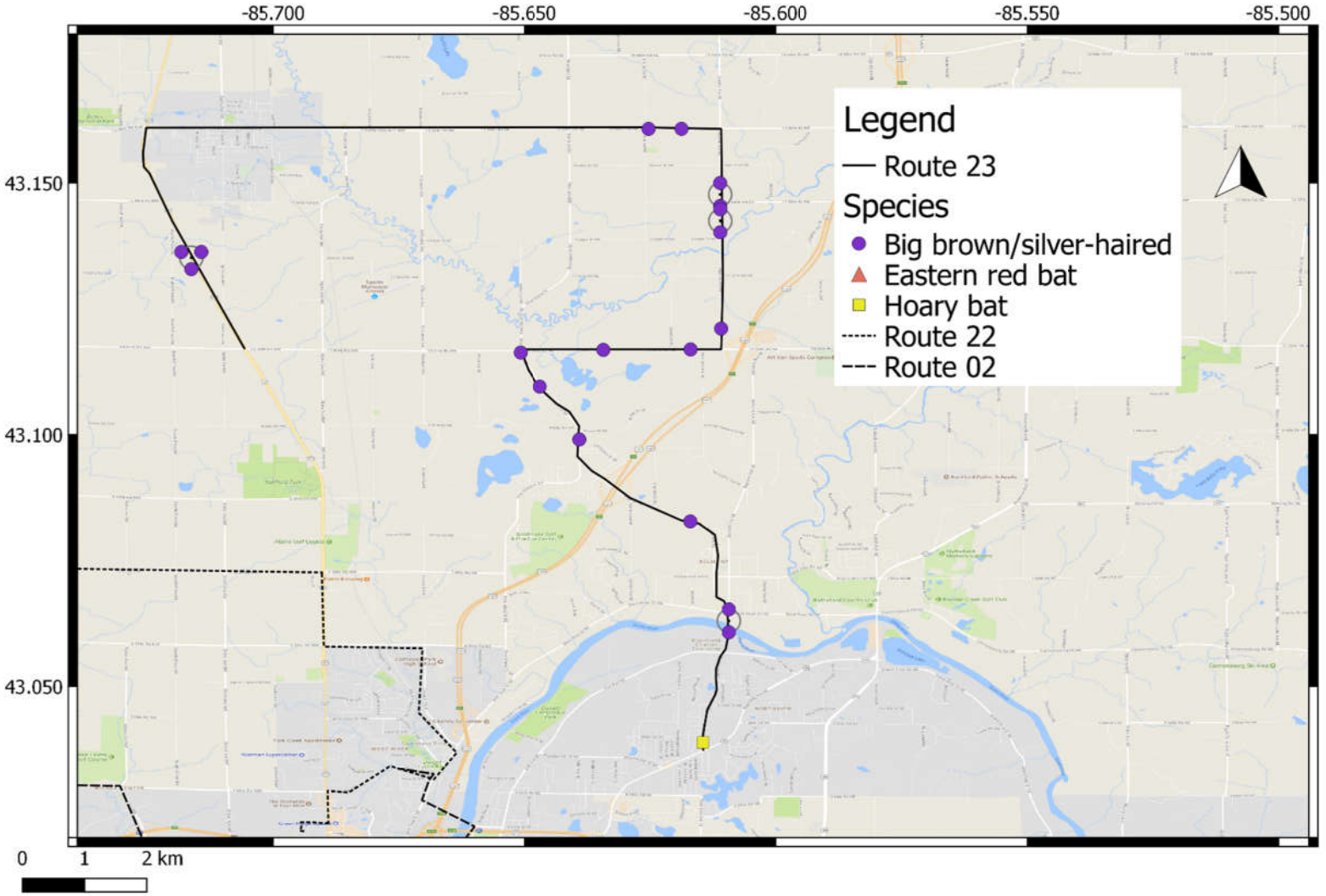

*Map 14. Route 20 path and final species designations. This route was done at Headlands Darks Sky Park, although it was very early in the season (May).*



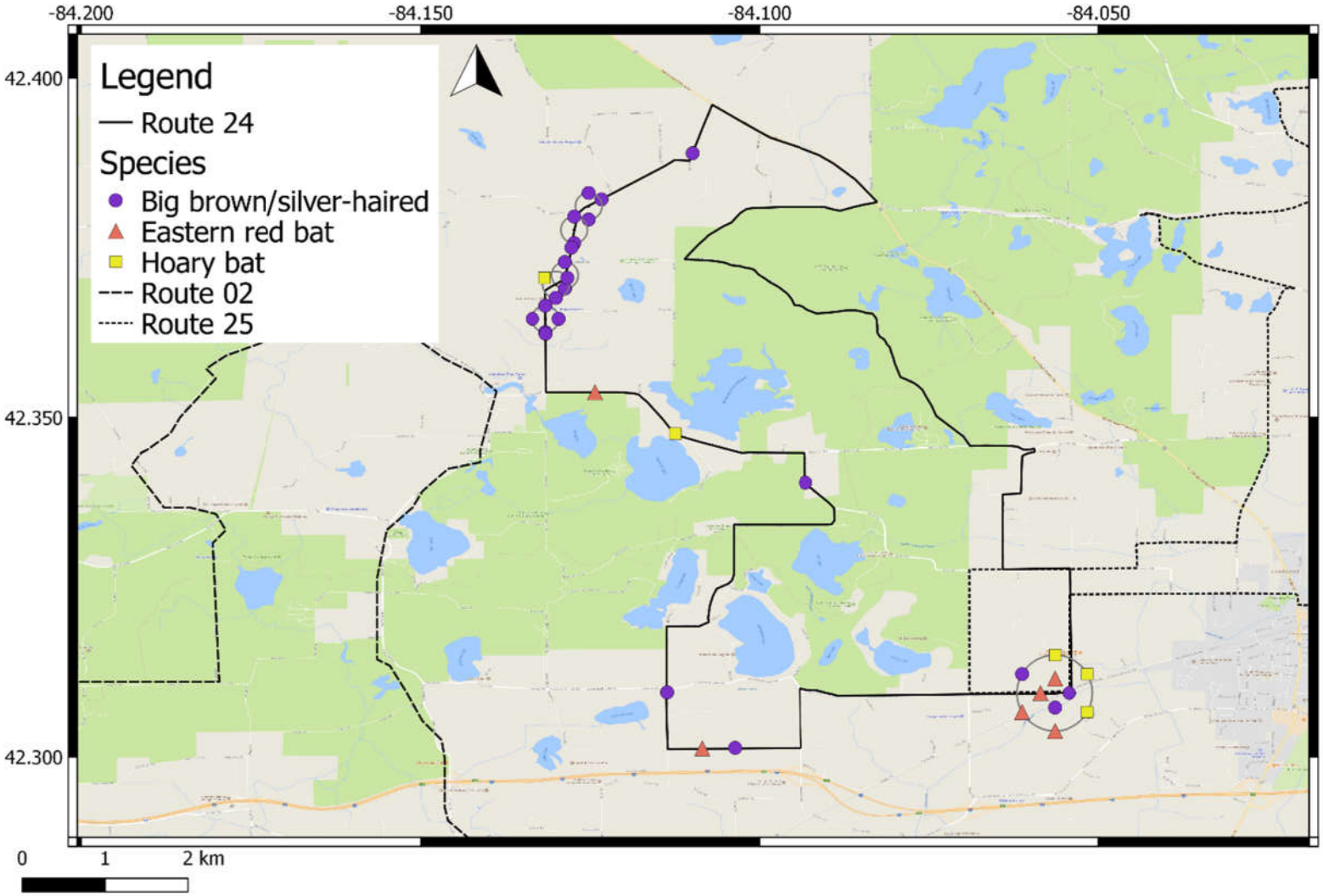

*Map 14. Route 21 path and final species designations.*



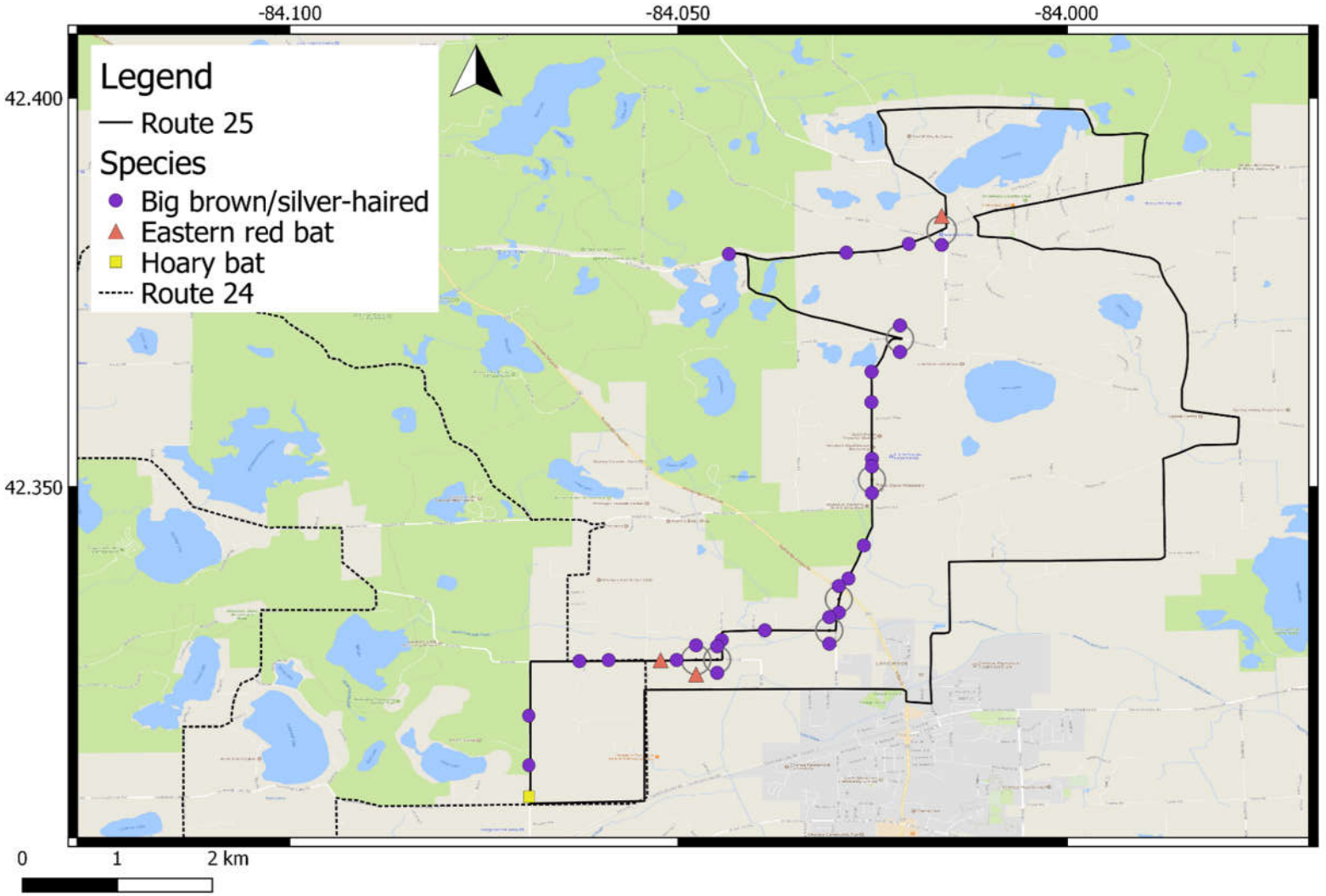

*Map 15. Route 22 path and final species designations.*




*Map 16. Route 23 path and final species designations.*




*Map 17. Route 24 path and final species designations.*




*Map 18. Route 25 path and final species designations.*