WISCONSIN BAT PROGRAM- Driving Acoustic Bat Survey Report 2023

Wisconsin Department of Natural Resources
Bureau of Natural Heritage Conservation
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In Brief

- ***There were 105 acoustic bat driving surveys in 51 counties conducted by 43 surveyors that included staff from Wisconsin Department of Natural Resources, Bad River Natural Resources Department (Tribal), U.S. Forest Service and private citizens.***
- ***Central Sand Hills region, for the eleventh year running, has consistently had the highest average bat calls per detector hour when compared to all other ecological landscapes.***
- ***In 2023, mean little brown bats recorded per kilometer/hour has remained unchanged since 2017, when the first effects of white-nose syndrome were observed in acoustic data.***

Introduction

In 2013, the Wisconsin Bat Program (WBP) expanded its offering of bat surveying opportunities by adding 38 predetermined driving bat surveys (transects; Appendix 1). The 2023 survey season marks the eleventh year conducting acoustic driving surveys. This report summarizes the methods and results from the driving survey transects that were conducted in Wisconsin in 2023 and compares this year's data to the previous ten years.

Methods

To better understand statewide changes in bat populations, emphasis was placed on repeating the 38 driving transects which were developed in 2013 by WBP in each of the 16 ecological landscapes (Table 1; Appendix 1). In coordination with national bat monitoring efforts, the following protocols were adopted to ensure standardization and quality-controlled data (Loeb et al., 2015). Each acoustic driving transect ranged from 20 to 30 miles per survey and used an acoustic detection system that passively recorded bat activity by detecting ultrasonic echolocation calls emitted by bats as they forage and navigate across the landscape. These echolocation calls were recorded and saved using an ultrasonic detector (Anabat SD1/2, AnaSwift, Titley Scientific LLC, Columbia, MO). The call files (bat encounters) and their geospatial information were collected through one of two methods: 1) using a hand-held computer (personal data assistant - PDA) (PDA, Hewlett-Packard Company iPAQ models) with a Global Positioning System (GPS; Global Sat, BC-337) or 2) data was directly saved to a compact flash card in the ultrasonic detector which is equipped with a mouse GPS (Global Sat, BC-355S4).

Surveyed routes in 2023 were driven one to three times across a six-week window, beginning June 1 and ending July 15**.** Surveys began approximately 30 minutes after local sunset time and were driven at a target speed of 20 miles per hour. Routes were to be completed at least once during the three primary survey periods: June 1 - June 15, June 16 - June 30 and July 1- July 15, and a minimum of five days was required between replicates of the same transect. Routes were surveyed on evenings with weather conditions suitable for bat activity which included low wind speed (<30 mph), no precipitation and a daytime temperature of 50^{O}F or above (Loeb et al., 2015). Survey equipment included the roof-mounted microphone, an AnaBat SD1/2 bat detector, a hand-held computer to interface with the AnaBat SD1/2, a compact flash GPS unit to record the location of each acoustic file, and other appropriate items (instructions, route maps, datasheets, batteries and cables).

Acoustic files were analyzed using Titley Scientific AnalookW (Version 4.7a) (Corben 2023). Surveys were manually filtered to separate files containing bat encounters and ignore those files with only extraneous noise from insects, birds, wind, road noise, and other sources of static. All acoustic data were processed through manual examination by one staff member who has >16 years of experience in identifying Wisconsin bat species and had an extensive call library to use as reference. Files with bat encounters were categorized into one of the following species: hoary bat (*Lasiurus cinereus*), big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), eastern red bat (*L. borealis*), tricolored bat (formerly eastern pipistrelle) (*Perimyotis subflavus*), little brown bat (*Myotis lucifugus),* northern long-eared bat-(*M. septentrionalis*), evening bat - (*Nycticeius humeralis*), or into species groups: big brown/silver-haired bat, tricolored/eastern red/evening bat, little brown/northern long-eared bat (Myotis), low frequency and high frequency. Species are grouped together because their calls are similar, and some pass files do not contain enough detail to accurately assign a species. Low and high frequency bat passes were later grouped as unclassified encounters because one of the following scenarios: there were too few calls recorded to further separate, the calls were of low-quality recording (i.e., fragmented), the bat pass did not contain search-phase calls (calls used to identify species), or general uncertainty. To compare our results year-to-year and to other state-wide acoustic inventories, results were evaluated using metrics to account for variations in driving speeds among surveyors: bat encounters-per-detector-hour [bat encounters divided by survey time (hours)] and bat encounters-per-kilometer-hour [bat encounters divided by kilometers traveled per hour].

Table 1: Ecological Landscapes in Wisconsin and associated abbreviations.

Ecological Landscape	Abbreviation
Central Lake Michigan Coastal	CLMC
Central Sand Hills	CSH
Central Sand Plains	CSP
Forest Transition	FT
North Central Forest	NCF
Northeast Sands	NES
Northern Highland	NH
Northern Lake Michigan Coastal	NLMC
Northwest Lowlands	NWL
Northwest Sands	NWS
Southeast Glacial Plains	SGP
Southern Lake Michigan Coastal	SLMC
Southwest Savanna	SWS
Superior Coastal Plain	SCP
Western Coulee and Ridges	WCR
Western Prairie	WP

Results

In 2023, 105 surveys were conducted in 51 counties by 43 individuals from Wisconsin Department of Natural Resources, Bad River Natural Resources Department (Tribal), U.S. Forest Service and citizen volunteers. These 105 completed surveys add to an invaluable data set (Table 2) bringing the total completed driving surveys to 1,004 since 2013. In 2023, the mean survey length was 52.6 km (32.7 miles; range 18.7 km/11.6 miles – 77.3 km/48.0 miles). Surveyors traveled over 5,300 kilometers (3,200 miles) and surveyed 8,320.4 hectares (20,560.0 acres) (Appendix 3, Table 3).

Two survey routes - NWL1 and SCP1 - were not surveyed in 2023. At least one survey was completed in each of Wisconsin's 16 ecological landscapes (EL), resulting in valid data for 36 of the possible 38 routes. Of the 25,092 total files recorded, 5,730 (22.8%) were identified as bat encounters. A mean of 31.7 bat calls per detector-hour were recorded (range 1.7 – 178.0 bat calls/detector/hour). For 11 consecutive years, Central Sand Hills region had the highest average bat calls per detector hour (58.4, Figure 1) and the Southern Lake Michigan Coastal region had the lowest average bat calls per detector hour (9.9). Surveyors recorded a mean of 54.6 bats calls (files) per survey (range: 3-273 bat calls per survey). The number of surveys varied by week with the most surveys completed in July (3rd sampling period; Figure 2) and bats were more likely to be detected toward the end of the third sampling period, which can be attributed to population recruitment by recently-volant (flying) juveniles. When comparing mean bat calls per survey for 8-day period from 2013-2023 driving routes (Figure 3), the box plots in the first and last week of sampling show the least amount of variation around the average, where the center line is the average and the size of the box indicate variation around the average.

Of the 5,730 bat encounters there were 3,753 (65.5%) call files classified as big brown bat (1,320), hoary bat (1,009), eastern red bat (692), silver-haired bat (444), little brown bat (279), evening bat (7) and tricolored bat (2). The northern long-eared bat was not detected on acoustic driving transects in 2023. The remaining 1,977 (34.5%) were classified into species groups: high frequency group (383), low frequency group (554), big brown/silver-haired bat (770), eastern red/tricolored/evening bat (241) and little brown/northern long-eared bat (16) because the bat passes have similar call characteristics to two or more species.

Big brown bats were the most ubiquitous and commonly encountered species in 11 of 16 ecological regions, followed by hoary bat (most common in three regions) and eastern red bat in two regions. (Figure 9). Of note, the little brown bat, which is highly susceptible to WNS, was the most encountered species in six ecological landscapes when the driving surveys began in 2013.

Table 2. Number of driving transects and surveyors by year.

Year	No. Driving Transects	No. Surveyors
2013	92	56
2014	78	45
2015	77	48
2016	71	50
2017	92	58
2018	96	55
2019	107	53
2020	73	28
2021	113	39
2022	101	38
2023	105	43

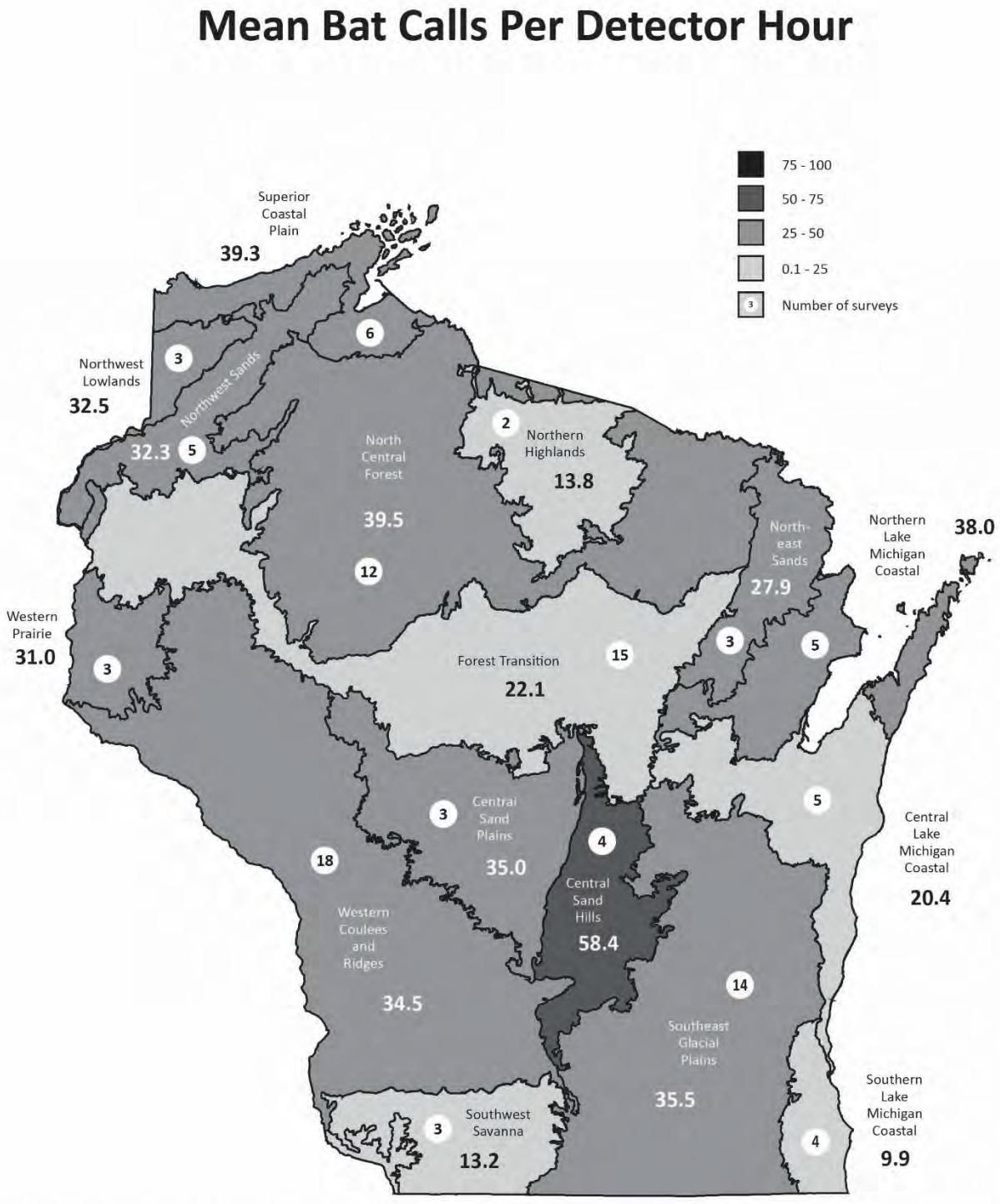

Figure 1. Central Sand Hills continues to have the highest mean bat calls per detector hour at 58.4 calls/detector/hour. Mean calls per detector hour across all landscapes was 31.7 in 2023.

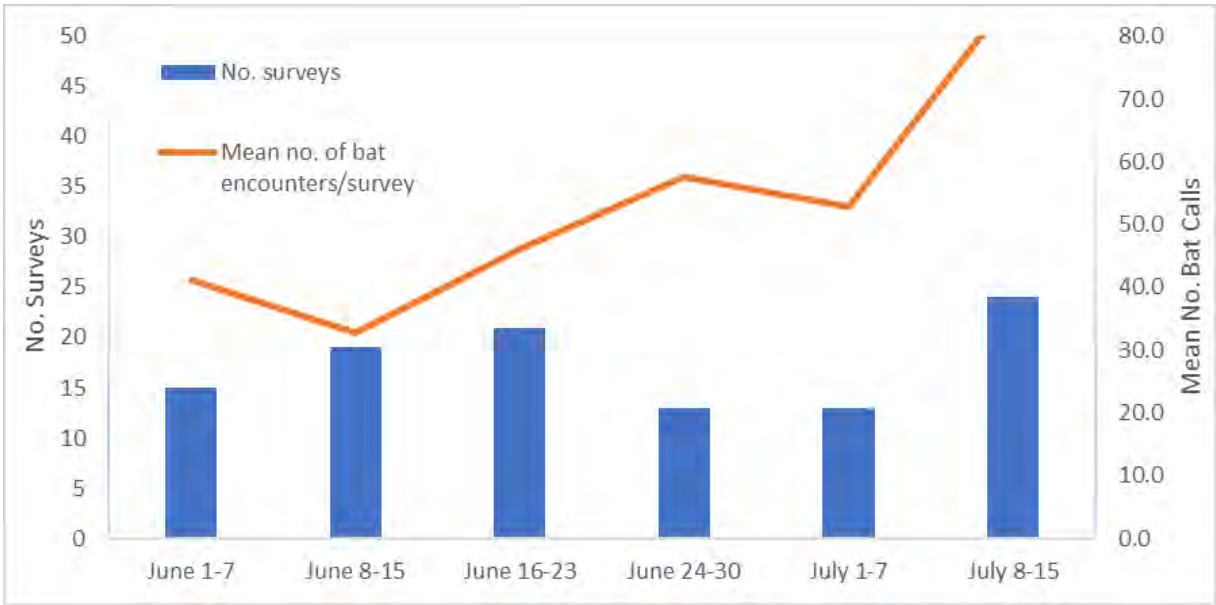

Figure 2. Total number of surveys by week and mean number of bat calls per survey by week (2023).

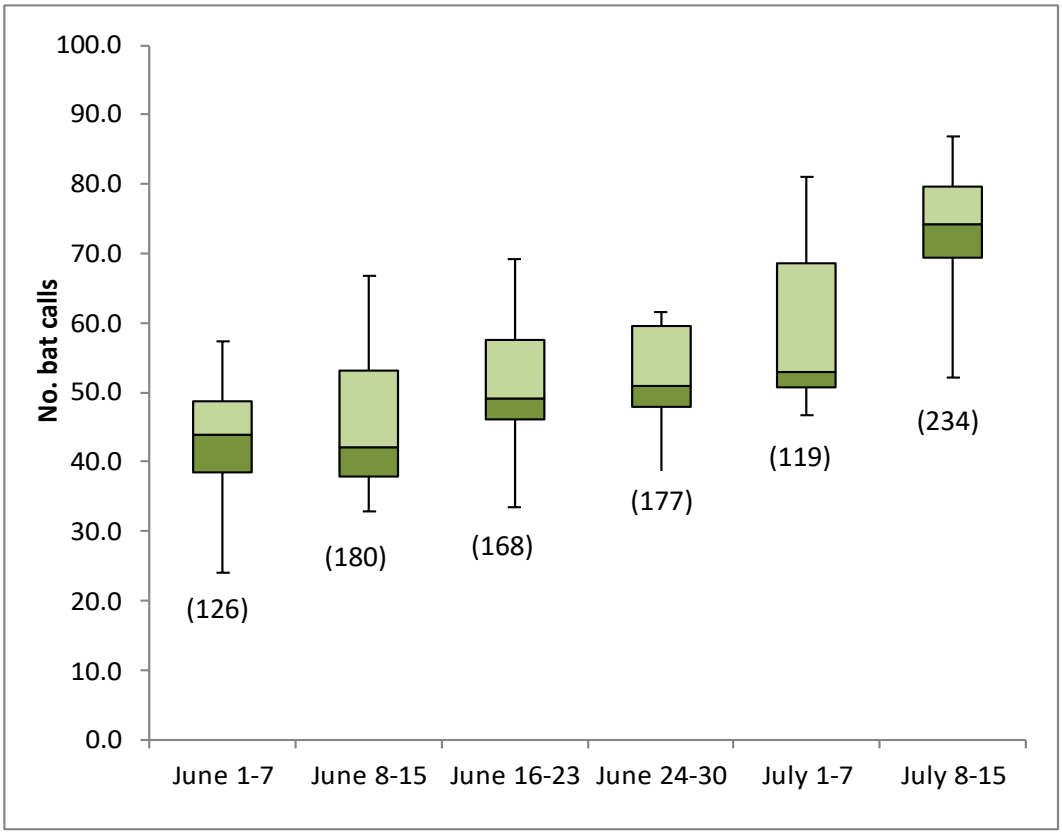

Figure 3. Comparison of mean bat calls per survey for 8-day period from 2013-2023 driving routes. Numbers in brackets indicate sample size (number of surveys). Boxes depict the 25th and 75th percentiles, lines within boxes mark the median, whiskers represent 95th and the 5th percentiles.

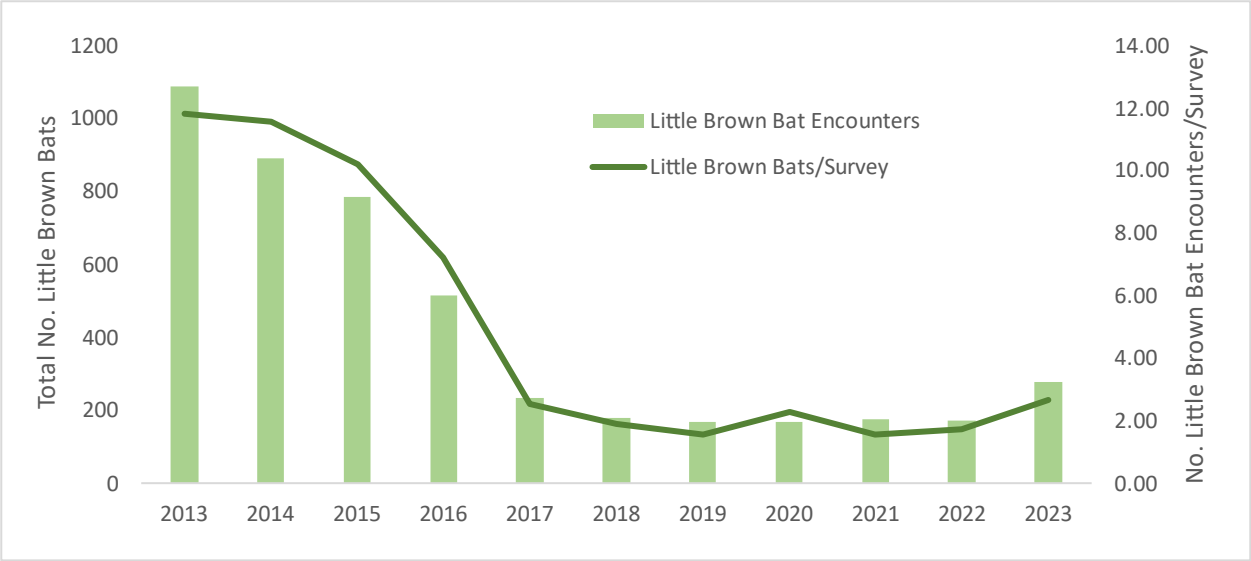

Figure 4. Yearly acoustic little brown encounters per survey (bats; left axis) and total little brown bat encounters on all surveys (line; right axis). Regardless of the presentation, both indices show the same general trend – a larger population or detection rate followed by declines, then reaching stabilization from 2017-2023.

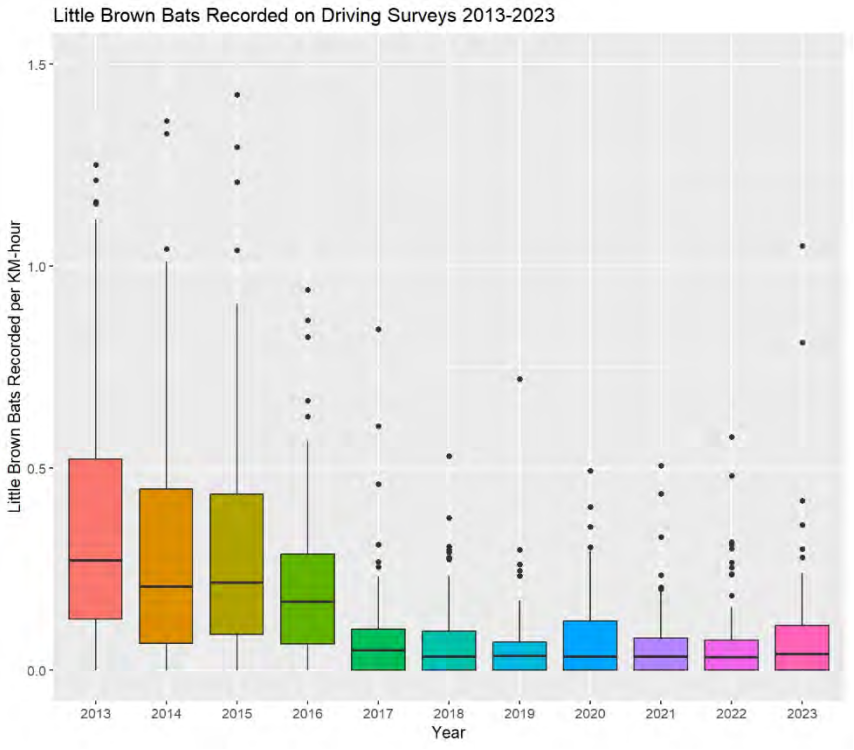

Figure 5. Little brown bat passes per kilometer hour by year. Little brown bat passes from driving transects in 2023 were similar to years 2017-2022. The bar is median, the outside edges of the boxes are 1st and 3rd quartiles, and the whiskers are, upper whisker = Q_3 + 1.5 * IQR, lower whisker = min. IQR is interquartile range.

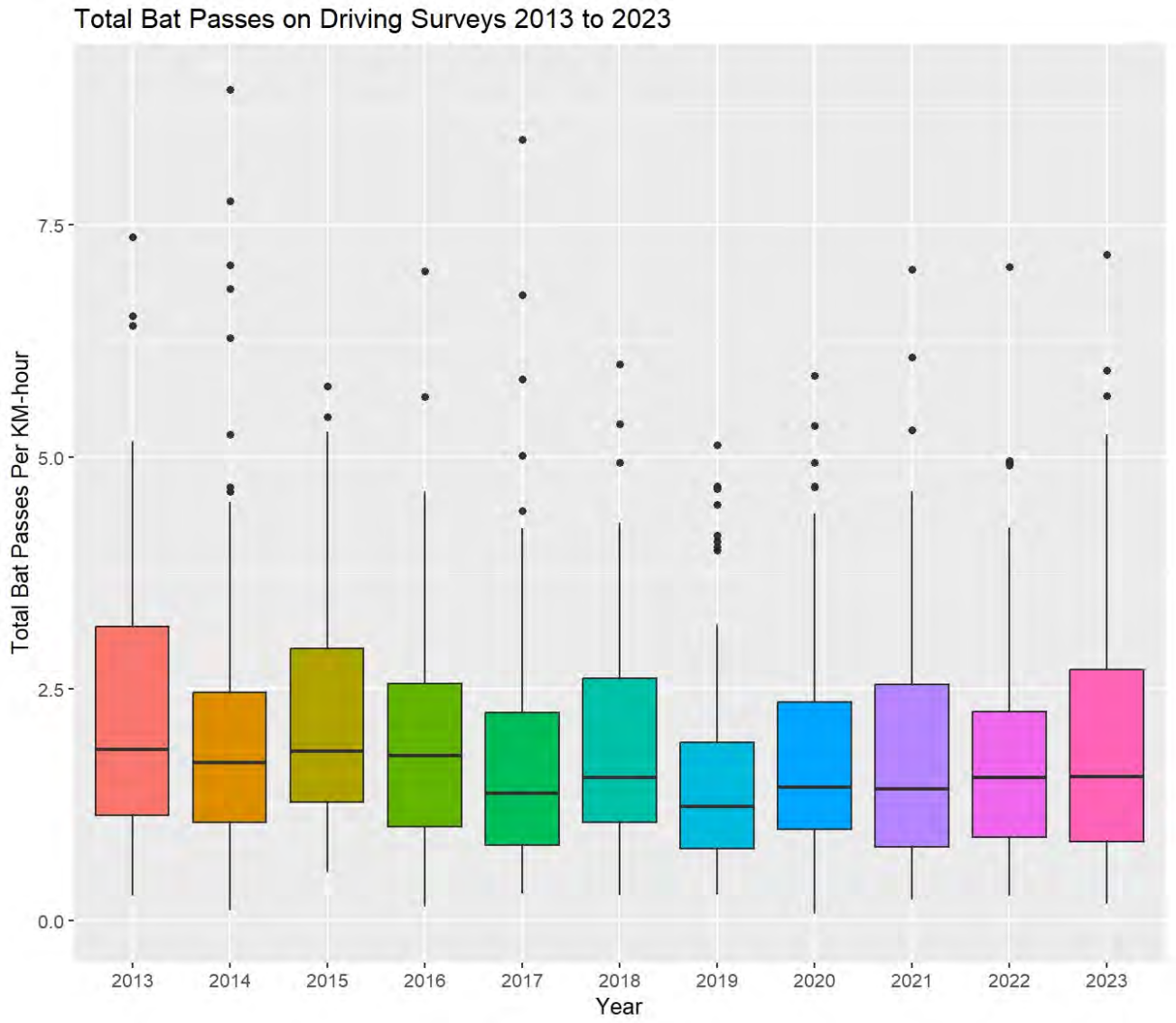

Figure 6. Total passes per kilometer hour by year. Total bat passes from driving transects in 2023 were not significantly different from previous years. The bar is median, the outside edges of the boxes are 1st and 3rd quartiles, and the whiskers are, upper whisker = Q_3 + 1.5 * IQR, lower whisker = min. IQR is interquartile range.

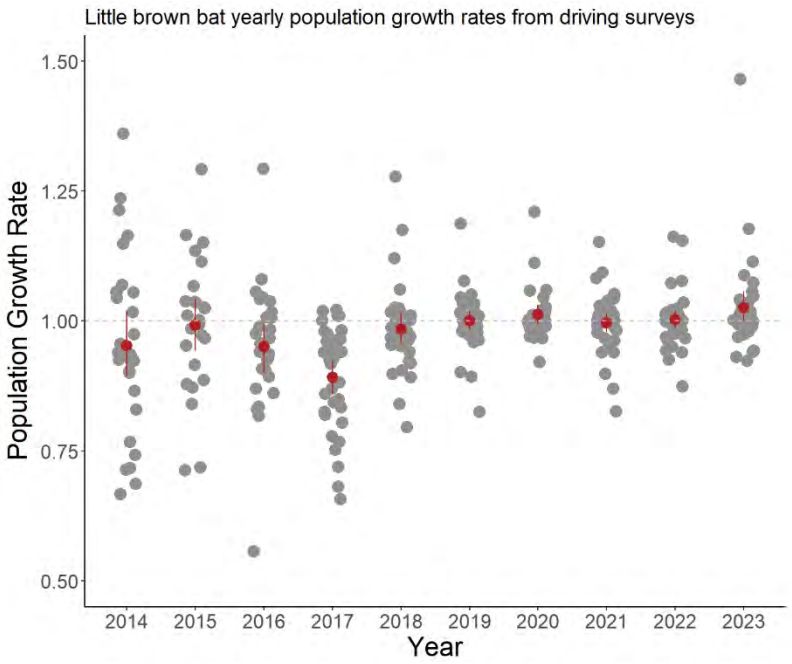

Figure 7. Yearly growth rate for little brown bats detected on acoustic driving surveys. The growth rate (lambda) was calculated from the change of calls per km-hr by year (year n/(year n-1)). Red dots indicate mean and whiskers show 95% confidence limits. Dotted line at 1 indicates stability and rates above/below indicate growing/declining populations. Historically, driving routes have been a poor detection tool for Myotis species, which could explain why dramatic changes aren't observed as in other datasets like winter hibernacula or summer roost counts. Jitter has been added along the x-axis to facilitate presentation.

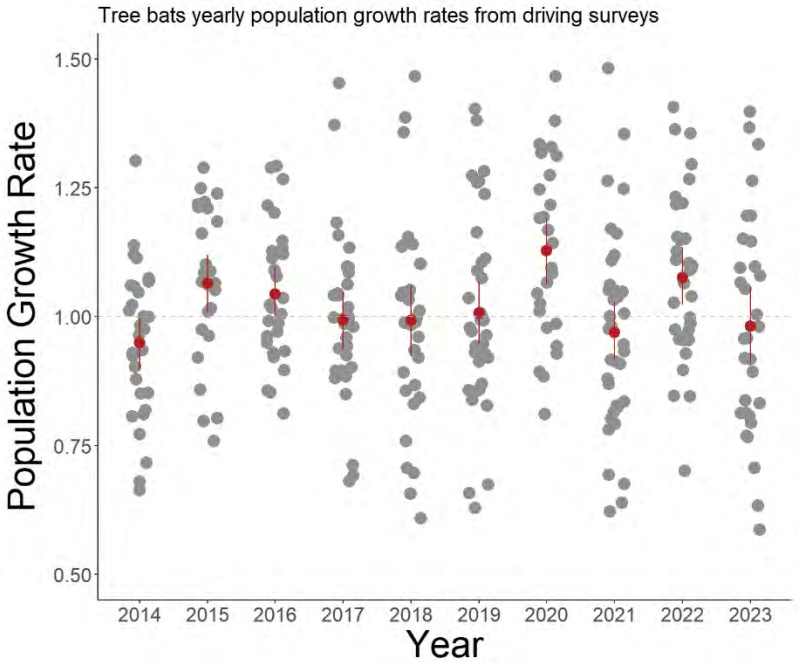

Figure 8. Yearly growth rate for all tree bat species (eastern red, hoary, evening and silver-haired bat) detected on acoustic driving surveys. The growth rate (lambda) was calculated from the change of calls per km-hr by year. Red dots indicate mean and whiskers show 95% confidence limits. Dotted line at 1 indicates stability and rates above/below indicate growing/declining populations The plot indicates some variation around stable growth rates notwithstanding of year. Jitter has been added along the x-axis to facilitate presentation.

Most Common Bat Species by Ecological Region

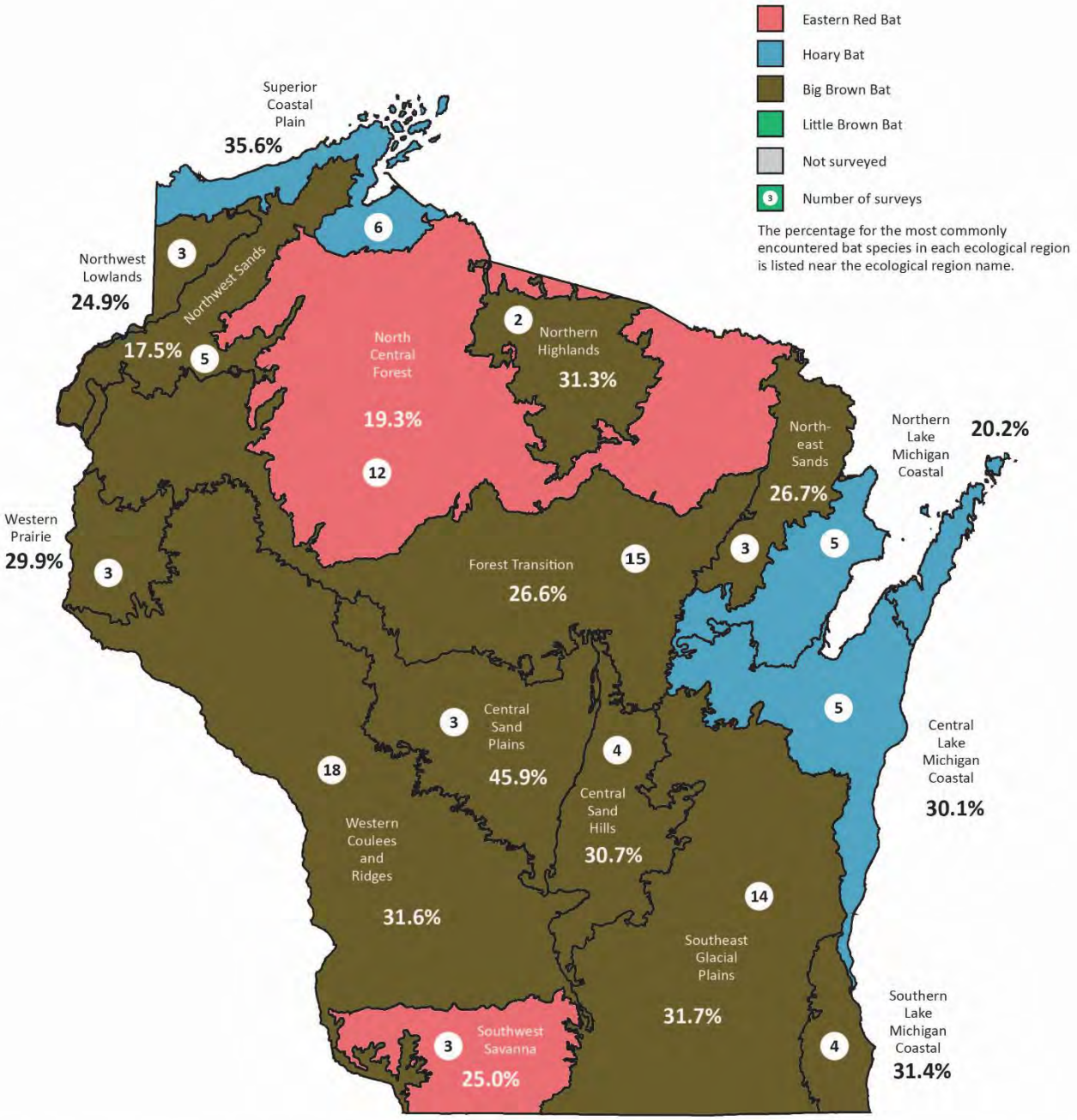

Figure 9. The most commonly encountered bat species by ecological region were the big brown bat (11), the hoary bat (3) and the eastern red bat (2) in 2023.

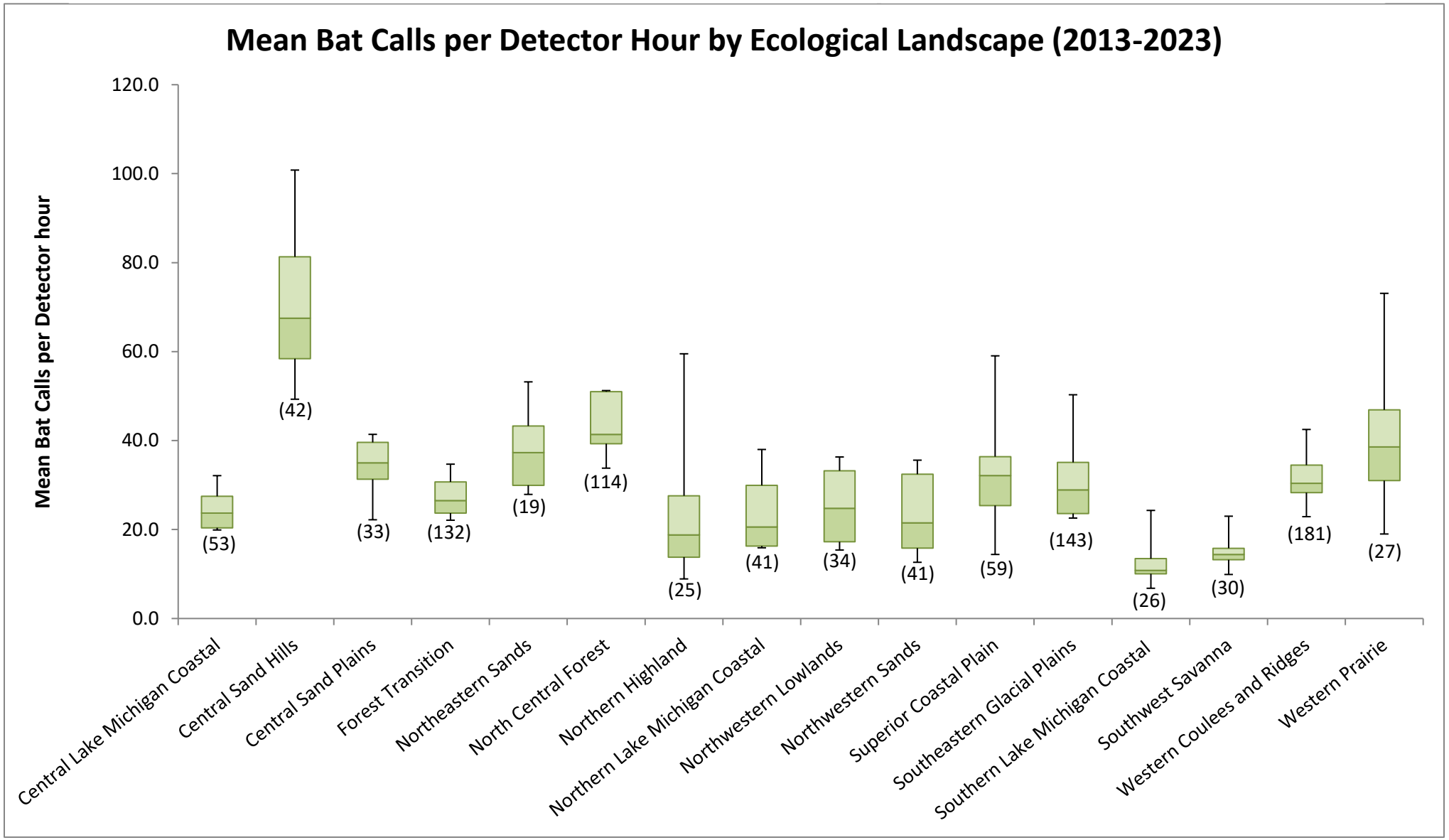

Figure 10. Mean bat calls per detector hour by ecological landscape 2013-2023 (center line in box). Bracketed numbers are total number of surveys per ecological landscape. A total of 1,004 acoustic driving surveys have been completed since 2013. Boxes depict the 25th and 75th percentiles, lines within boxes mark the median, whiskers represent 95th and the 5th percentiles.

Discussion

Acoustic driving surveys, now in the eleventh year, continue to help the Wisconsin Bat Program (WBP) describe population dynamics of Wisconsin's bat species. The surveys allowed WBP to follow populations before the arrival of white-nose syndrome (WNS) – the deadly fungal disease that affects cave bats disproportionally - through the disease invasion period and now in the disease-established phase. Acoustic driving surveys have helped the WBP describe differential population effects of WNS. For example, cave bat species, in particular Myotis species (northern long-eared bat and little brown bat) and the tricolored bat showed significant declines in the years following the arrival of WNS (Figure 5) while tree bats species have showed stable or positive trends depending on the year (Figure 8). Due to the diametric position of cave bats detections (decreasing) and tree bat species (stable or increasing), the total bat passes per kilometer hour has changed very little over the eleven-year period (Figure 6). In a similar effort using acoustic survey data, Mallinger et al., 2023 looked at nine US National Parks within the Great Lakes region and found a significant decline in Myotis species acoustic abundance while tree bat species (not affected by WNS) like the hoary bat showed significant increase in acoustic abundance, similar to observations in Wisconsin (Figure 17). Both study areas are regionally similar and the species-specific responses to WNS identified through acoustic bat data help management agencies and research partners identify vulnerable, secure or even increasing bat populations which are important when allocating limited resources or considering species protections.

While collectively acoustic detections for northern long-eared and tricolored bats remain at or just above zero, little brown bat detections were up from the previous two years, which was illustrated in the yearly growth rate plot in Figure 7, though 2023 little brown bat detections were not significantly different from 2017-2022. The yearly population growth plot derived from acoustic driving data indicated a positive growth rate or increasing population growth for little brown bat, which is similar to trends noticed in 39 little brown bat roosts that were extensively monitored before, during and post WNS-invasion in Wisconsin. Roost and acoustic data combined from little brown bats show that disease resistance or resiliency may be possible, unfortunately however that inference doesn't extend to the other highly affected cave bat species. A listing decision on the state-threatened but proposed as federally endangered tricolored has not been released while the northern long-eared bat was uplisted from federally threatened to endangered in spring of 2023.

Besides assessing bat status and trends, the acoustic driving data can be used as a tool to identify rare or species of special concern. With the driving surveys distributed by Wisconsin's 16 ecological landscapes; key habitats, aquatic features or natural communities can be targeted for further research. In the United Kingdom, O'Malley et al., (2023) used acoustic bat monitoring to locate specific colonies of rare bats. They developed survey methodology for locating the woodland-specialist barbastelle bat; the same can be done with WBP's acoustic dataset. It's worth noting that while driving surveys are more broad-scale than the fine-scale project of the barbastelle bat, repeated years of data collection from the same routes can be leveraged for the same purpose. As we continue to investigate Wisconsin's bat population through acoustic driving surveys, we will look for ways to use the data you've collected to conserve bat populations.

To those that have completed the driving surveys (past and present), thank you for all you have done to help us better understand Wisconsin's bat population.

Acknowledgements

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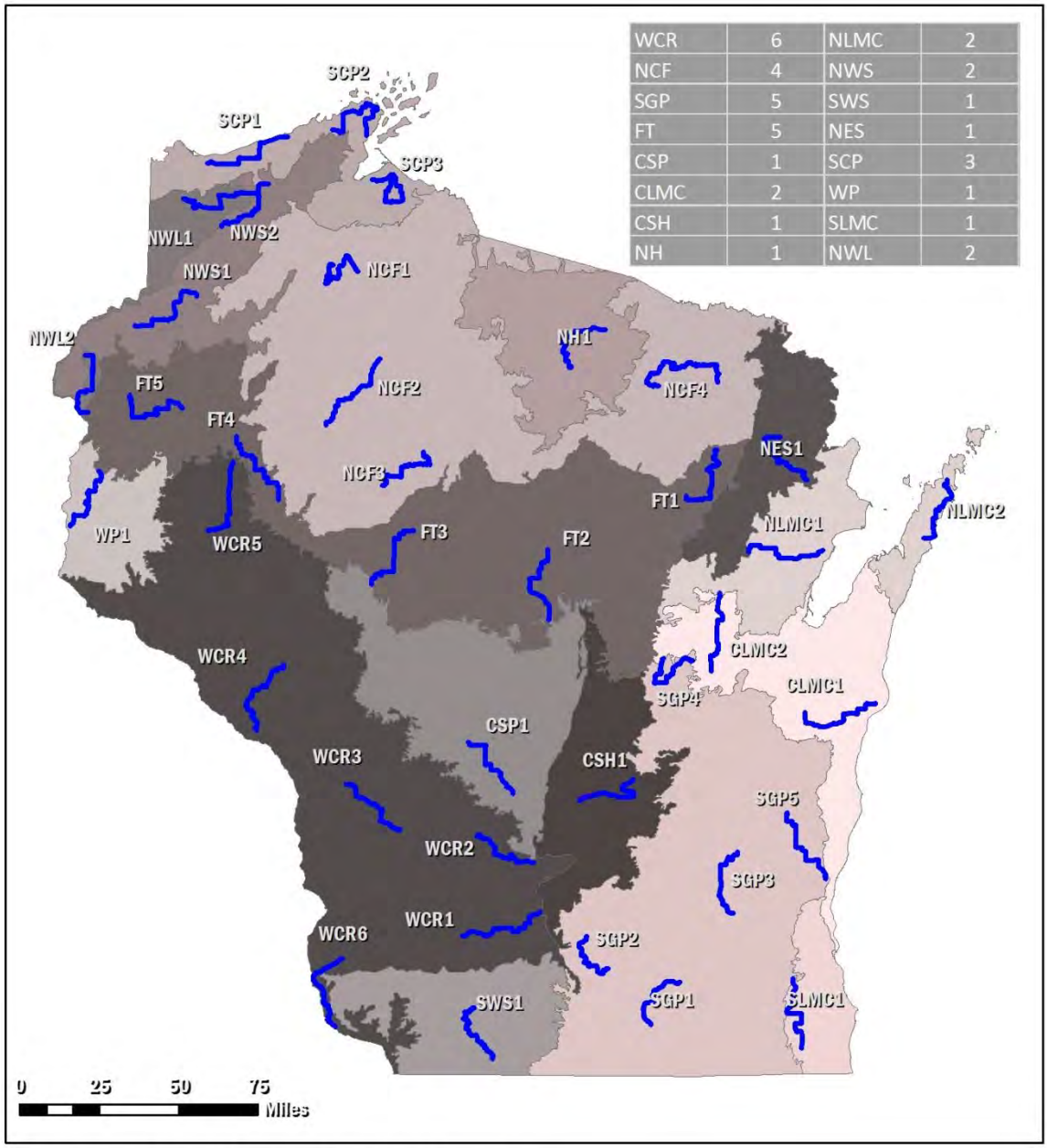
Appendix 1 Acoustic Bat Driving Transects by Ecological Landscape



Ecological Landscapes: Central Lake Michigan Coastal (CLMC), Central Sand Hills (CSH), Central Sand Plains (CSP), Forest Transition (FT), North Central Forest (NCF), Northeast Sands (NES), Northern Highland (NH), Northern Lake Michigan Coastal (NLMC), Northwest Lowlands (NWL), Northwest Sands (NWS), Southeast Glacial Plains (SGP), Southern Lake Michigan Coastal (SLMC), Southwest Savanna (SWS), Superior Coastal Plain (SCP), Western Coulees and Ridges (WCR) and Western Prairie (WP).

Appendix 2 (Figures 11-14) Bat species encounter by ecological landscape

Note: A map was not created for the evening bat or tricolored bat due only a few statewide encounters. A map for the northern long-eared bat were also not created because these species were not detected in 2023.

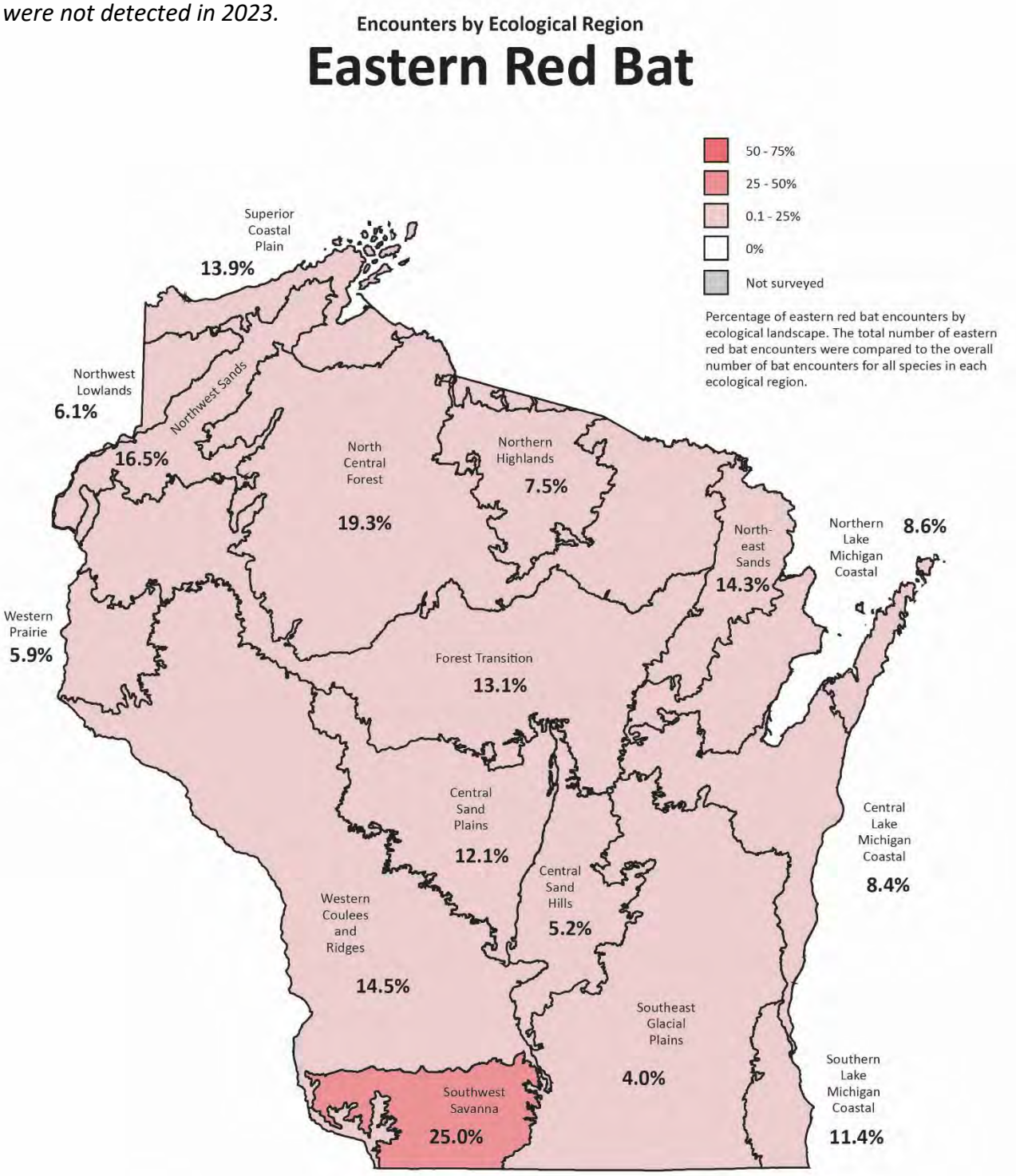


Figure 11. The eastern red bat had the highest encounter rate (25.0%) in the Southwest Savanna Region and comprised 18.4% of all recorded bat passes during driving surveys in 2023.

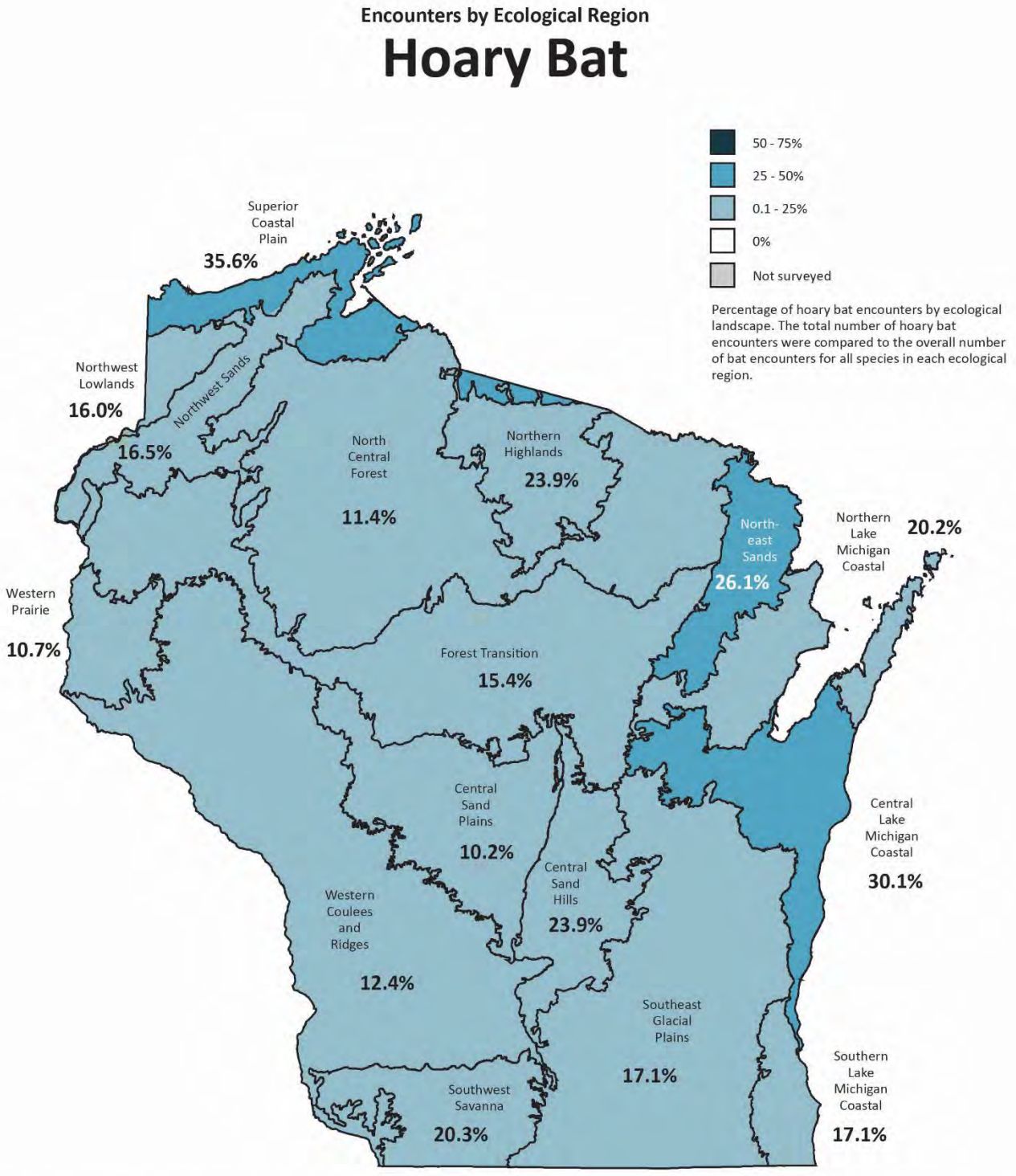


Figure 12. The hoary bat had the highest encounter rate (35.6%) in the Superior Coastal Plain Region and comprised 26.9% of all bat encounters recorded during driving surveys in 2023.

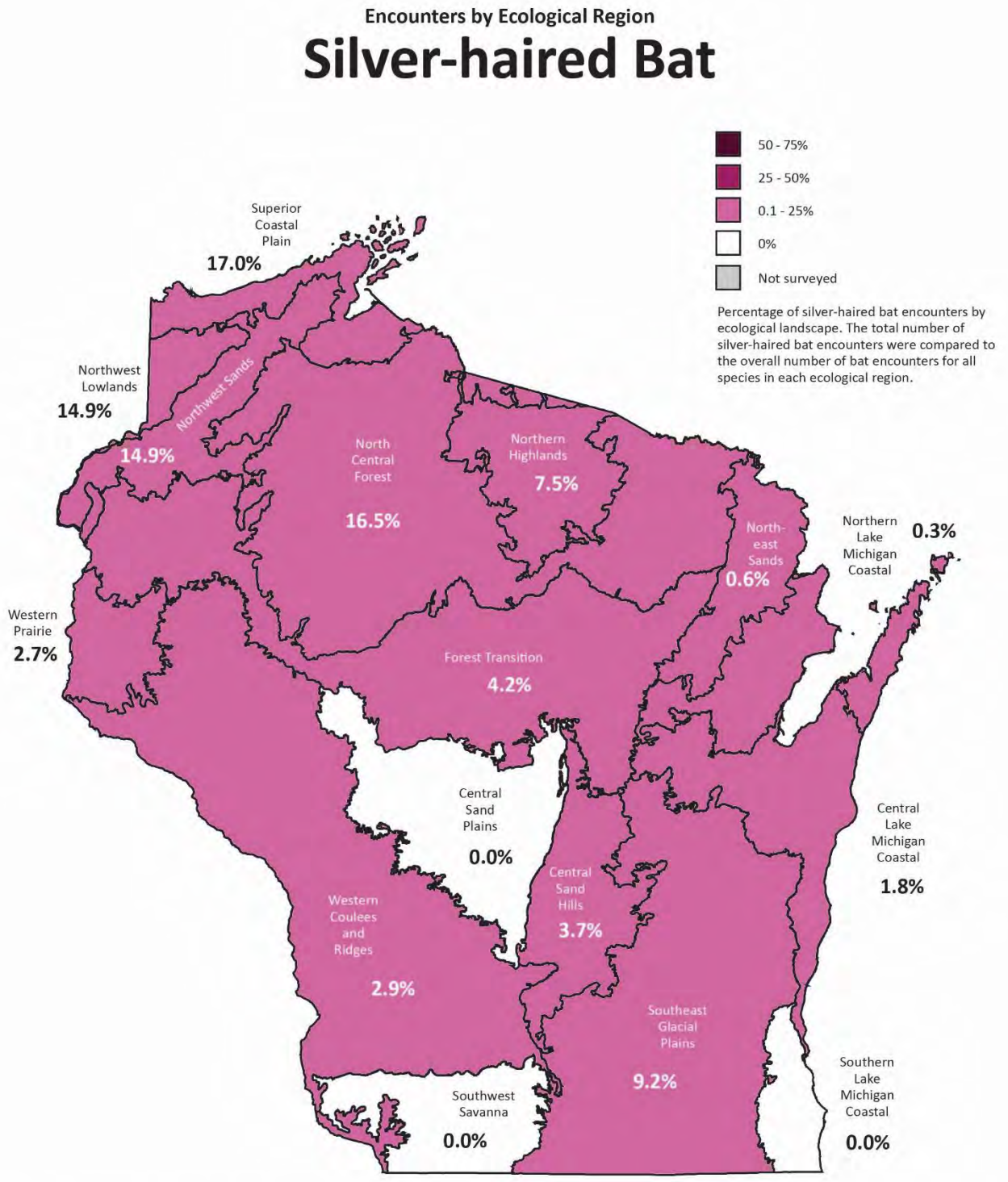


Figure 13. Silver-haired bat encounters accounted for 11.8% of all encounters recorded during driving surveys in 2023.

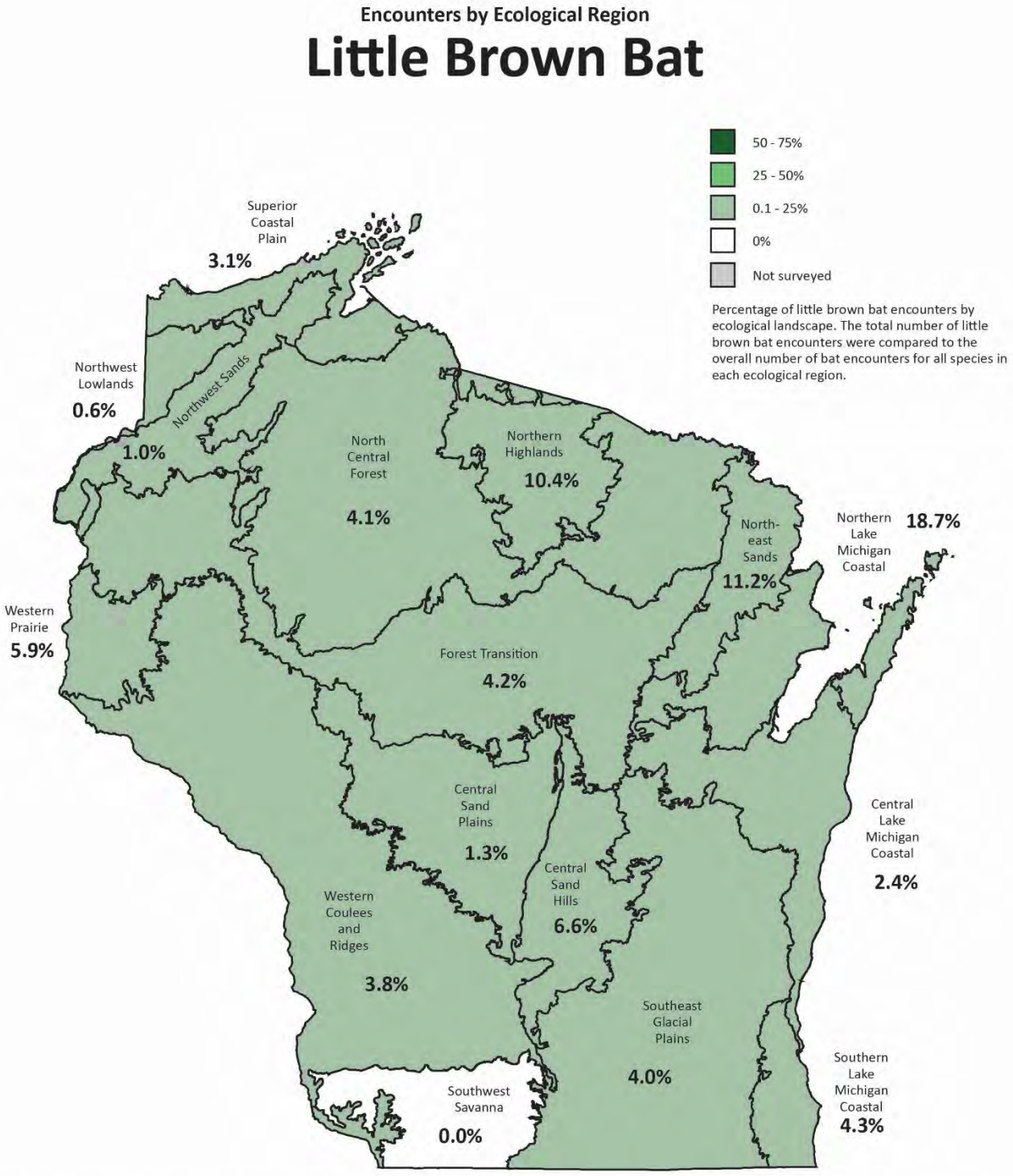


Figure 14. The little brown bat encounters accounted for 7.4% of all bat encounters recorded during driving surveys in 2023. Of note, little brown bat comprised 34.3% of all encounters in 2013 driving surveys.

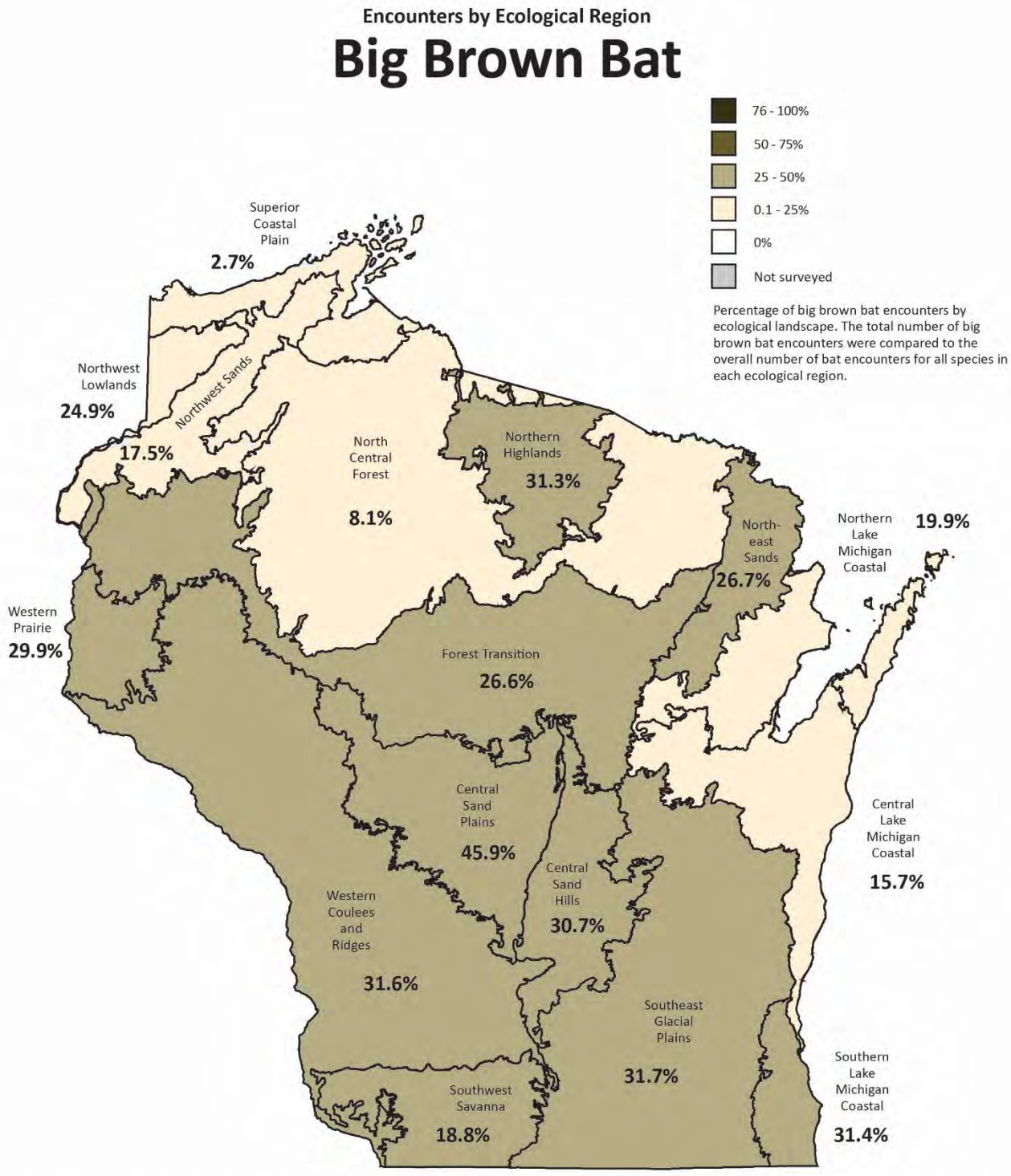


Figure 15. The big brown bat had the highest encounter rate (45.9%) in Central Sand Plains region, and comprised 35.2% of all bat encounters during driving surveys in 2023.

Appendix 3 Table 3. Total area surveyed in June-July 2023

Ecological Landscape	No. Surveys	Total Kilometers	Total Miles	Acres surveyed	Hectares surveyed
CLMC 1	2	105.2	65.4	396.4	160.4
CLMC 2	3	173.1	107.6	652.1	263.9
CSH 1	4	203.8	126.7	767.9	310.8
CSP 1	3	137.9	85.7	519.4	210.2
FT 1	3	152.7	94.9	575.2	232.8
FT 2	3	160.4	99.6	603.6	244.3
FT 3	3	147.6	91.7	555.8	224.9
FT 4	3	165.6	102.9	623.6	252.4
FT 5	3	161.6	100.4	608.5	246.2
NCF 1	3	149.9	93.2	564.8	228.6
NCF 2	3	176.1	109.4	663.0	268.3
NCF 3	3	147.8	91.8	556.4	225.2
NCF 4	3	224.4	139.4	844.8	341.9
NES 1	3	156.8	97.4	590.3	238.9
NH 1	2	100.2	62.3	377.6	152.8
NLMC 1	3	158.3	98.3	595.8	241.1
NLMC 2	2	99.9	62.1	376.4	152.3
NWL 2	3	144.4	89.7	543.6	220.0
NWS 1	3	159.2	98.9	599.4	242.6
NWS 2	2	100.1	62.2	377.0	152.6
SCP 2	3	178.3	110.8	671.5	271.8
SCP 3	3	167.9	104.3	632.1	255.8
SGP 1	3	120.0	74.6	452.1	183.0
SGP 2	3	125.7	78.1	473.3	191.6
SGP 3	3	148.0	91.9	557.0	225.4
SGP 4	2	97.7	60.7	367.9	148.9
SGP 5	3	160.3	99.6	603.6	244.3
SLMC 1	4	149.4	92.8	562.4	227.6
SWS 1	3	159.9	99.4	602.4	243.8
WCR 1	3	171.9	106.8	647.3	261.9
WCR 2	3	174.4	108.4	657.0	265.9
WCR 3	3	157.4	97.8	592.7	239.9
WCR 4	3	149.5	92.9	563.0	227.9
WCR 5	3	149.1	92.7	561.8	227.4
WCR 6	3	167.8	104.3	632.1	255.8
WP 1	3	157.2	97.7	592.1	239.6
Total	**105**	**5510.4**	**3424.0**	**20560.0**	**8320.4**
Mean	**2.9**	**151.5**	**94.1**	**571.1**	**231.1**

AnaBat Acoustic Transects (USFS Protocol 2012):[Transect length (miles) x 5280 feet/1 mile x Width of the AnaBat field of detection* (feet)] divided by 43,560 feet/acre = X acres

*Assuming a 50 foot field of detection

Appendix 4. The following Figures (16-17) depict the big brown bat and hoary bat.

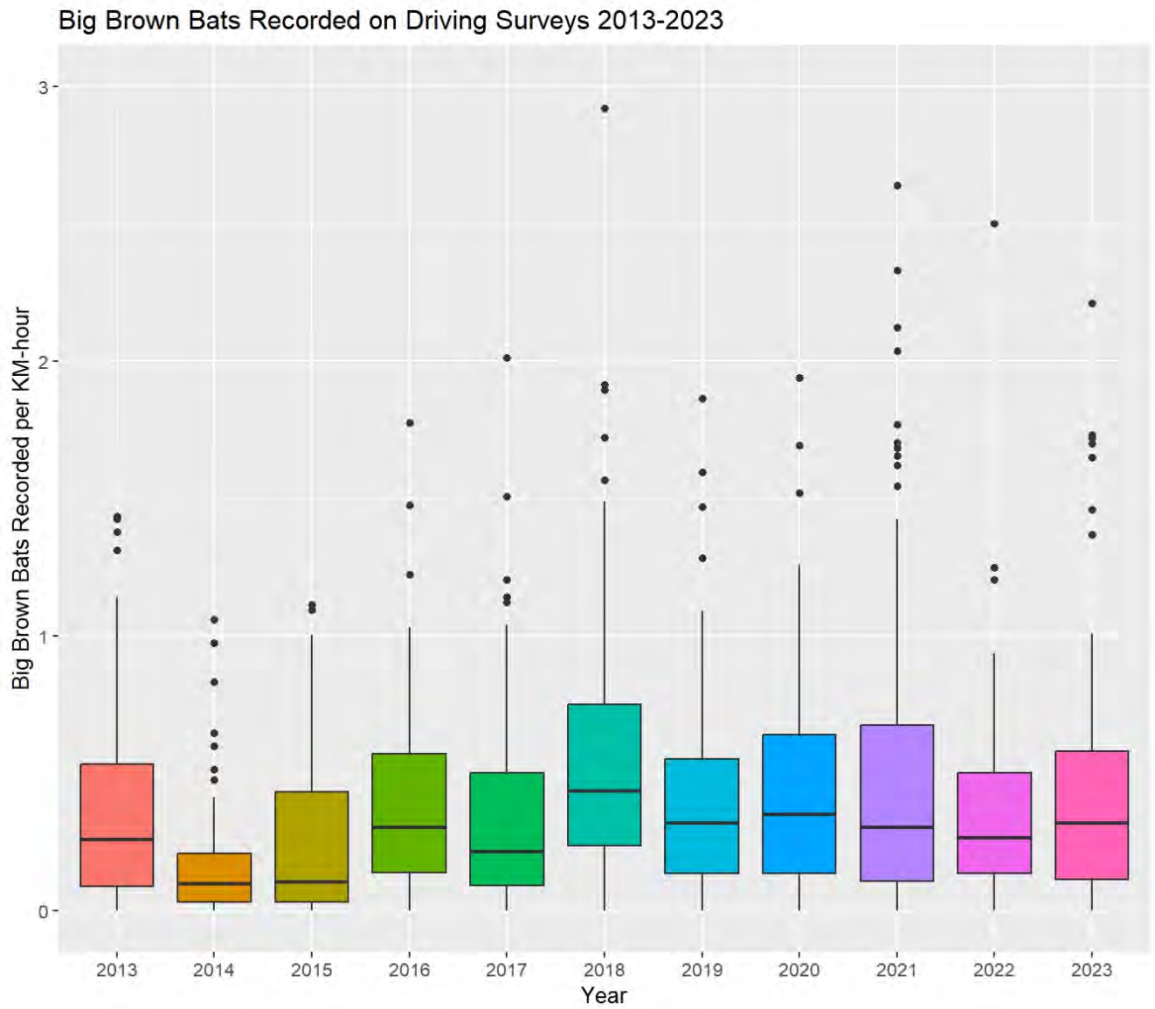


Figure 16. Big brown bat passes per kilometer hour by year. The bar is median, the outside edges of the boxes are 1st and 3rd quartiles, and the whiskers are, upper whisker = Q_3 + 1.5 * IQR, lower whisker = min. IQR is interquartile range.

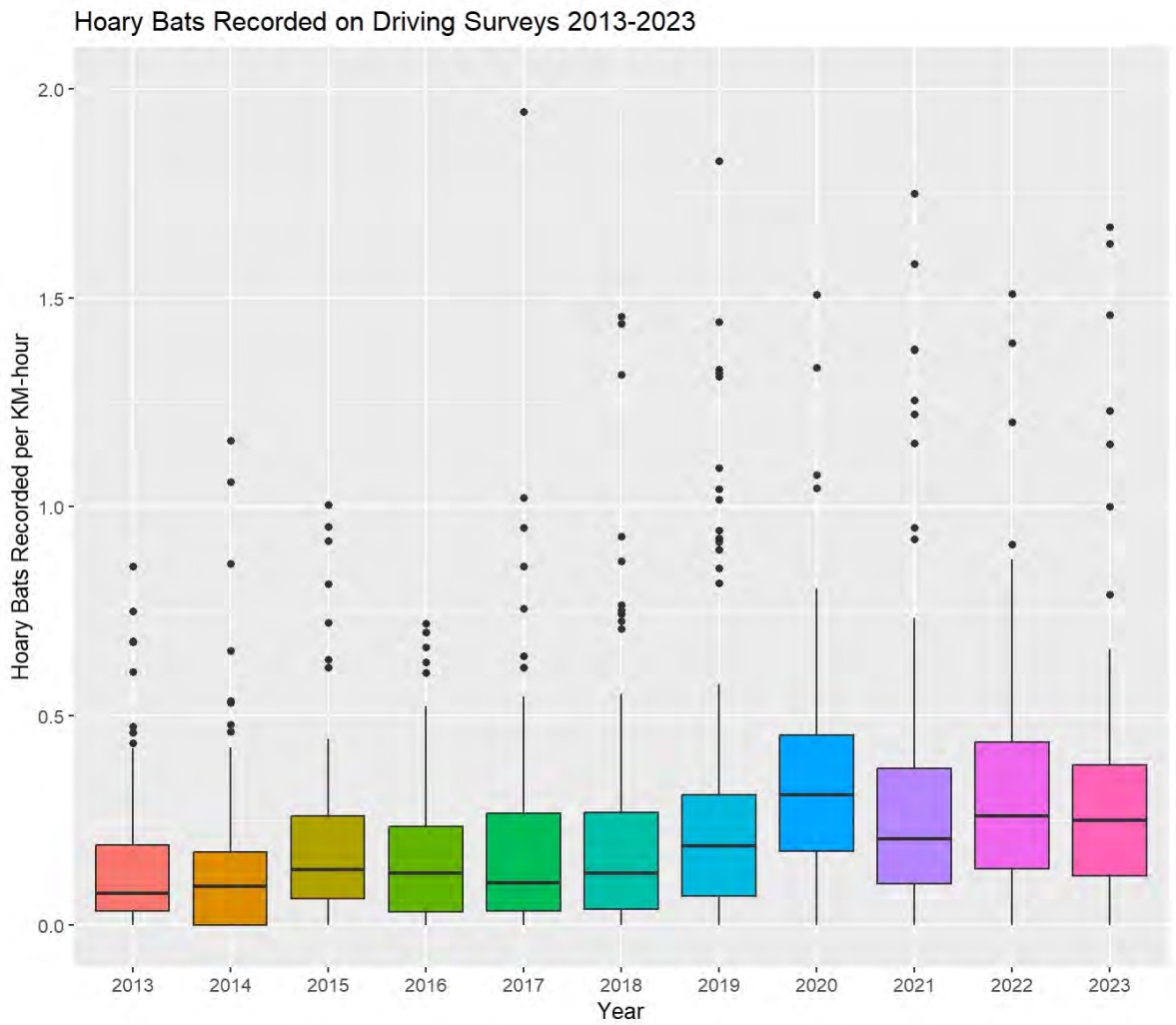


Figure 17. Hoary bat passes per kilometer hour by year. The bar is median, the outside edges of the boxes are 1st and 3rd quartiles, and the whiskers are, upper whisker = Q_3 + 1.5 * IQR, lower whisker = min. IQR is interquartile range. Hoary bat passes per km/hr were significantly higher in 2020 than previous years, but not statistically significantly different from 2023 which is also significantly higher than 2013-2019.