Wisconsin Department of Natural Resources
Bureau of Natural Heritage Conservation
101 South Webster Street
Madison, WI 53703

In Brief

- There were 75 acoustic bat driving surveys conducted by 50 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 has consistently had the highest average bat calls per detector hour when compared to all other ecological landscapes (2013: 81.2, 2014: 75.4, 2015: 100.8 and 2016: 96.2).
- Of the 13 ecological landscapes with little brown bat detections in 2016, 10 of the 13 experienced declines in mean encounter rates when compared to the three-year average (2013-2015). There was an overall decline of -32.1% in little brown bat mean encounter rate when compared to the previous three year mean (min -88.8, max 51.7, SD 40.9).
- The declines in cave bats species vulnerable to white-nose syndrome, previously only seen on bat hibernacula counts, are now being observed in statewide summer acoustic bat data. While driving transects remain economically viable for assessing multiple bat species on a statewide scale, the driving survey still lacks in its ability to assess species distribution and abundance for species like the northern long-eared bat and eastern pipistrelle.

Introduction

In 2013, the Wisconsin Bat Program (WBP) expanded its offering of bat surveying opportunities by adding 37 predetermined driving bat surveys (transects). The 2016 survey season marks the fourth year of operation for the driving bat surveys. This report summarizes the methods and results from the driving survey transects that were conducted in Wisconsin in 2016 and also compares this year's data to the previous three years.

Methods

In order to better understand statewide changes in bat populations, emphasis was placed on repeating the 37 driving transects which were developed in 2013 by WBP in each of the 16 ecological landscapes (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 records bat activity by detecting ultrasonic echolocation calls emitted as bats forage and navigate across the landscape. These echolocation calls are saved on either a hand-held computer (personal data assistant) or directly to a compact flash card in the ultrasonic detector.

Surveyed routes in 2016 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 is required between replicates of the same transect. Routes were surveyed on evenings with weather conditions suitable for bat activity which included low wind (<30 mph), no precipitation and a daytime temperature of 50F° or above. 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 4.1t). Surveys were manually filtered to separate files containing bat encounters and ignore those with only extraneous noise from insects, birds, wind, road noise, and other sources of static. All acoustic data was processed through manual examination by one staff member who has >6 years of experience in identifying Wisconsin bat species and has an extensive call library from which to reference. Files with bat encounters were then categorized into one of the following seven species or species group categories: (1) hoary-LACI (*Lasiurus cinereus*), (2) big brown-EPFU (*Eptesicus fuscus*), (3) silver-haired-LANO (*Lasionycteris noctivagans*), (4) eastern red-LABO (*L. borealis*), (5) eastern pipistrelle-PESU (*Perimyotis subflavus*), (6) little brown-MYLU (*Myotis lucifugus),* (7) northern long-eared-MYSE (*M. septentrionalis*), (8) big brown/silver-haired, (9) eastern pipistrelle/eastern red, (10) little brown/northern long-eared, (11) low frequency and (12) high frequency. 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 (fragmented), the bat pass did not contain search-phase calls, or general uncertainty. In order to compare our results year-to-year and to other state-wide acoustic inventories, results were evaluated using a bat encounters-per-detector-hour metric to mitigate for variations in driving speeds among surveyors.

Results

There were 75 surveys conducted by 50 individuals from Wisconsin Department of Natural Resources, Bad River Natural Resources Department (Tribal), U.S. Forest Service and citizen volunteers. Of those surveys, 71 (95%) returned complete acoustic results, down from all other years (77-2015, 77-2014, 92-2013). Of the 71 routes, 30.9 miles was the mean survey length, with the greatest distance being 45.4 miles (NCF4) and the shortest distance being 20.1 miles (NCF2). There was at least one route driven in each ecological landscape with the exception of the Northern and Southern Lake Michigan Coastal regions. Due to technical difficulties, four surveys were incomplete and were not included in the results, leaving valid data for 28 of the 37 routes. Technical issues ranged from loss of GPS data to surveyor error when setting the record options. 20,618 files were recorded on 71 surveys, 4,099 files (19.9%) were identified as bat encounters. Surveys had a mean of 33.4 bat calls per detector-hour which was the

Mean Bat Calls Per Detector Hour

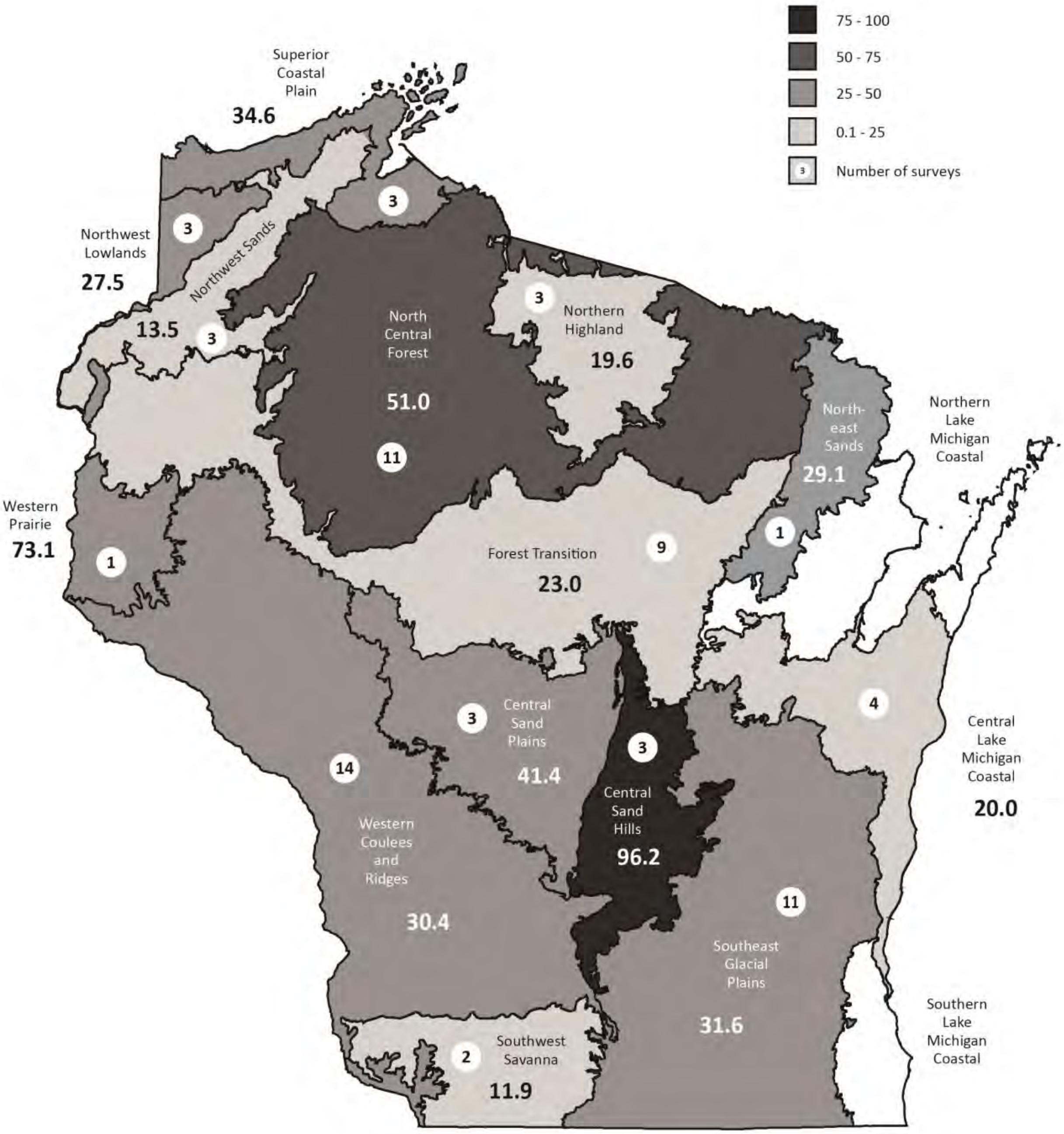


Figure 1. For the fourth year in a row, the highest mean bat calls per detector hour was the Central Sand Hills at 96.2 calls/detector/hour.

lowest observed average since the surveys began in 2013; with a minimum bat calls per-detector hour of 3.1 (SWS 1 on 8 June) and a maximum of 142.2 (CSH1 on 10 July). For four consecutive years, Central Sand Hills region had the highest average bat calls per detector hour (2013: 81.2, 2014: 75.4, 2015: 100.81, and 2016: 96.21) and the Central Lake Michigan Coastal region had the lowest average bat calls per detector hour (2016: 3.65) which was down considerably from last year at 11.18. Worth nothing, the Southern Lake Michigan Coastal route was not completed this year, which consistently had the lowest average bat calls per detector hour since the transects were created (2013: 12.8, 2014: 10.4, 2015: 14.1) (Figure 1). The number of call files per completed survey had a mean of 57.7 and ranged from 5 (SWS1 on 8 June) to 218 (CSH1 on 10 July). The number of mean bat calls per survey was the lowest since the surveys began in 2013. However there was a spike in mean calls during the June 16th through June 23rd time frame when compared to the three years prior; then mean calls abruptly dipped back down during the following week's surveys. Overall, the mean bat calls followed similar trajectories as other years, but were slightly lower than the average (Figure 3). Nearly a third of 2016 surveys (29.6%) had between 26-50 bat encounters detected, while 26.8% of completed surveys had between 51-75 bat encounters detected (Figure 4).

The big brown bat (27.2%), silver-haired bat (23.9%), eastern red bat (13.5%) and hoary bat (8.5%) experienced increases in the 2016 mean encounters frequency across all ecological regions when compared to the previous three year average(Figure 5). The three cave bat species most heavily affected by WNS (eastern pipistrelle: -288.0%, little brown bat: -32.1%, and northern long-eared bat: -7.9%) all observed declines in 2016 mean frequency across all ecological regions when compared to the three year average (Figure 6).

Of the 4,099 encounters, 1,675 (40.9%) were classified into species groups: high frequency group (598), low frequency group (527), big brown/silver-haired (476), eastern red/eastern pipistrelle (53) and little brown/northern long-eared (21) because the bat passes have similar characteristics to two or more species. The remaining 2,424 (59.1%) files were classified as big brown (34.1%), eastern red (25.5%), little brown (21.2%), hoary (15.1%), silver-haired (4.0%), eastern pipistrelle (0.2%) and the northern long-eared bat (0.0%). Among the 14 ecological regions that were surveyed (missing Northern and Southern Lake Michigan Coastal regions), big brown bats (n=8 regions) were the most commonly encountered species followed by the eastern red bat (n=3 regions) and the hoary bat (n=2 regions) (Figure 7) (Table 2). Of note, the little brown bat was the most commonly encountered species in five regions last year.

Figure 2. Total number of surveys by week and average number of bat calls per survey by week, 2016. Partial surveys (n=4) excluded.

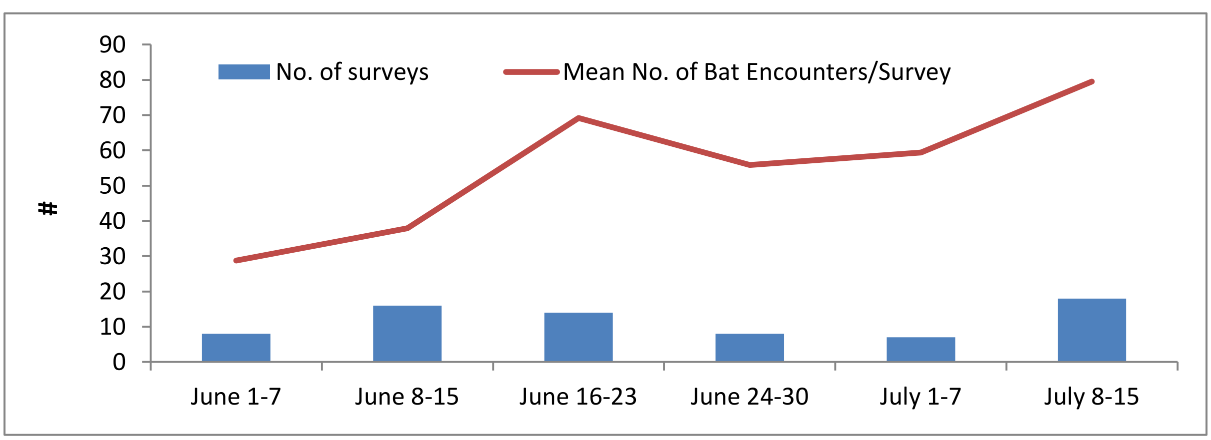


Figure 3. Comparison of mean calls per detector hours over time from 2013-2016 driving routes.

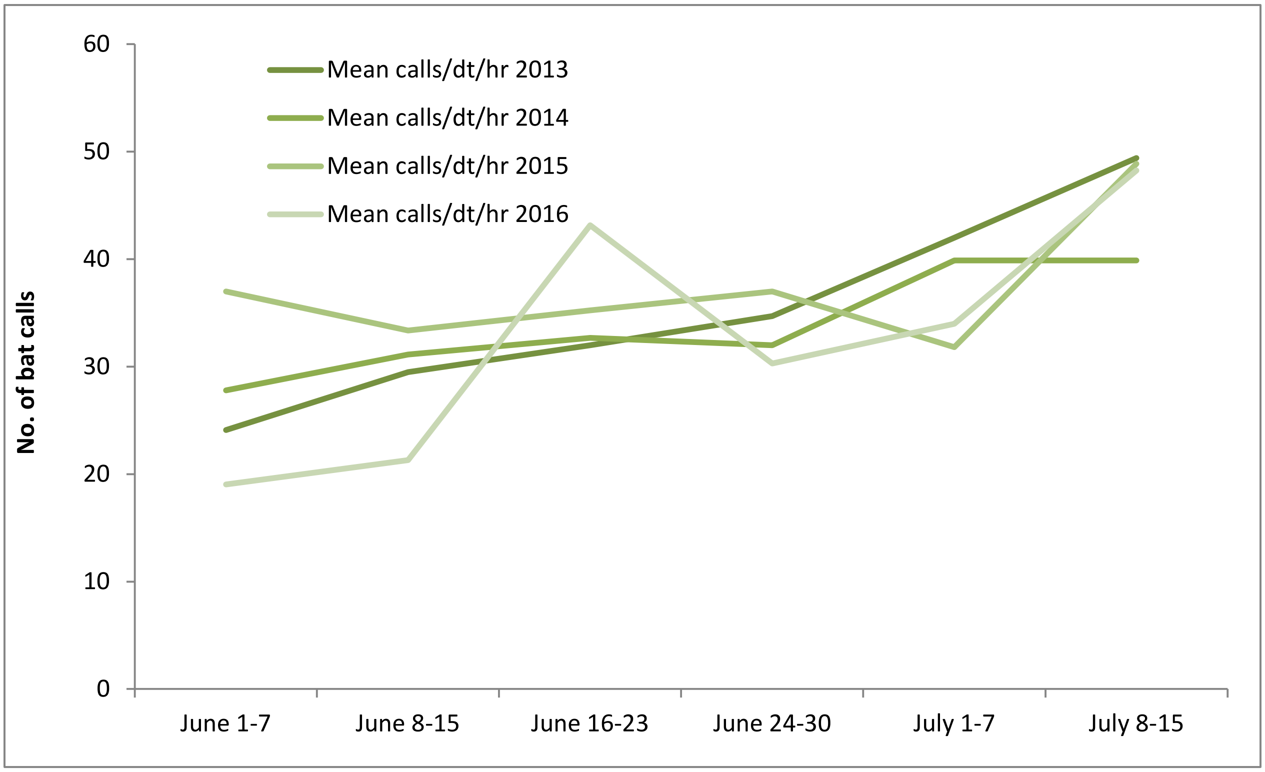


Figure 4. A comparison of the number of bat calls detected from 2013-2016.

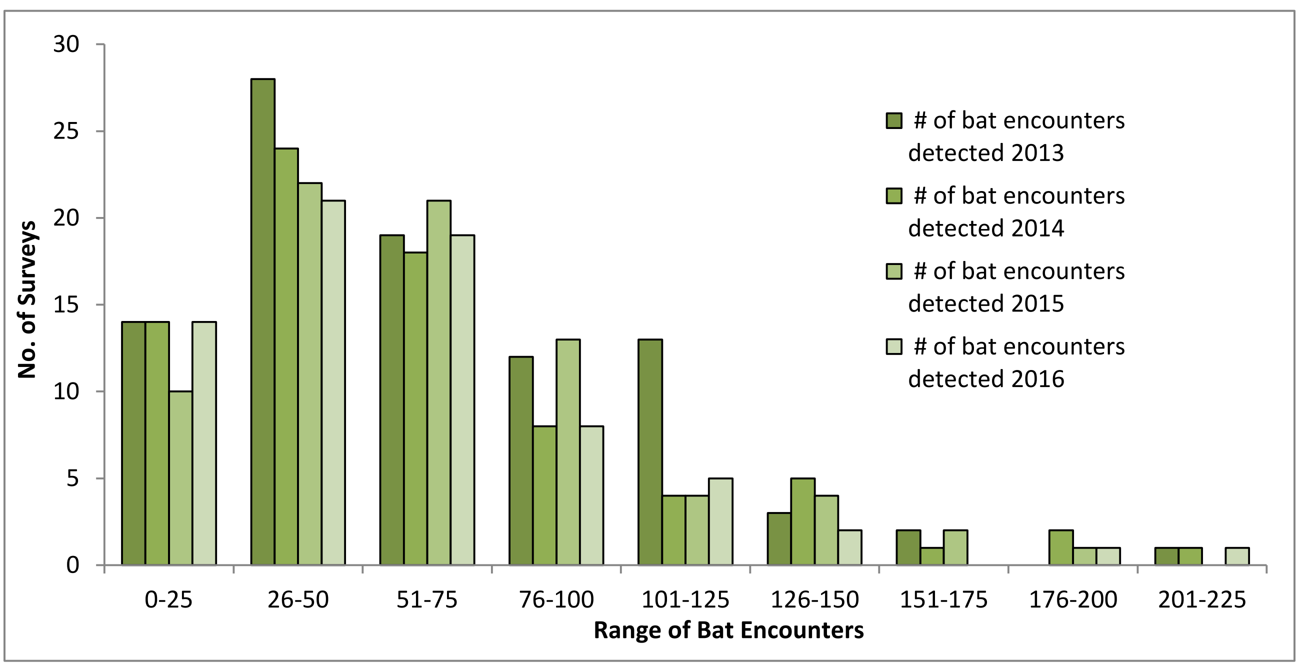
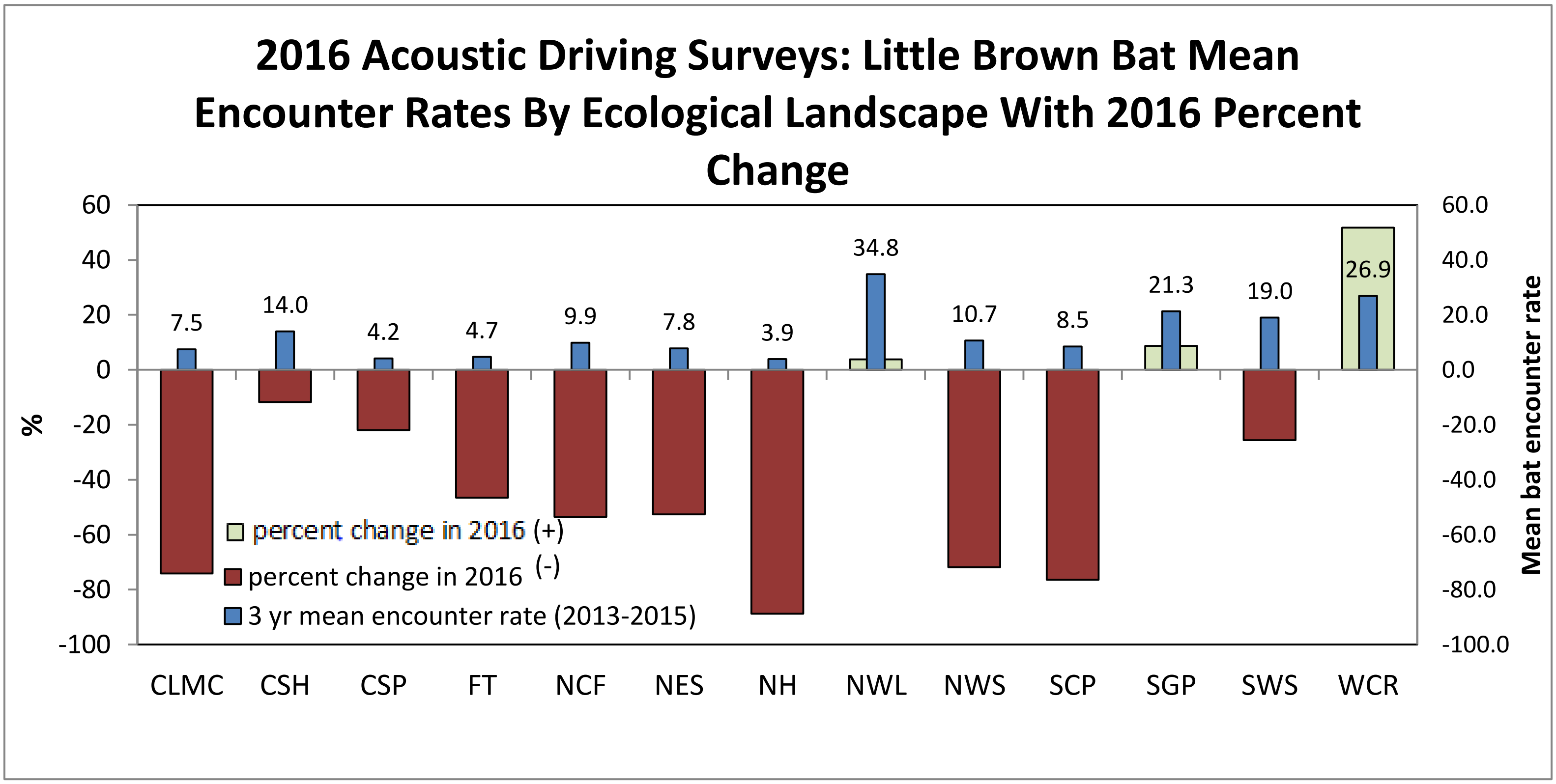
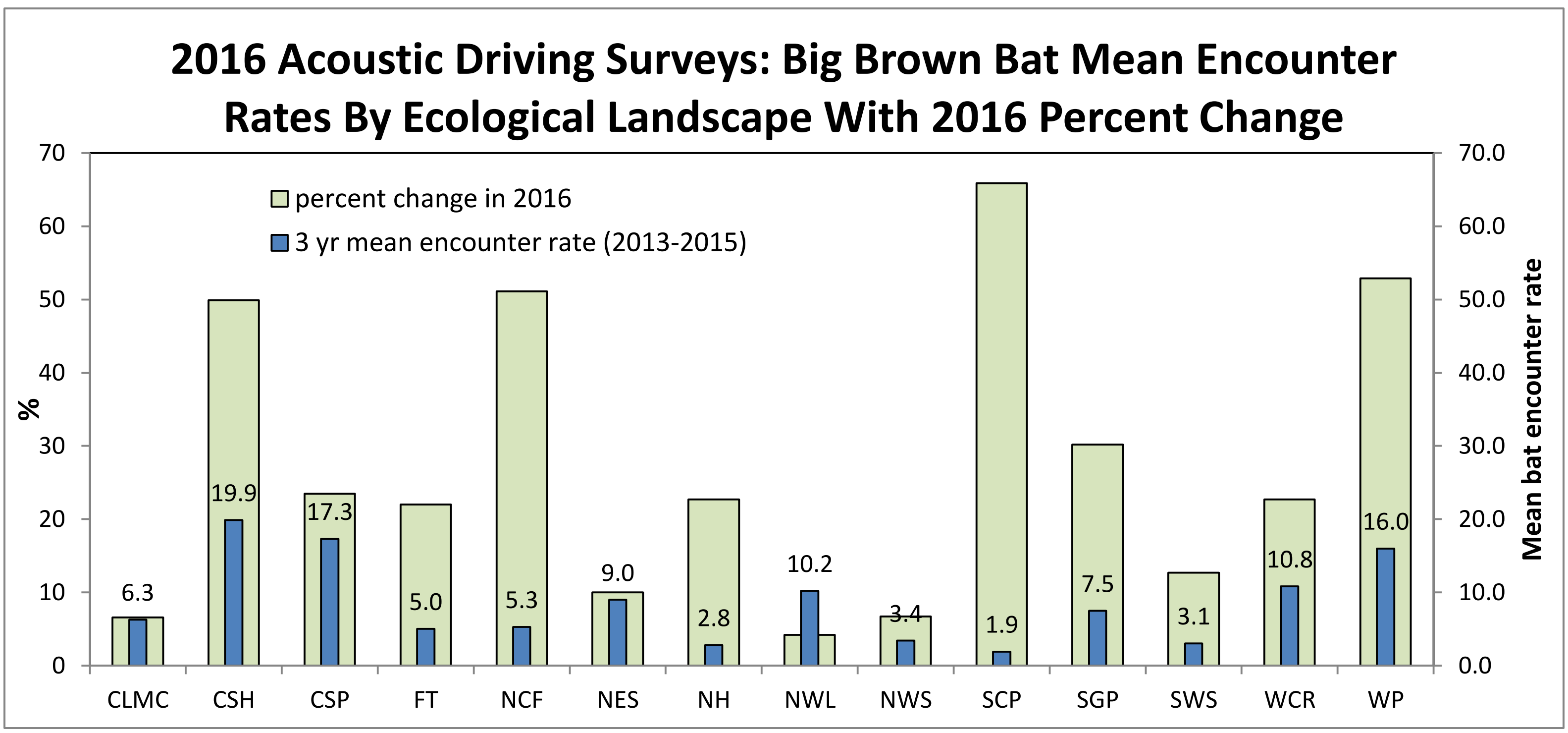


Figure 5 and 6. Percent change of bat encounters on 2016 acoustic driving surveys from the 3 year mean is represented on the primary axis. The secondary axis represents a comparison of mean bat encounter rates from 2013-2015 to 2016 mean encounter rates by ecological landscape. Note, if a landscape was not surveyed in 2016 (i.e. NLMC & SLMC) or a species had not been detected previously, these landscapes were omitted from graphs as calculation of percent change is not possible.





Most Common Bat Species by Ecological Region

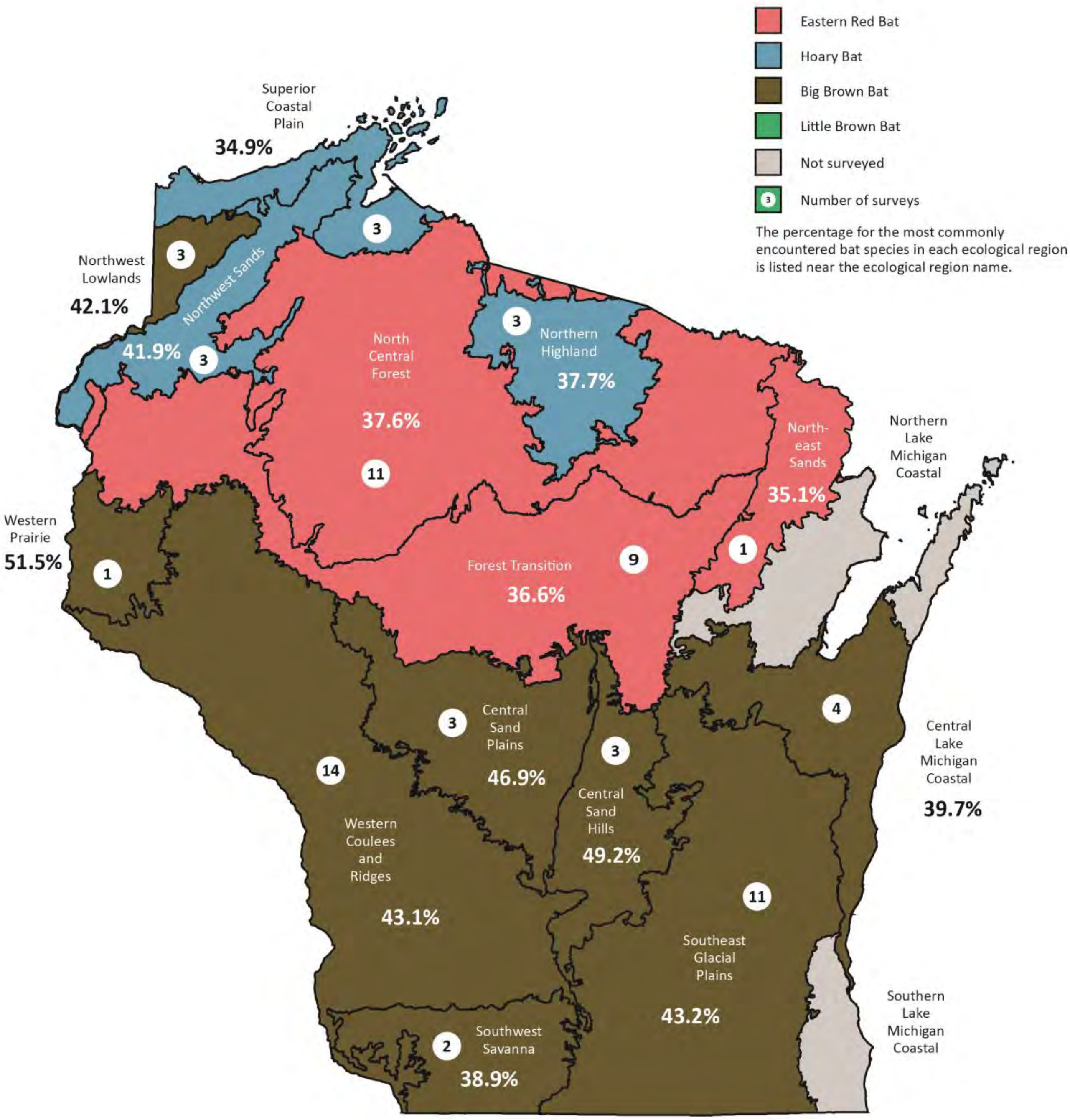


Figure 7. The most commonly encountered bat species by ecological region were the eastern red bat (3) hoary bat (3) and the big brown bat (8).

Figure 8. Mean bat calls per detector hour by ecological landscape (2013-2016). Boxes depict 50th and 75th percentiles, lines within boxes mark the median.

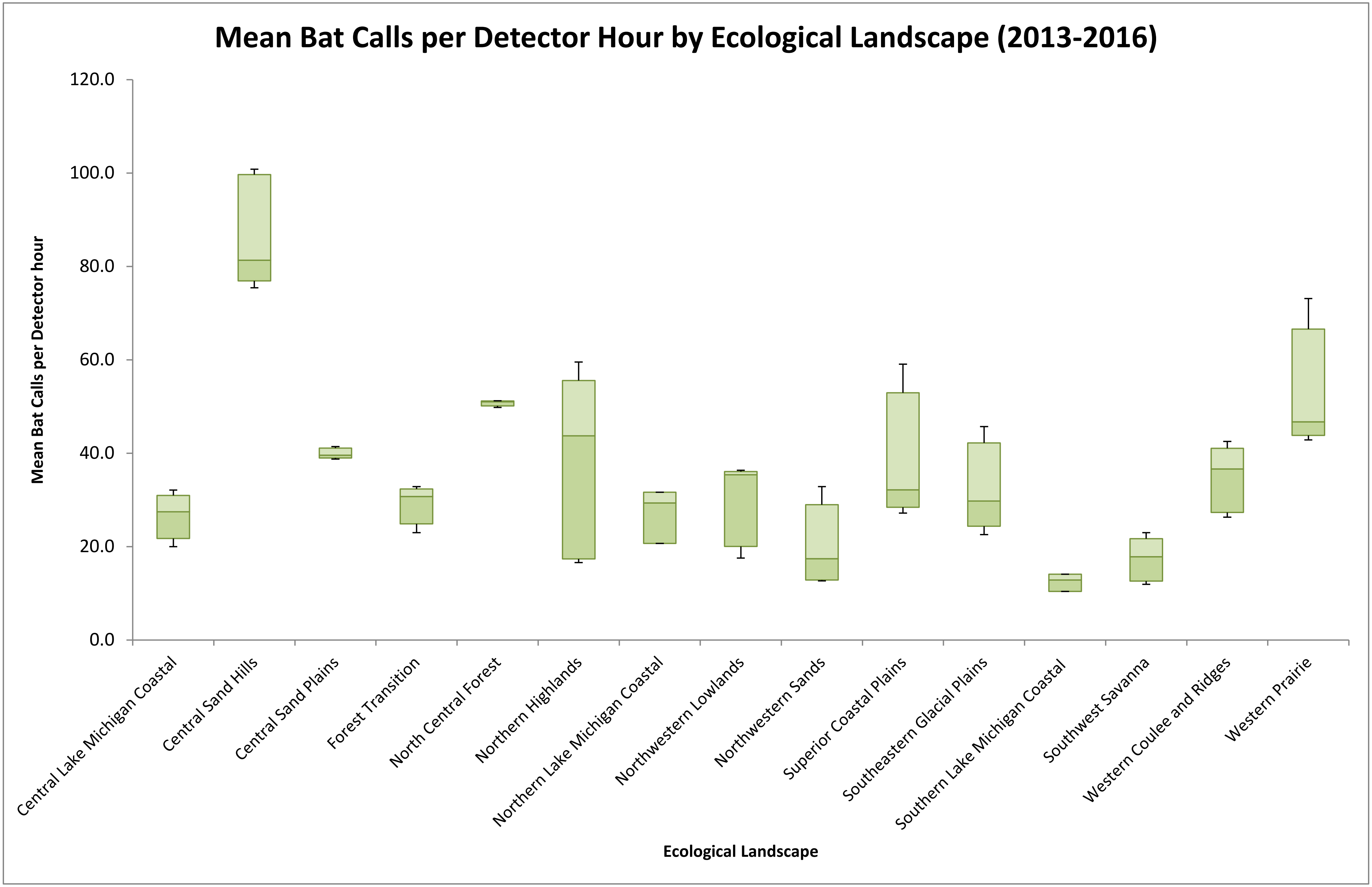


Table 1. Driving acoustic bat surveys (n=71) conducted in Wisconsin, June-July 2016. Incomplete surveys (n=4) excluded.

Ecological landscape	No. Surveys	Total Miles	Total detector-mins	Total detector-hours	mean detector-hours	Mean Speed (mph)	Total Calls detected	Mean Distance/RT (mi)	Mean Calls per detector-hour
CLMC 1	3	124.3	271	4.5	1.5	20.3	120	30.7	25.5
CLMC 2	1	32.2	115	1.9	1.9	16.8	7	32.2	3.65
CSH 1	3	87.1	267	4.5	1.5	19.6	432	29.0	96.2
CSP 1	3	83.6	316	5.3	1.8	15.9	217	27.9	41.4
FT 1	3	92.5	301	5.0	1.7	18.4	155	30.8	30.9
FT 3	3	96.0	295	4.9	1.6	19.5	97	32.0	19.8
FT 4	3	100.7	313	5.2	1.7	19.3	96	33.6	18.2
NCF 1	2	59.2	235	3.9	2.0	15.5	155	29.6	43.1
NCF 2	3	86.4	305	5.1	1.7	17.0	205	28.8	40.2
NCF 3	3	90.0	275	4.6	1.5	19.6	403	30.0	88.0
NCF 4	3	136.3	439	7.3	2.4	18.6	221	45.4	30.2
NES 1	1	31.3	97	1.6	1.6	19.3	47	31.3	29.1
NH 1	3	89.6	372	6.2	2.1	14.5	121	29.9	19.6
NWL 2	3	86.5	309	5.2	1.7	17.0	147	28.8	27.5
NWS 2	3	91.6	360	6.0	2.0	15.3	81	30.5	13.5
SCP 2	3	110.1	382	6.4	2.1	17.3	221	36.7	34.6
SGP 1	3	77.3	225	3.7	1.3	20.7	132	25.8	35.4
SGP 2	2	48.3	165	2.8	1.4	17.6	80	24.1	29.0
SGP 3	2	59.6	188	3.1	1.6	19.3	79	29.8	26.7
SGP 4	3	84.4	271	4.5	1.5	18.7	152	28.1	33.5
SGP 5	1	32.4	74	1.2	1.2	26.2	37	32.4	30.0
SWS 1	2	59.7	184	3.1	1.5	19.5	36	29.9	11.9
WCR 1	3	100.6	311	5.2	1.7	19.4	221	33.5	42.9
WCR 2	2	66.4	243	4.1	2.0	16.5	96	33.2	24.1
WCR 3	3	91.4	310	5.2	1.7	17.7	204	30.5	39.3
WCR 4	3	89.5	285	4.8	1.6	18.9	145	29.8	30.6
WCR 5	3	89.0	377	6.3	2.1	14.7	86	29.7	13.1
WP 1	1	30.2	87	1.5	1.5	20.8	106	30.2	73.1
Total	**71**	**2226**	**7372**	**123**			**4099**		
Mean	**2.5**	**79.5**	**263.3**	**4.4**	**1.7**	**18.4**	**146.4**	**30.9**	**34.3**

Table 2. Mean number of encounters by species or species group per route during driving acoustic surveys in Wisconsin, June-July 2016. The category "All bats" represents total mean encounters of all species and species groups per route. Data are listed in an approximated north-to-south direction by, and within, ecological region. Incomplete surveys (n=4) excluded.

Location	No. Surveys	Big brown	Hoary	Eastern red	Silver-haired	Little brown	Eastern Pipistrelle	Northern long-eared	Little brown/Northern long-eared	Eastern red/Eastern pipistrelle	Big brown/Silver-haired	Unclassified	All Bats
Central Lake Michigan Coastal													
CLMC1	3	8.33	5.00	5.00	1.67	1.00	0.00	1.00	0.00	0.00	8.33	10.70	**20.00**
CLMC2	1	2.00	1.00	1.00	0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.50	**3.00**
Central Sand Hills													
CSH1	3	39.67	5.33	4.33	0.67	30.67	0.00	0.00	0.33	0.67	17.00	22.67	**94.00**
Central Sand Plains													
CSP1	3	22.67	6.67	10.67	0.00	8.33	0.00	0.00	0.00	0.00	5.67	9.17	**32.33**
Forest Transition													
FT1	3	7.00	1.00	15.00	0.00	9.00	0.00	0.00	0.33	0.00	5.00	7.17	**28.67**
FT3	3	7.00	2.67	5.67	1.33	3.67	0.00	0.00	0.00	0.67	3.00	4.17	**15.67**
FT4	3	5.33	3.33	5.33	3.67	1.00	0.00	1.00	0.00	0.00	4.00	4.67	**14.33**
North Central Forest													
NCF1	2	3.00	14.50	22.00	2.50	6.00	0.00	0.00	0.50	0.50	8.00	10.25	**35.50**
NCF2	3	14.33	6.67	15.33	2.00	3.67	0.00	0.00	1.00	2.00	6.00	8.67	**30.00**
NCF3	3	15.33	8.67	28.33	3.33	20.00	0.00	0.00	0.67	0.33	21.33	18.17	**78.67**
NCF4	3	8.00	12.00	14.67	1.00	8.67	0.00	0.00	0.67	0.33	8.67	9.83	**38.00**
Northeastern Sands													
NES	1	10.00	5.00	13.00	0.00	9.00	0.00	0.00	0.00	0.00	3.00	3.50	**19.00**
Nothern Highlands													
NH1	3	3.67	9.67	6.33	3.00	3.00	0.00	0.00	0.00	0.00	3.33	5.67	**17.67**
Nortwest Lowland													
NWL2	3	10.67	1.33	8.33	0.67	4.33	0.00	0.00	0.33	0.33	5.67	8.67	**28.00**
Northwest Sands													
NWS2	3	3.67	6.00	0.67	2.67	1.33	0.00	0.00	0.00	0.33	5.33	3.50	**14.00**
Superior Coastal Plain													
SCP2	3	5.67	15.00	12.00	8.00	2.33	0.00	0.00	0.00	0.33	11.67	9.33	**33.00**
Southeast Glacial Plains													
SGP1	3	12.00	0.67	2.00	0.00	11.67	0.00	0.00	0.33	1.00	2.67	6.83	**29.33**
SGP2	2	6.50	1.50	10.50	0.00	5.00	0.00	0.00	0.00	1.00	3.00	6.25	**21.50**
SGP3	2	16.00	1.50	2.00	0.00	2.50	0.00	0.00	0.50	0.50	6.00	5.25	**20.00**
SGP4	3	9.00	1.67	2.33	1.00	13.33	0.00	0.00	0.33	0.67	6.33	8.00	**36.67**
SGP5	1	10.00	4.00	3.00	0.00	4.00	0.00	0.00	1.00	1.00	3.00	5.50	**20.00**
Southwest Sands													
SWS1	2	3.50	2.50	3.00	0.00	0.00	0.00	0.00	0.00	3.00	1.50	2.25	**9.00**
Wester Coulee and Ridges													
WCR1	3	21.33	6.67	9.67	0.00	9.00	0.67	0.00	0.33	2.00	4.67	9.67	**36.00**
WCR2	2	8.50	2.00	5.00	1.00	6.00	1.00	0.00	0.50	2.00	7.50	7.25	**31.50**
WCR3	3	19.67	1.67	13.33	0.67	4.67	0.00	0.00	0.00	0.33	10.00	8.83	**32.67**
WCR4	3	10.67	6.00	7.00	0.00	7.00	0.00	0.00	0.67	2.00	6.33	4.33	**24.67**
WCR5	3	8.00	3.33	5.33	0.00	1.33	0.00	0.00	0.33	1.33	0.67	4.17	**12.00**
Western Prairie													
WP1	1	34.00	1.00	2.00	0.00	29.00	0.00	0.00	1.00	1.00	10.00	14.00	**69.00**

Discussion

Surveyors drove over 2,100 miles on Wisconsin roads while surveying acoustic bat driving transects. Species encounter rates varied by ecological region with the highest mean encounter rate of big brown bats (39.7 EPFU) in the Central Sand Hills (Table 2). The most commonly encountered species on driving transects when combing ecological regions were big brown bats (6.7/detector/hr), eastern red bats (5.0/detector/hr), little brown bats (4.2/detector/hr) and hoary bats (3.0/detector/hr). Although the percentage of encounters per species varied by ecological region as seen in Appendix 2 (Figures 9-15), in general the tree bat species (eastern red bat, silver-haired bat and hoary bat) were more commonly observed in the northern third of Wisconsin.

As in previous years, eastern pipistrelle acoustic encounters remained extremely low (0.17% or 4 of 2424 bat passes). For the second year in a row, the northern long-eared bat remained undetected by acoustic driving transects in 2016, which, beyond the effects of WNS, could be a result of poor-quality echolocation calls, low intensity of calls of the species and habitat surveyed.

Table 3. A comparison of mean number of bat calls per detector by ecological landscape (2013-2016), including total number of surveys completed in each year.

Ecological Landscape	2013	2014	2015	2016	SD (S.E.)
CLMC	27.0 (4)	27.5 (3)	32.1 (3)	20.0 (4)	5.0 (2.5)
CSH	81.3 (3)	75.4 (3)	100.8 (3)	96.2 (3)	12.0 (6.0)
CSP	40.2 (3)	38.8 (3)	39.6 (3)	41.4 (3)	1.1 (0.6)
FT	30.4 (12)	32.9 (10)	30.7 (12)	23.0 (9)	4.3 (2.2)
NCF	51.0 (8)	49.8 (12)	51.2 (12)	51.0 (11)	0.6 (0.3)
NES	33.0 (1)	N/A	N/A	29.1 (1)	2.0 (2.8)
NH	59.5 (1)	43.7 (2)	16.6 (3)	19.6 (3)	2.8 (10.2)
NLMC	20.7 (4)	31.6 (4)	29.4 (3)	N/A	5.8 (3.3)
NWL	36.3 (4)	17.5 (3)	35.4 (3)	27.5 (3)	8.7 (4.4)
NWS	32.8 (5)	17.4 (1)	12.6 (3)	13.5 (3)	9.4 (4.7)
SCP	27.2 (4)	59.1 (4)	32.1 (5)	34.6 (3)	14.2 (7.1)
SGP	29.7 (15)	22.6 (9)	45.7 (8)	31.6 (11)	9.7 (4.2)
SLMC	12.8 (3)	10.4 (3)	14.1 (1)	N/A	1.9 (1.1)
SWS	14.8 (3)	17.8 (3)	23.0 (2)	11.9 (2)	4.7 (2.4)
WCR	42.5 (19)	26.3 (16)	36.6 (15)	30.4 (14)	7.1 (3.6)
WP	46.7 (3)	46.9 (2)	42.9 (1)	73.1 (1)	13.9 (7.0)
Mean (Total #)	***36.9 (91)***	***34.5 (78)***	***38.5 (77)***	***34.3 (71)***	***6.5 (3.9)***

The data continues to indicate that some bat species like the eastern pipistrelle and northern long-eared bat remain underrepresented which likely relates to their aversion for roads and roadside habitat (Roche et al., 2011, Whitby et al. 2014). But for some species, like the tree bat cohort (eastern red, hoary and silver-haired bats) who are not readily found in summer or winter colonies, acoustic surveys are the only method available for assessing distributions and occupancy, especially on statewide scale(Loeb et al., 2015).

The standard deviation has increased from less than 7.5 in 2015 to 23.6 in 2016 for the mean bat calls per detector hour, indicating the four years (2013-2016) of data is now getting farther from the mean as detection rates for WNS-impacted species like the little brown bat has decreased dramatically (Table 3). Interestingly, in the North Central Forest region, which is comprised of four survey routes and has had 43 surveys completed over a four-year period, has the lowest standard deviation (0.6) of any ecological landscape and has remained virtually unchanged since the surveys began in 2013 (Figure 8).

At the time of writing, white-nose syndrome or the causative fungal agent had been detected in 42 sites in 14 counties in Wisconsin, which included the largest three hibernating sites in the state (accounting for ~97% of the hibernating little brown bat population). The continual spread of this disease has caused steep declines among infected hibernating bat populations in Wisconsin as predicted by Peery et al. (2013) who discussed the potential impacts of white-nose syndrome on Wisconsin's cave bats through their spatial modeling approach. Just as eastern states reported significant declines in summer foraging activity (Ford et al., 2011), the losses observed in the winter in Wisconsin are now being observed in the summer through the efforts of citizen-based bat monitoring projects. The -32.1 % mean decrease in little brown bat detections from the 2016 driving transect data is just one metric to understand the effects of WNS. Another, possibly more sobering metric is the increasing reports of vanishing bats and/or entire colonies by those who monitor cave bat maternity colonies (Kaarakka, 2016). The winter and summer losses remain dissimilar which is likely due to adjacent states harboring hibernating populations of bats that use Wisconsin as summer habitat, but each describe a changing landscape where cave bat densities are declining. The little brown bat, once considered by Hartley T. Jackson in Mammals of Wisconsin (1961) as "the most abundant bat in Wisconsin" is now on a downward trajectory that could likely lead to regional extirpation within the foreseeable future. The declines described in this report should not discourage volunteers; rather it should sharpen the focus of future bat monitoring efforts. Immediate information about changing bat communities derived from acoustic bat monitoring efforts will highlight surviving populations allowing for a more concerted and cost-effective conservation strategy.

Acknowledgements

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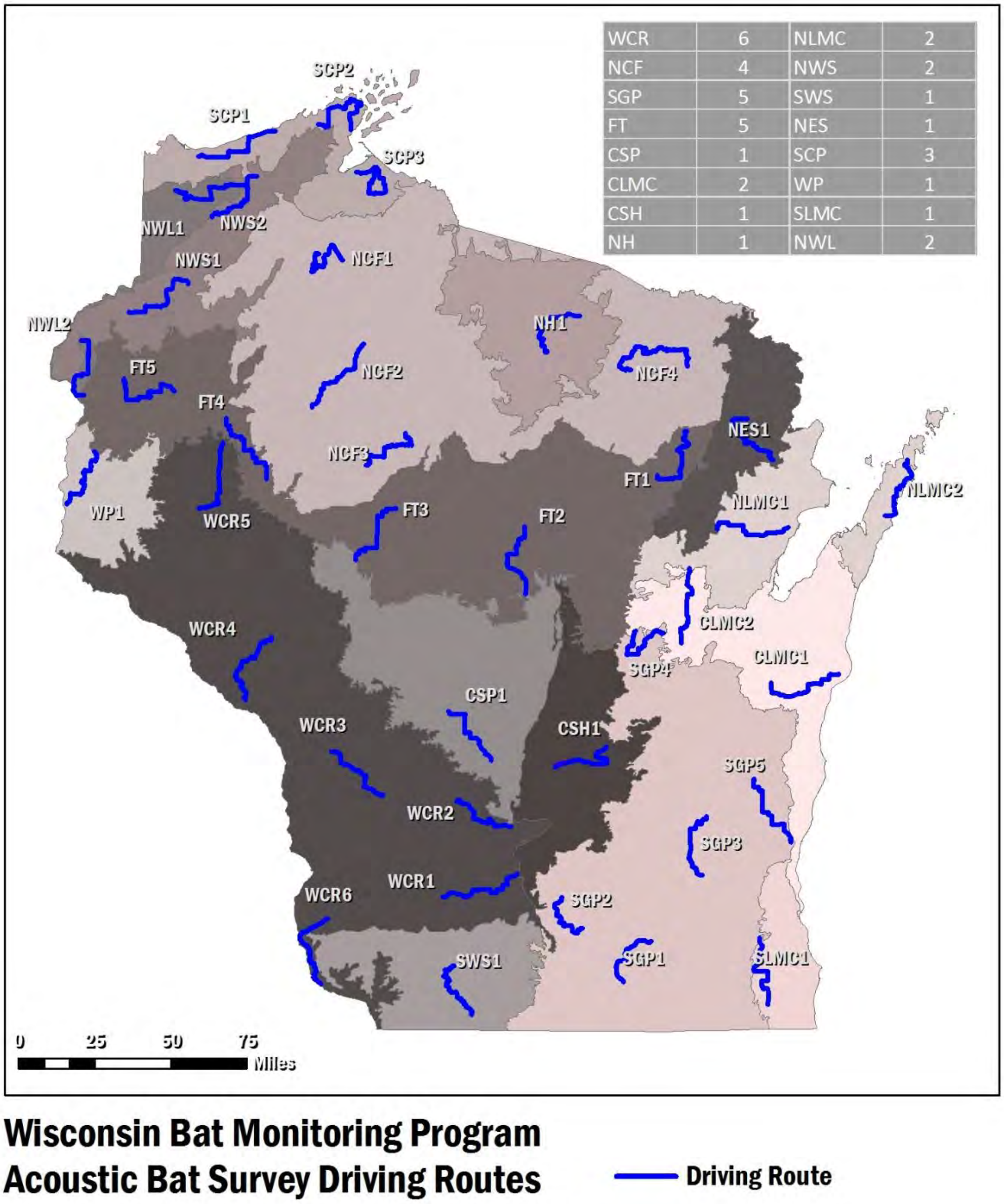
Appendix 1 Acoustic Bat Driving Transects by Ecological Landscape



Ecological Landscapes: Central Lake Michigan Coastal (CLMC), Central Sand Hills (CSH), Central Sand Plains (CSP), Forest Transition (FT), North Central Forest (NCT), Northeast Sands (NS), Northern Highland (NH), Northern Lake Michigan Coastal (NLMC), Northwest Lowlands (NL), Northwest Sands (NS), Southeast Glacial Plain (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 9-15) Bat species encounter by ecological landscape

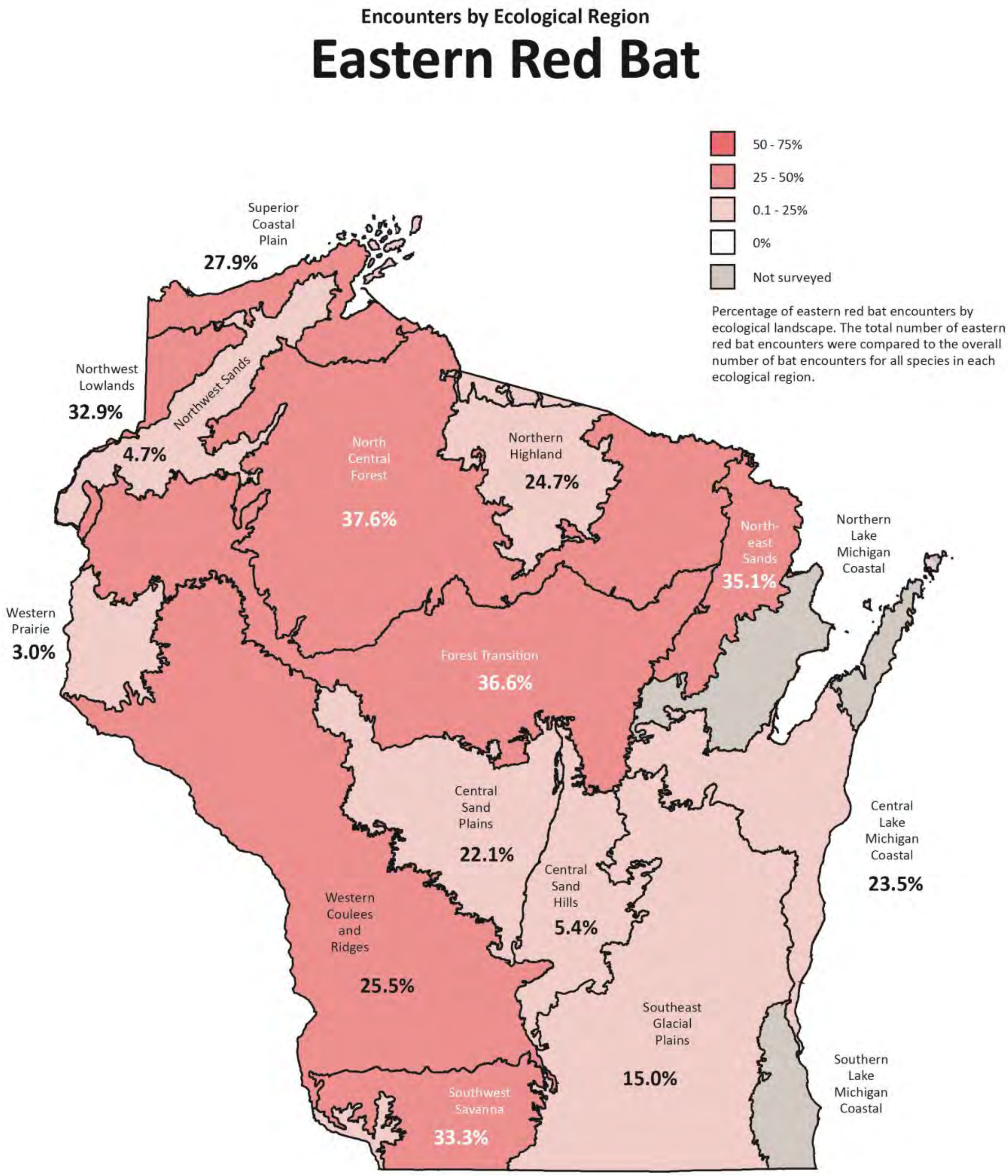


Figure 9. The eastern red bat encounters accounted for 37.6% of all encounters in the North Central Forest region.

Encounters by Ecological Region

Hoary Bat

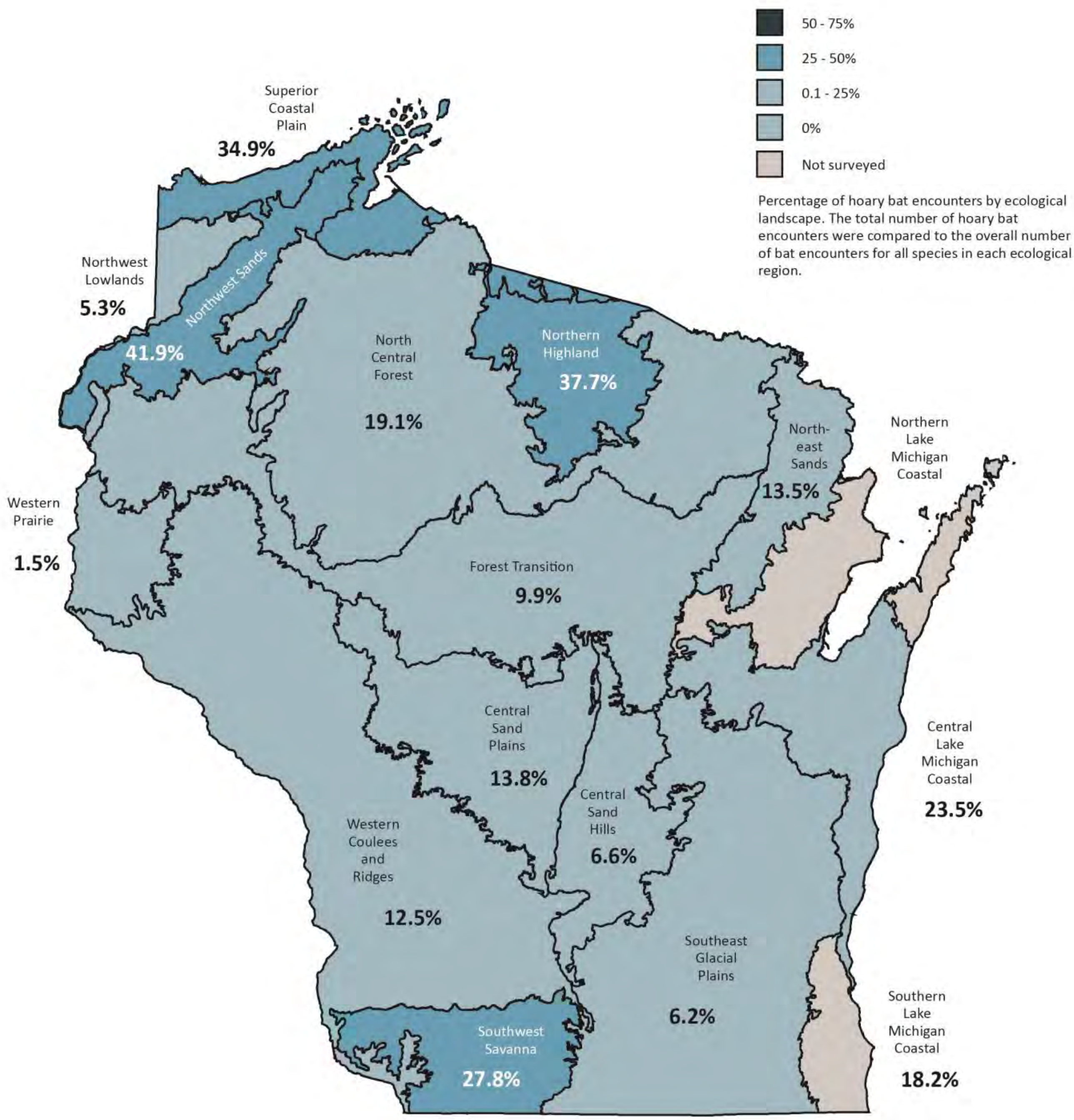


Figure 10. The hoary bat accounted for 41.9% of all encounters in the Northwest Sands region.

Encounters by Ecological Region

Silver-haired Bat

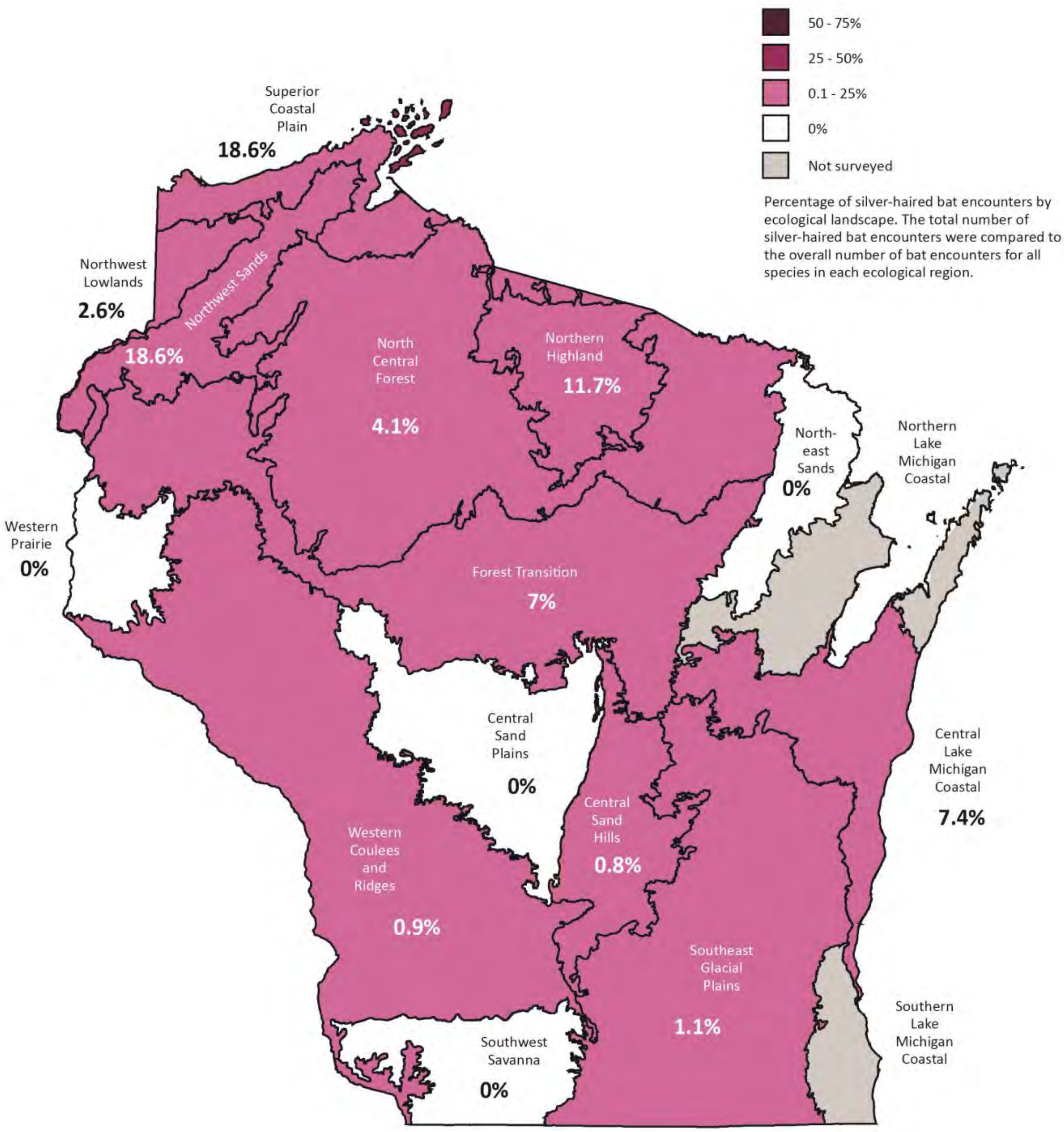


Figure 11. Silver-haired bat encounters accounted for 18.6% of all encounters in the Superior Coastal Plain region and the Northwest Sands region.

Encounters by Ecological Region

Little Brown Bat

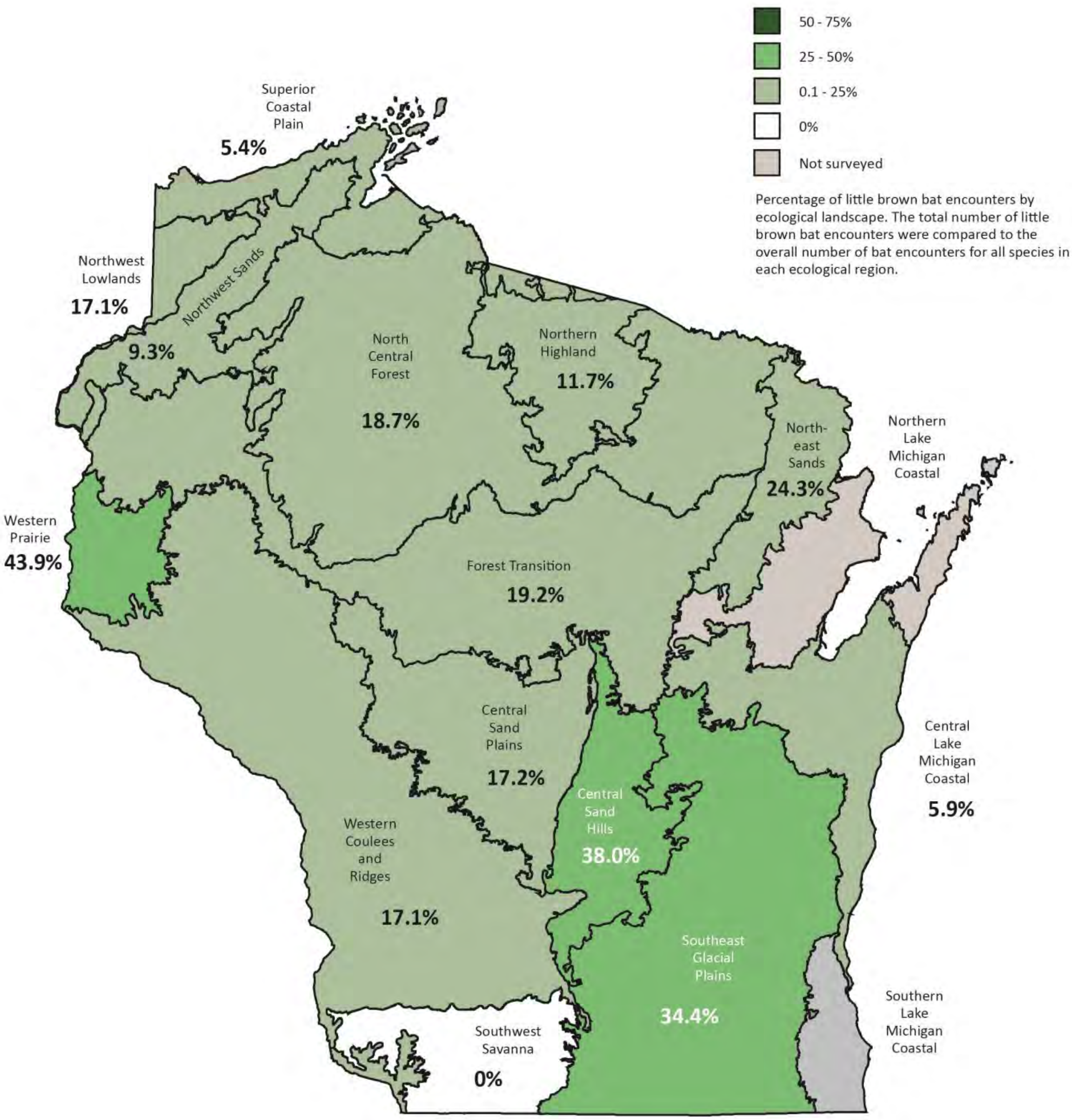


Figure 12. The little brown bat encounters accounted for 43.9% of all encounters in the Western Prairie region.

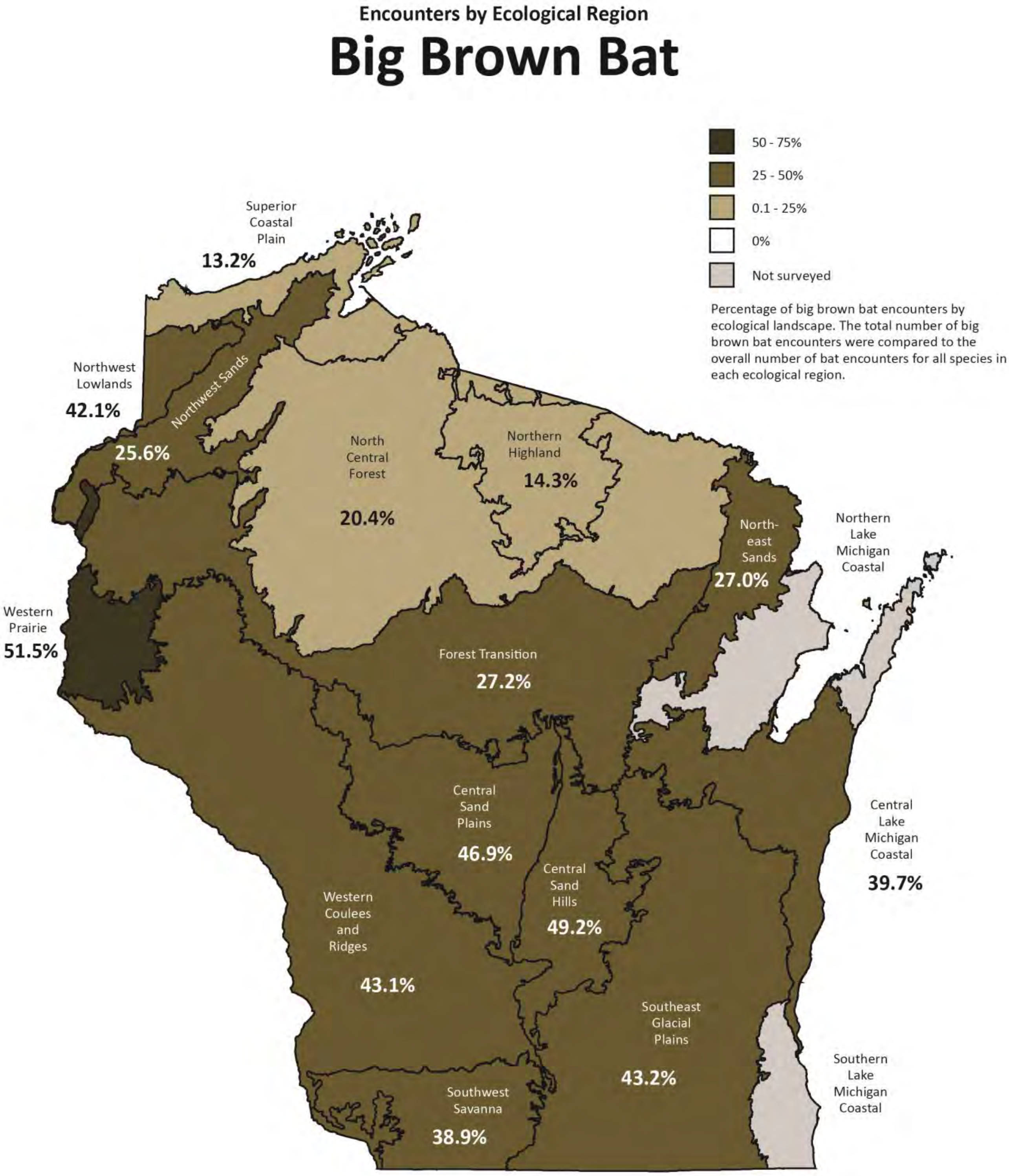


Figure 13. The big brown bat had the highest encounter rate (51.1%) in Western Prairie region.

Encounters by Ecological Region

Eastern Pipistrelle

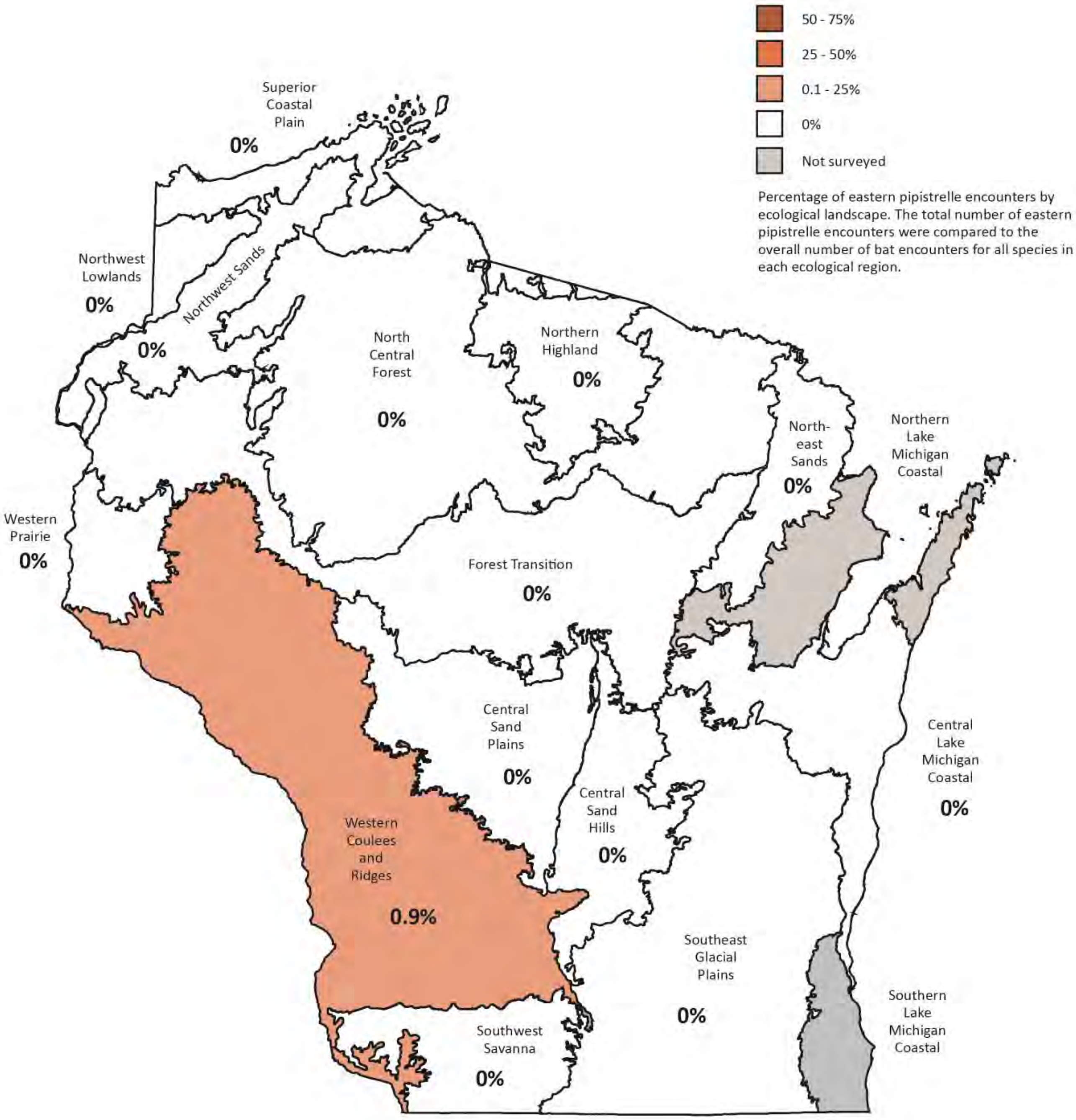


Figure 14. The eastern pipistrelle was only recorded in the Western Coulees and Ridges region in 2016 compared to data from 2015, where it was observed in four ecological regions.

Encounters by Ecological Region

Northern Long-eared Bat

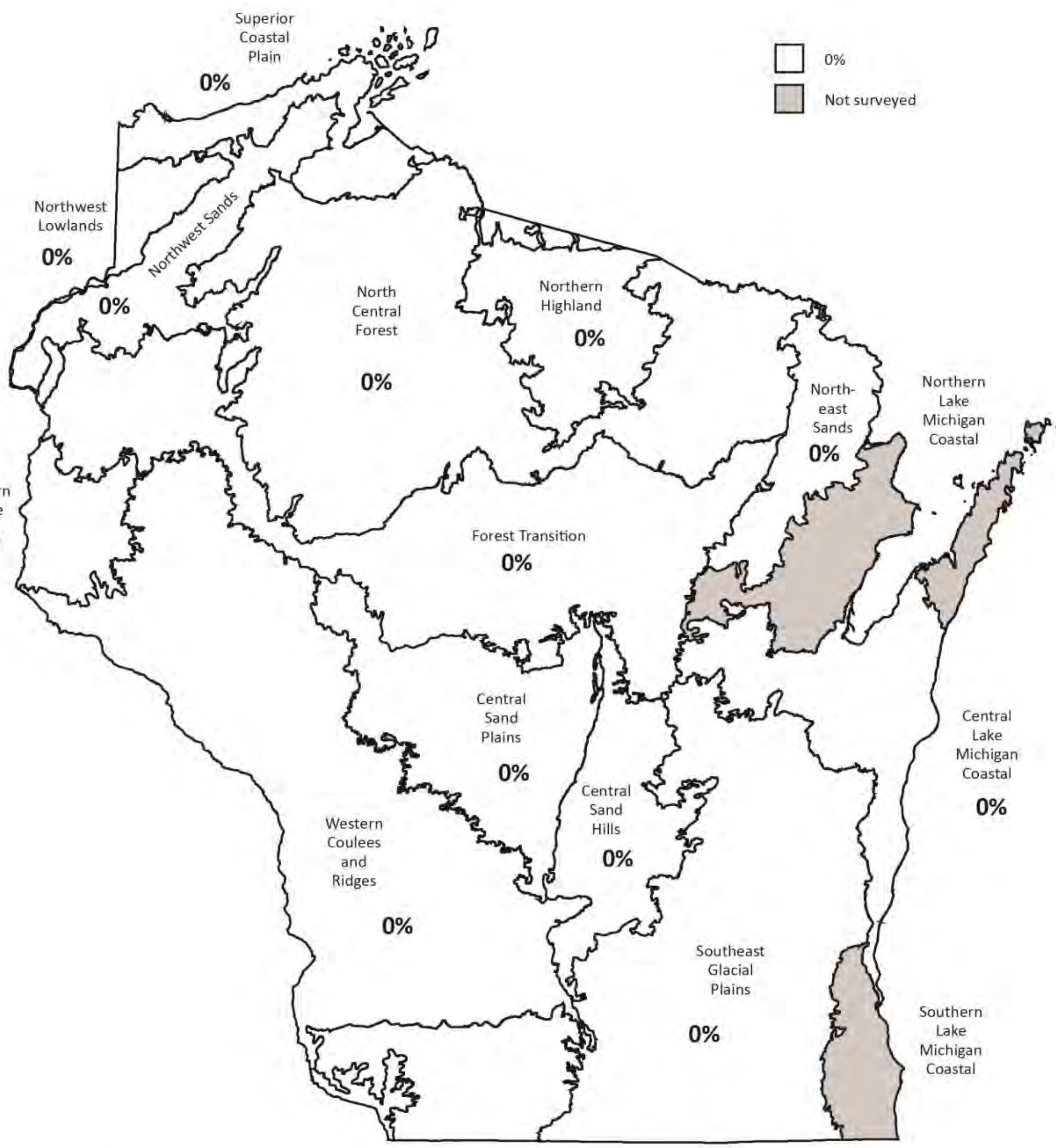


Figure 15. The northern long-eared bat was not observed during acoustic driving surveys in 2016.