WISCONSIN BAT PROGRAM- Driving Acoustic Bat Survey Report 2017

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

In Brief

- ***There were 93 acoustic bat driving surveys conducted by 58 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.***
- ***The proportion of little brown bat detections on driving surveys in 2017 was the lowest ever percentage recorded for this species at 9.3%, which was down 56.5% from 2016 (21.2%).***
- ***While little brown bat detections plummeted, the relative abundance of big brown, eastern red and hoary bats were the highest-ever recorded in 2017.***

Introduction

In 2013, the Wisconsin Bat Program (WBP) expanded its offering of bat surveying opportunities by adding 38 predetermined driving bat surveys (transects). The 2017 survey season marks the fifth year conducting driving surveys. This report summarizes the methods and results from the driving survey transects that were conducted in Wisconsin in 2017 and compares this year's data to the previous four 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 (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 2017 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 >7 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 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. 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 93 surveys conducted by 58 individuals from Wisconsin Department of Natural Resources, Bad River Natural Resources Department (Tribal), U.S. Forest Service and citizen volunteers. Of those surveys, 92 (99%) returned complete acoustic results, which was identical effort to the first year of these driving transects (71- 2016, 77-2015, 77-2014, 92-2013). Of the 92 routes, 49.2 kilometers (30.6 miles) was the mean survey length, with the greatest distance being 73.2 km (45.5 mi) (NCF4) and the shortest distance being 35.1 km (21.8 mi) (NCF1). There was at least one route driven in each ecological landscape except for the Southern Lake Michigan Coastal region. Due to technical difficulties, one survey was incomplete and was not included in the results, leaving valid data for 34 of the 38 routes. Routes without data included FT5, SCP1, NWL1, and SLMC1. Technical issues ranged from loss of GPS data to surveyor error when setting the record options. In total, 26,224 files were recorded on 92 surveys and 4,712 files (18.0 %) were identified as bat encounters. Surveys had a mean of 30.6 bat calls per detector-hour which was the lowest observed average since the surveys began in 2013; with a minimum bat calls per-detector hour of 3.7 (SCP 2 on 3 June) and a maximum of 134.2 (CSH1 on 14 July). For five consecutive years, Central Sand Hills region had the highest average bat calls per detector hour (2013: 81.2, 2014: 75.4, 2015: 100.81, 2016: 96.21 and 2017: 76.1) and the Northern Highland region had the lowest average bat calls per detector hour (2017: 8.9) which was noticeably down from last year at 19.6. The number of call files per

Mean Bat Calls Per Detector Hour

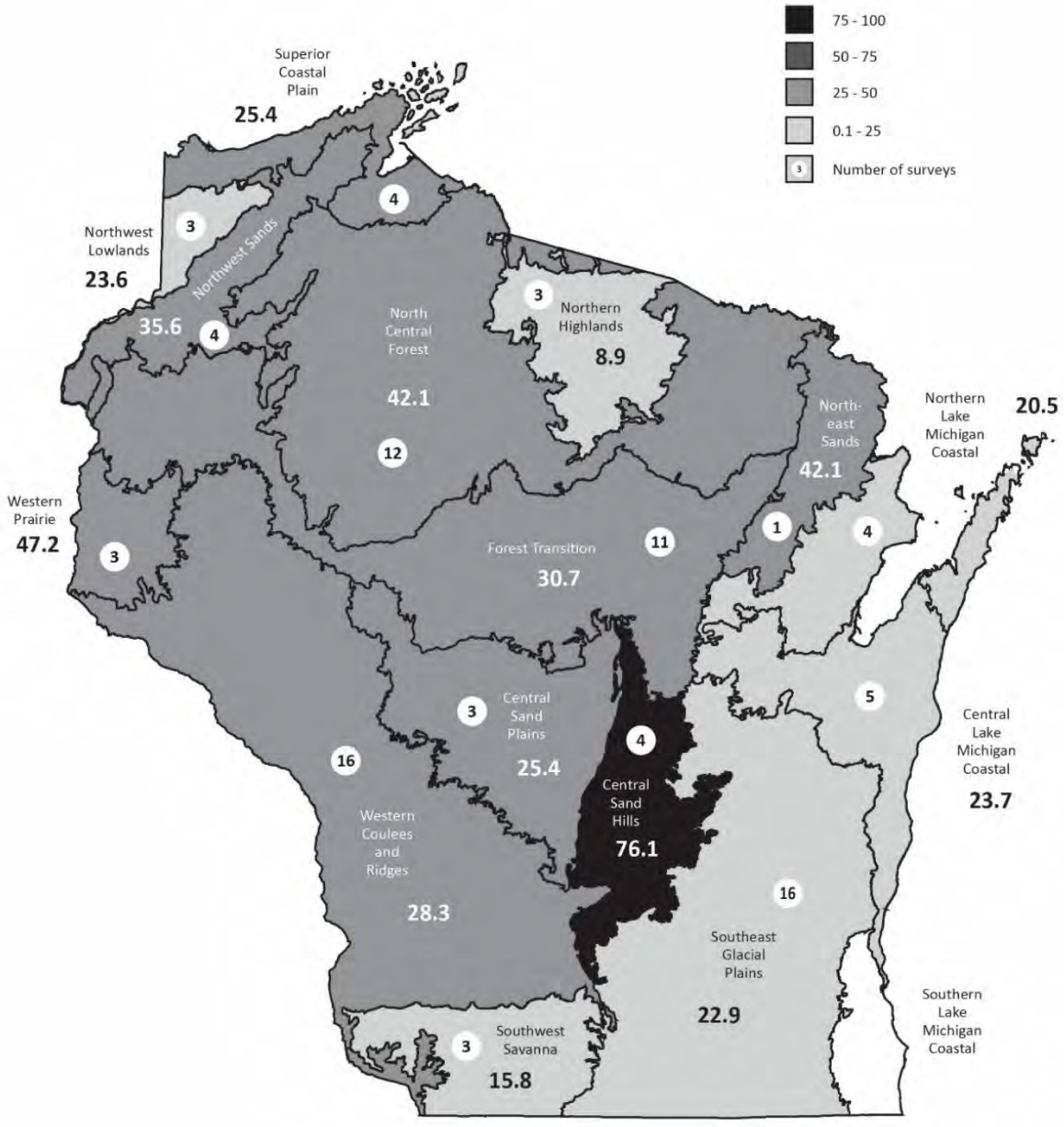


Figure 1. For the fifth year in a row, the highest mean bat calls per detector hour was the Central Sand Hills at 76.1 calls/detector/hour. Mean calls per detector hour across all landscapes was 30.6.

completed survey had a mean of 51.2 and ranged from 8 (SCP2 on 3 June) to 225 (NCF4 on 29 June). The number of mean bat calls per survey was the lowest since the surveys began in 2013. Over two thirds of the 2017 surveys (65.2%) had number of encounters ranging from 1-50, with 34.8% of the encounters falling into the 51-225 category (Figure 4).

Of the 4,712 encounters, 2,198 (53.9%) were classified into species groups: high frequency group (613), low frequency group (918), big brown/silver-haired (478), eastern red/eastern pipistrelle (140) and little brown/northern long-eared (32) because the bat passes have similar characteristics to two or more species. The remaining 2,514, (53.4%) files were classified as big brown (38.3%), eastern red (30.1%), hoary (20.2%), little brown (9.2%), silver-haired (1.9%), eastern pipistrelle (0.2%), evening (0.0%) and the northern long-eared bat (0.0%). Among the 15 ecological regions that were surveyed (missing Southern Lake Michigan Coastal), big brown bats (n=10 regions) were the most commonly encountered species followed by the eastern red bat (n=4 regions) and the hoary bat (n=1 region) (Figure 7) (Table 2). Of note, the little brown bat was the most commonly encountered species in six ecological landscapes when the driving surveys began in 2013.

Figure 2. Total number of surveys by week and mean number of bat calls per survey by week, 2017. One partial survey was excluded.

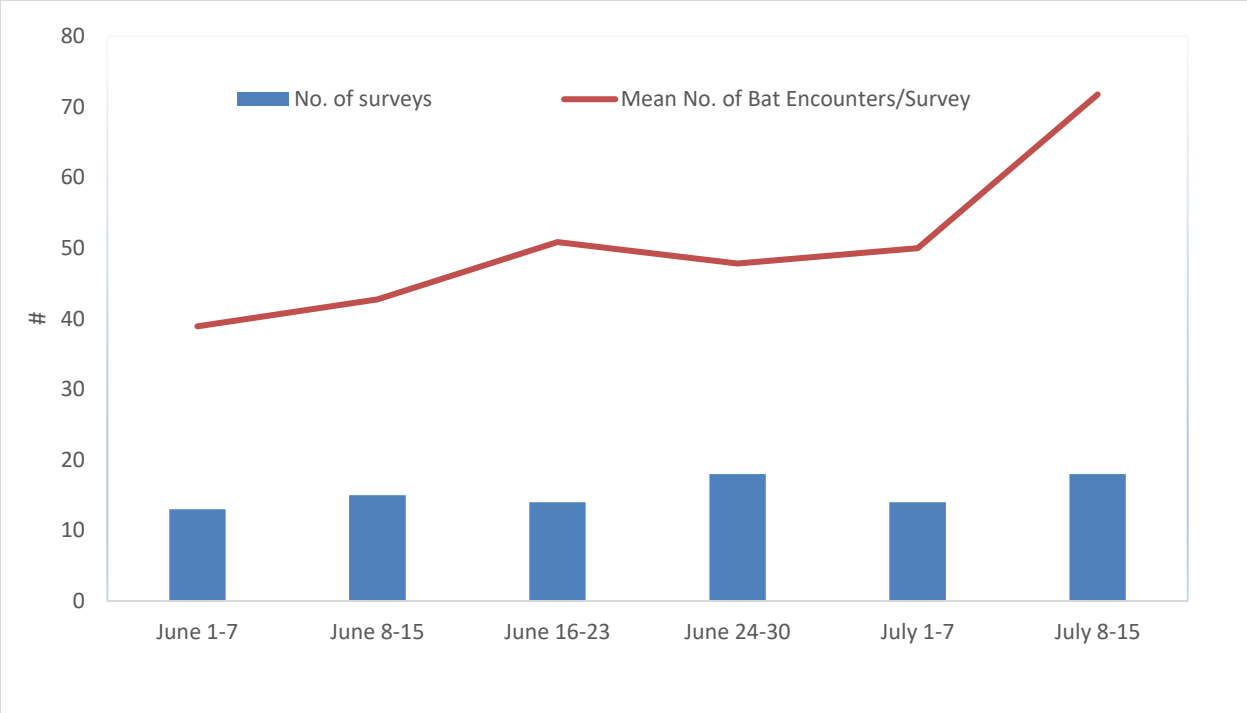


Figure 3. Comparison of mean bat calls per detector hour over time from 2013-2017 driving routes. Numbers in brackets indicate sample size. Boxes depict the 25th and 75th percentiles, lines within boxes mark the median, whiskers represent 95th and the 5th percentiles.

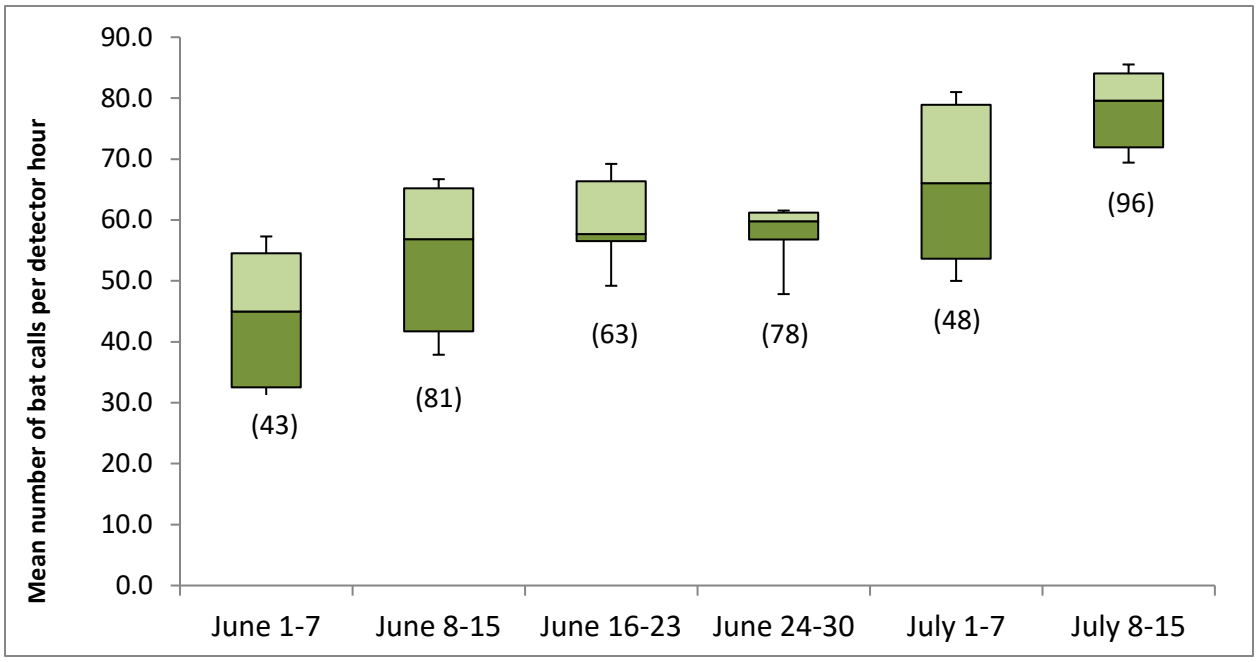


Figure 4. Percentage of driving surveys in each bat encounter category from 2013-2017.

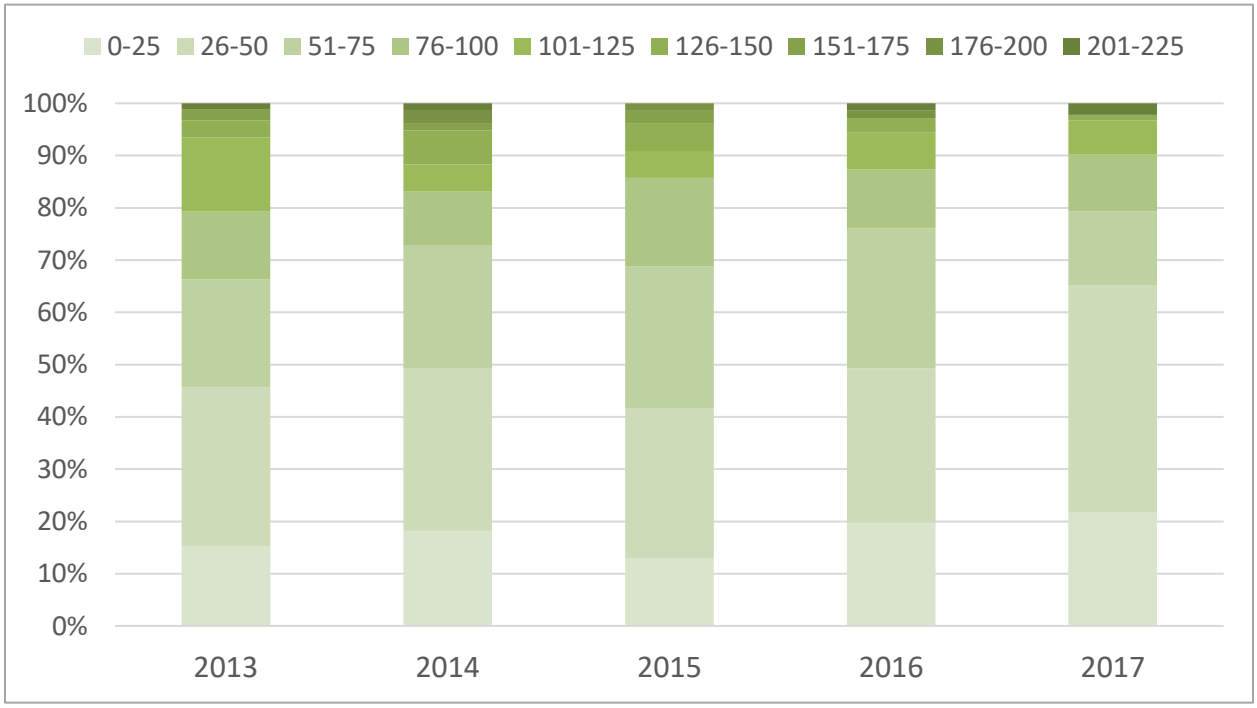


Figure 5. Relative abundance of bat species on driving transects from 2013-2017. Three infrequently detected species were omitted from chart (northern long-eared bat, eastern pipistrelle and evening bat); none of which ever registered a value higher than 0.5%.

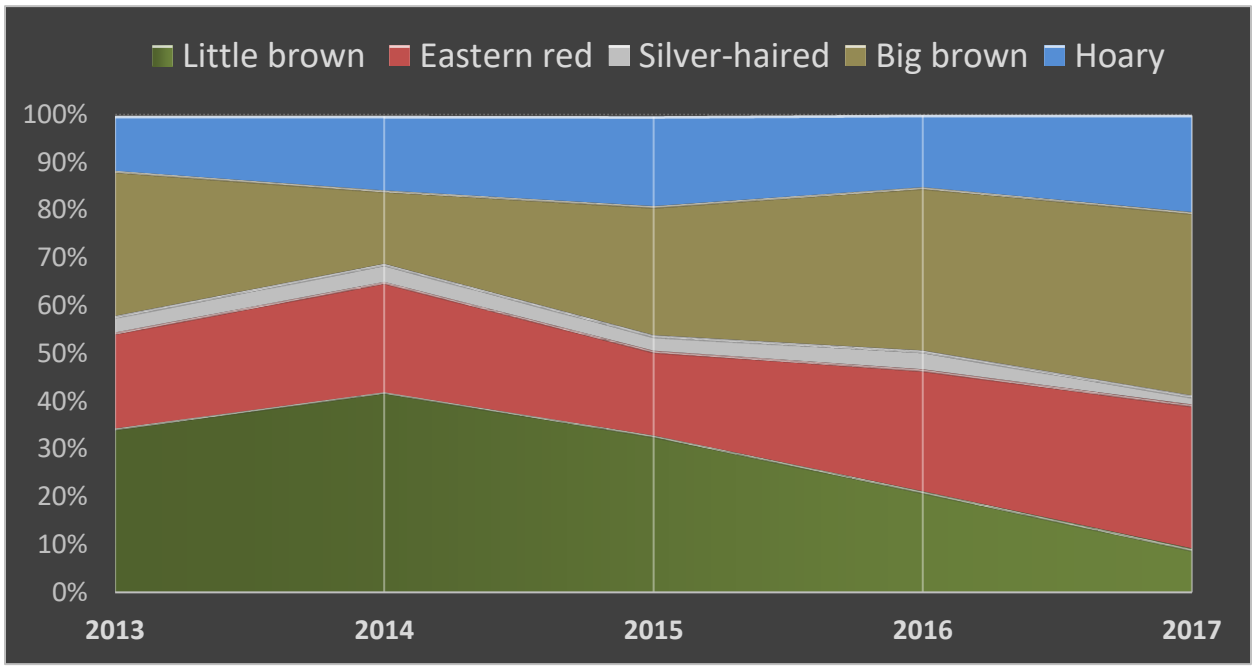
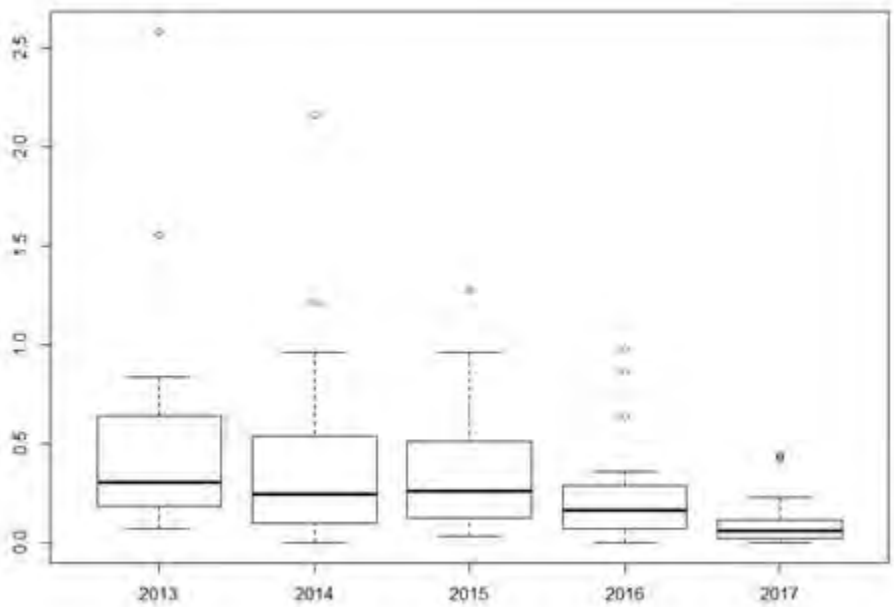


Figure 6. Little brown bat encounters per kilometer hour. The bar is median, the outside edges of the boxes are 1st and 3rd quartiles and the whiskers are, upper whisker = Q_3 + 1.5 * IQR, lower whisker = min. IQR is interquartile range.



Most Common Bat Species by Ecological Region

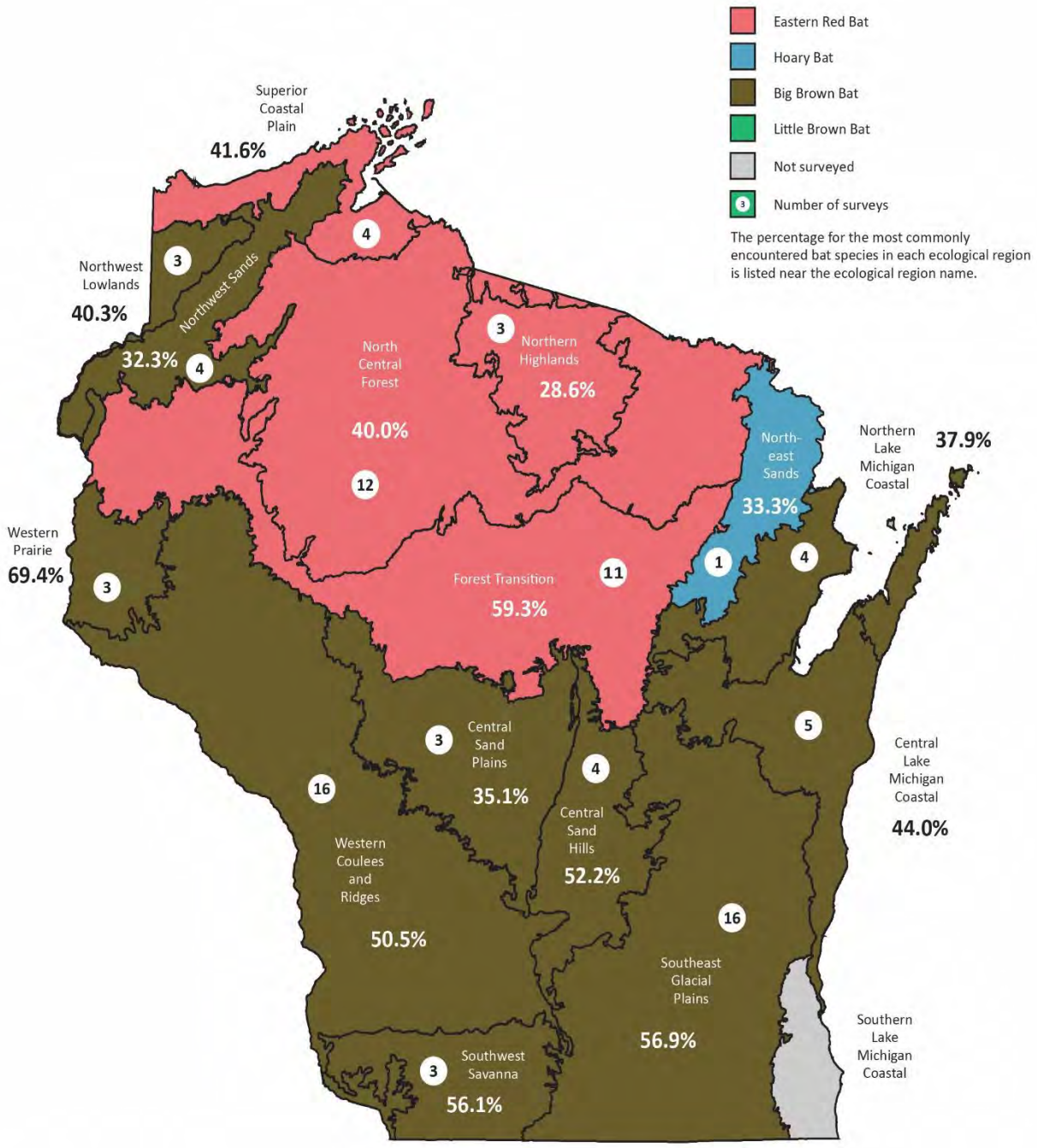


Figure 7. The most commonly encountered bat species by ecological region were the eastern red bat (4) hoary bat (1) and the big brown bat (10).

Figure 8. Mean bat calls per detector hour by ecological landscape (2013-2017). Numbers in brackets indicate number of surveys per ecological landscape. Boxes depict the 25th and 75th percentiles, lines within boxes mark the median, whiskers represent 95th and the 5th percentiles.

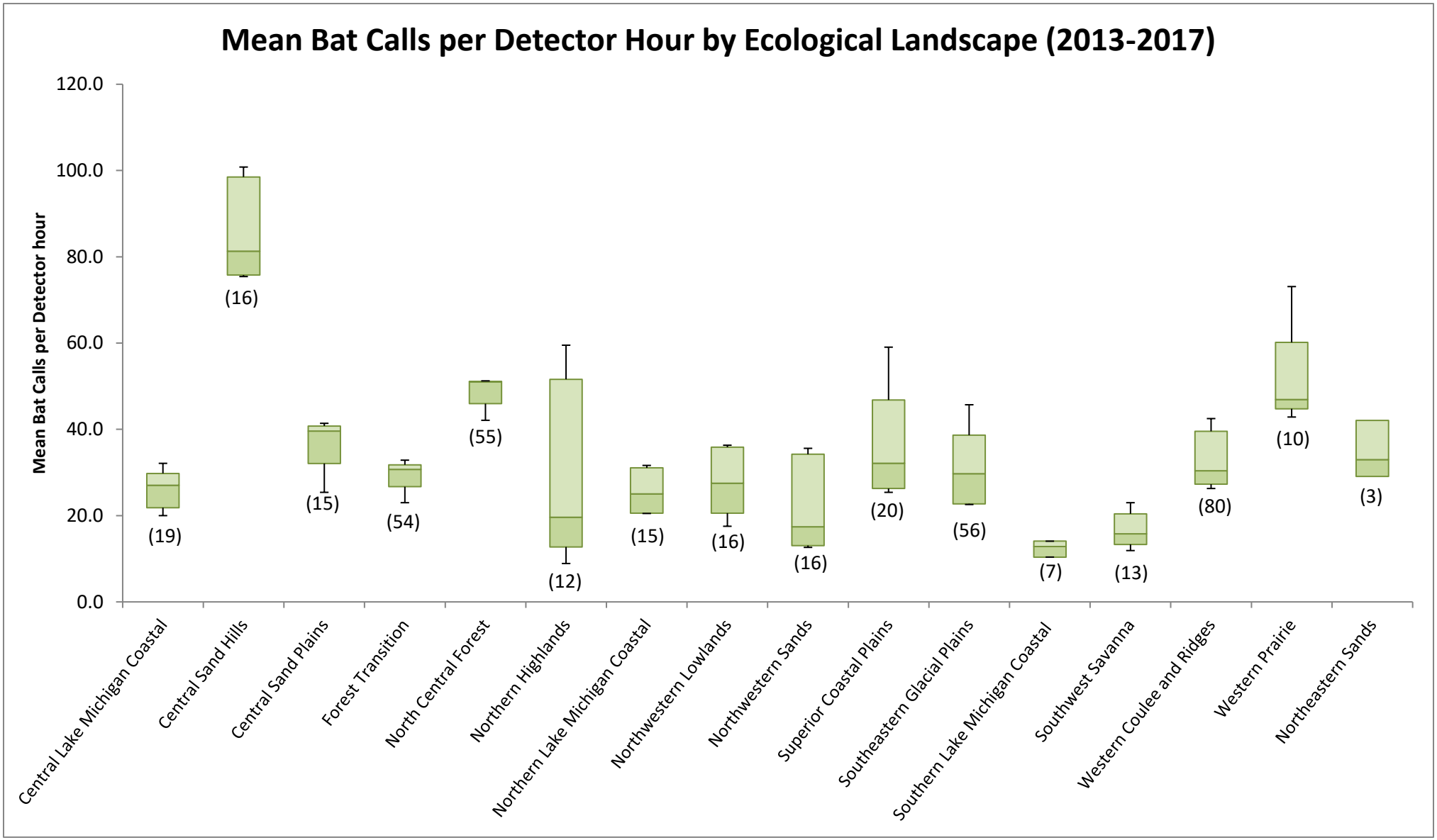


Table 1. Mean number of encounters by species or species group per route during driving acoustic surveys in Wisconsin, June-July 2017. The category "All bats" represents total mean encounters of all species and species groups per route. Data are listed in an approximated north-to-south direction by, and within, ecological region. Incomplete survey (n=1) excluded.

Location	No. Surveys	Big brown	Hoary	Eastern red	Silver-haired	Little brown	Eastern Pipistrelle	Northern long-eared	Evening	Little brown/Northern long-eared	Eastern red/Eastern pipistrelle/Evening	Big brown/Silver-haired	Unclassified	All Bats
Central Lake Michigan Coastal														
CLMC1	3	10.7	3.7	3.3	0.0	1.0	0.0	0.0	0.0	0.0	0.0	5.0	10.7	**34.3**
CLMC2	2	8.0	4.0	13.0	0.0	1.5	0.0	0.0	0.0	0.0	2.5	2.0	13.0	**44.0**
Central Sand Hills														
CSH1	4	32.8	8.5	8.0	0.3	13.3	0.0	0.0	0.0	1.8	0.8	11.0	40.0	**116.3**
Central Sand Plains														
CSP1	3	9.0	5.3	8.0	0.0	3.3	0.0	0.0	0.0	0.0	0.3	3.0	11.3	**40.3**
Forest Transition														
FT1	3	4.0	8.7	42.7	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.7	44.3	**108.0**
FT2	2	12.5	4.5	13.5	0.5	1.0	0.0	0.0	0.0	0.5	0.5	10.0	10.0	**53.0**
FT3	3	3.7	2.0	3.3	0.7	1.7	0.0	0.0	0.0	0.3	0.0	3.3	13.7	**28.7**
FT4	3	3.7	2.3	3.7	0.0	1.3	0.0	0.0	0.0	0.0	0.0	3.3	7.3	**21.7**
North Central Forest														
NCF1	3	4.3	15.3	18.0	0.0	2.3	0.0	0.3	0.0	2.3	8.7	2.3	30.7	**84.3**
NCF2	3	3.7	3.7	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0.3	6.3	6.7	**29.3**
NCF3	3	15.7	10.3	18.7	1.3	3.0	0.0	0.0	0.0	0.0	5.0	3.7	39.0	**96.7**
NCF4	3	10.0	26.7	20.0	0.3	1.0	0.0	0.0	0.0	0.0	2.3	2.7	43.7	**106.7**
Northeastern Sands														
NES	1	10.0	14.0	13.0	0.0	2.0	0.0	0.0	0.0	1.0	4.0	3.0	12.0	**59.0**
Nothern Highlands														
NH1	3	1.7	2.3	2.7	0.0	2.7	0.0	0.0	0.0	0.0	1.0	1.0	5.7	**17.0**
Northern Lake Michigan Coastal Region														
NLMC1	2	10.5	3.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	10.0	35.5
NLMC2	2	6.0	3.5	4.0	0.0	11.5	0.0	0.0	0.0	0.5	1.0	1.0	7.5	35.0
Northwest Lowland														
NWL2	3	8.3	2.7	6.3	0.7	2.7	0.0	0.0	0.0	0.0	0.0	7.7	11.3	**39.7**
Northwest Sands														
NWS1	2	15.5	5.5	8.5	2.5	2.5	0.0	0.0	0.0	0.0	1.0	11.5	44.0	**60.5**
NWS2	3	5.5	13.5	2.0	9.0	0.5	0.0	0.0	0.0	0.5	0.0	17.0	30.5	**61.0**
Superior Coastal Plain														
SCP2	3	4.3	3.7	11.3	1.3	1.7	0.0	0.0	0.0	0.3	0.0	8.7	8.7	**40.0**
SCP3	1	4.0	18.0	8.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	26.0	31.0	**91.0**
Southeast Glacial Plains														
SGP1	6	11.8	1.3	1.0	0.0	1.7	0.2	0.0	0.0	0.3	0.7	6.8	13.5	**37.3**
SGP2	3	5.0	2.3	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	3.7	7.7	**27.3**
SGP3	3	11.3	2.3	2.7	0.0	0.0	0.3	0.0	0.0	0.3	0.0	1.3	6.7	**25.0**
SGP4	3	6.7	3.3	5.0	1.0	2.7	0.0	0.0	0.0	0.0	0.0	4.7	10.7	**34.0**
SGP5	1	13.0	1.0	4.0	0.0	3.0	0.0	0.0	0.0	1.0	1.0	2.0	21.0	46.0
Southwest Sands														
SWS1	3	7.7	2.7	3.0	0.0	0.3	0.0	0.0	0.0	0.0	2.0	1.3	4.3	**21.3**
Western Coulee and Ridges														
WCR1	3	19.0	3.0	7.0	0.0	3.7	0.0	0.0	0.0	0.3	3.0	4.3	20.0	**60.3**
WCR2	3	9.7	2.0	3.7	0.0	3.3	0.3	0.0	0.0	0.3	1.7	2.7	11.3	**35.0**
WCR3	3	18.3	7.7	8.3	0.7	4.0	0.0	0.0	0.0	0.3	1.7	8.7	20.3	**70.0**
WCR4	3	13.7	4.3	5.3	0.3	1.0	0.0	0.0	0.0	0.0	1.3	2.7	11.0	**39.7**
WCR5	3	7.0	3.7	4.0	0.0	0.3	0.0	0.0	0.0	0.3	0.7	1.7	6.3	**24.0**
WCR6	1	10.0	2.0	16.0	0.0	3.0	0.0	0.0	0.0	1.0	1.0	4.0	13.0	**50.0**
Western Prairie														
WP1	3	25.7	2.7	2.0	0.3	6.0	0.3	0.0	0.0	1.0	2.7	8.3	34.0	**83.0**

Discussion

Surveyors drove over 2,800 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 (42.7 LABO) on Forest Transition route 1 (Table 2). The most commonly encountered species on driving transects when combing ecological regions were big brown bats (6.2/detector/hr), eastern red bats (4.9/detector/hr), hoary bats (3.3/detector/hr) and little brown bats (1.5/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 and northern long-eared bat acoustic encounters remained extremely low, accounting for only 0.20% or 5 of 2514 labeled bat passes. Historically these two bat species are difficult to detect using the driving survey method likely due to habitat preferences (aversion to roads) and call characteristics (Braun de Torrez 2017, Whitby 2013). Add the detrimental effect of white-nose syndrome (WNS) on these two bat species and it will likely eliminate further opportunities to detect these bats on any appreciable level using this survey method (Frick et al. 2010).

Table 2. A comparison of mean number of bat calls per detector by ecological landscape (2013-2017), including total number of surveys completed in each year. For regions that were not surveyed that year, data are not available (N/A).

Ecological Landscape	2013	2014	2015	2016	2017	SD (S.E.)
CLMC	27.0 (4)	27.5 (3)	32.1 (3)	20.0 (4)	23.7 (5)	4.9 (2.0)
CSH	81.3 (3)	75.4 (3)	100.8 (3)	96.2 (3)	76.1 (3)	11.8 (5.3)
CSP	40.2 (3)	38.8 (3)	39.6 (3)	41.4 (3)	25.4 (3)	6.6 (2.9)
FT	30.4 (12)	32.9 (10)	30.7 (12)	23.0 (9)	30.7 (11)	3.8 (1.7)
NCF	51.0 (8)	49.8 (12)	51.2 (12)	51.0 (11)	42.1 (12)	3.6 (1.8)
NES	33.0 (1)	N/A	N/A	29.1 (1)	42.1 (1)	6.7 (3.9)
NH	59.5 (1)	43.7 (2)	16.6 (3)	19.6 (3)	8.9 (3)	21.2 (9.5)
NLMC	20.7 (4)	31.6 (4)	29.4 (3)	N/A	20.5 (4)	5.8 (2.9)
NWL	36.3 (4)	17.5 (3)	35.4 (3)	27.5 (3)	23.6 (3)	8.0 (3.6)
NWS	32.8 (5)	17.4 (1)	12.6 (3)	13.5 (3)	35.6 (4)	11.0 (4.9)
SCP	27.2 (4)	59.1 (4)	32.1 (5)	34.6 (3)	25.4 (4)	13.6 (6.1)
SGP	29.7 (15)	22.6 (9)	45.7 (8)	31.6 (11)	22.9 (16)	9.4 (4.2)
SLMC	12.8 (3)	10.4 (3)	14.1 (1)	N/A	N/A	1.9 (1.1)
SWS	14.8 (3)	17.8 (3)	23.0 (2)	11.9 (2)	15.8 (3)	4.1 (1.9)
WCR	42.5 (19)	26.3 (16)	36.6 (15)	30.4 (14)	28.3 (16)	6.7 (3.0)
WP	46.7 (3)	46.9 (2)	42.9 (1)	73.1 (1)	47.2 (3)	12.3 (5.5)
Mean (Total #)	***36.9 (92)***	***34.5 (78)***	***38.5 (77)***	***34.3 (71)***	***30.6 (92)***	***23.0 (1.1)***

The bat activity recorded on driving routes describes the annual phenology and in-season changes that occur over time (Figure 3). Since half of Wisconsin's bat species migrate from other states, there is likely a lag-effect during early summer as bats move to their summer habitat. The same could be said with cave bats, who may hibernate in other states and their emergence from those overwintering sites might be affected by local climatic conditions, thus delaying their arrival to Wisconsin and their ability to be acoustically detected. By the middle of June, colonial bats have congregated and mothers, who are near-term, must meet the resource demands imposed by a developing fetus. Pregnant females adjust their foraging behavior to meet their current energy demands and are seen foraging more readily than in spring.

Barclay (1989) found that as lactation progresses, individuals departed to forage earlier and spent more time foraging per night and less time roosting with their young. Home-range of little brown bats in Quebec, Canada reduced by 51% between pregnancy and lactation, resulting in a 35% decrease in flight distances (Henry et al. 2002). The findings by Henry et al. (2002) could, in-part explain the slight depression in bat activity during the last week in June (24^{th}-30^{th}). The subsequent escalation of bat activity in July would likely be explained by the growing number of mothers and now-volant pups foraging (Ford et at. 2011). After young are volant (able to fly) which is typically three-four weeks post-birth, they forage in near proximity of their roost, presumably as they become adept at flying and capturing prey (Racey and Swift 1985). After weeks, juveniles move increasingly further and their attempted feeding also increase progressively during this period (Racey and Swift 1985).

Interestingly, the Central Sand Hills ecological landscape has consistently had the highest bats per detector-hour of any other landscape since driving surveys began in 2013 (Table 2, Figure 8). It remains unclear why this landscape continues dominate in bat detections as this landscape does not rank high in forest or water resources that would likely contribute to food and/or roosting opportunities. For example, Central Sand Hills has the eighth largest number of acres of wetlands and the seventh highest percentage of wetlands (18%), compared to other ecological landscapes (WDNR 2015). There's also a range in water quality values as with most landscapes. Of the 1,389,00 acres, approximately 34% is forested, with predominate cover type as oak-hickory (47%). The WBP will continue to investigate attributes of this landscape that make it appealing to bats.

The declines in little brown bat detections (Figures 5 and 6) in Wisconsin through driving surveys now bear a resemblance to the losses observed in New England in the four years following the onset of WNS (Brooks 2011). In 2010, Frick et al., painted a grim picture of regional extinction of little brown bats due to WNS within 16 years. At that time, 13 northeastern and mid-Atlantic states were infected. Fast forward eight years, the pathogen is now found in at least 31 states, which include both the east and west coasts of North America. Locally, Wisconsin is now in its fifth year of infection and is now considered in the WNS-endemic zone (USGS 2017). From hibernation surveys in Wisconsin, little brown bats in sites in year's three and four of infection experience a decline of 91.8% and 99.3% respectively, when compared to pre-WNS average. Despite these staggering statistics, we still see cave bats on the summer landscape, albeit in smaller detections. These bat detections, however small, now prove invaluable as the Department looks to identify and protect those individuals that remain.

Acknowledgements

The Wisconsin Bat Program would like to sincerely thank the following surveyors for their dedication to the acoustic bat driving project: A. & M. Ledin, B.& H. Heeringa, B. Johnston, B. Olby, B. Paulan, B. Scriver, B. & J. Van Ryzin, B. & S. Volenec, C. & T. Arnold, C. Nelson, D. Smith, D. Wolfson, E. Cronk, H. Helms, Hillstead, I. Arnold, J. Jorgensen, J. Lencowski, J. Miller, J. Montaine, J. Nondorf, J. Redell, J. Summers, K. & W. Duhn, L. Bradshaw, L. Johnson, L. Radke, M., N., & M. Berg, M. Herrmann, M. Lins, N. Gremban, N. Kilger, N. Schutt, O. Pomdova, R. & T. Jay, Rilo, R. Konkle, R. Gedemer, S. Scully, S. Smith, Stuckert, T. & L. Ludwig, T. Shults, T. Trapp, V. Delos Santos and W. Mueller. We would also like to recognize Andrew Badje for his mapping services and Heather Kaarakka, who individually analyzed each of the >20,000 calls submitted to the program in 2017. Mobile acoustic bat surveys in Wisconsin were funded by WNS Grants to States Program (S-1TW-1) and public contributions to the Wisconsin Bat Conservation fund.

Literature cited

Barclay, R.M.R. Behavior Ecology Sociobiology (1989) 24: 31. https://doi.org/10.1007/BF00300115

Braun de Torrez E.C., M.A. Wallrichs, H.K. Ober and R. A. McCleery. Mobile acoustic transects miss rare bat species: implications of survey method and spatio-temporal sampling for monitoring bats. Veirs S, ed. PeerJ. 2017; 5:e3940. doi:10.7717/peerj.3940.

Brooks, R.T. 2011. Declines in summer bat activity in central New England 4 years following the initial detection of white-nose syndrome. Biodiversity and Conservation 20:2537-2541.

Ford, W. M., E. R. Britzke, C. A. Dobony, J. L. Rodrigue, and J. B. Johnson. 2011. Patterns of acoustical activity of bats prior to and following white-nose syndrome occurrence. Journal of Fish and Wildlife Management 2:125-134.

Ford, W. M., J. M. Menzel, M. A. Menzel, J. W. Edwards, and J. C. Kilgo. 2006. Presence and absence of bats across habitat scales in the upper coastal plain of South Carolina. Journal of Wildlife Management 70:1200-1209.

Frick W.F., J.F. Pollock, A.C. Hicks, K.E. Langwig, D.S. Reynolds, G.G. Turner, C.M. Butchkoski, and T.H. Kunz. 2010. An Emerging Disease Causes Regional Population Collapse of a Common North American Bat Species. Science 329:679-682.

Loeb, S.C., T.J. Rodhouse, L.E. Ellison, C.L. Lausen, J.D. Reichard, K.M. Irvine, T.E. Ingersoll, J.T.H. Coleman, W.E. Thogmartin, J.R. Sauer, C.M. Francis, M.L. Bayless, T.R. Stanley, and D.H. Johnson. 2015. A plan for the North American Bat Monitoring Program (NABat). General Technical Report SRS-208. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 112 p.

Henry, M., D.W. Thomas, R. Vaudry, and M. Carrier; Foraging Distances and Home Range of Pregnant and Lactating Little Brown Bats (Myotis Lucifugus), Journal of Mammalogy, Volume 83, Issue 3, 1 August 2002, Pages 767–774, https://doi.org/10.1644/1545-1542(2002)083<0767:FDAHRO>2.0.CO;2

Racey, P. A., and S. M. Swift. “Feeding Ecology of Pipistrellus Pipistrellus (Chiroptera: Vespertilionidae) during Pregnancy and Lactation. I. Foraging Behaviour.” Journal of Animal Ecology, vol. 54, no. 1, 1985, pp. 205–215. JSTOR, JSTOR, www.jstor.org/stable/4631.

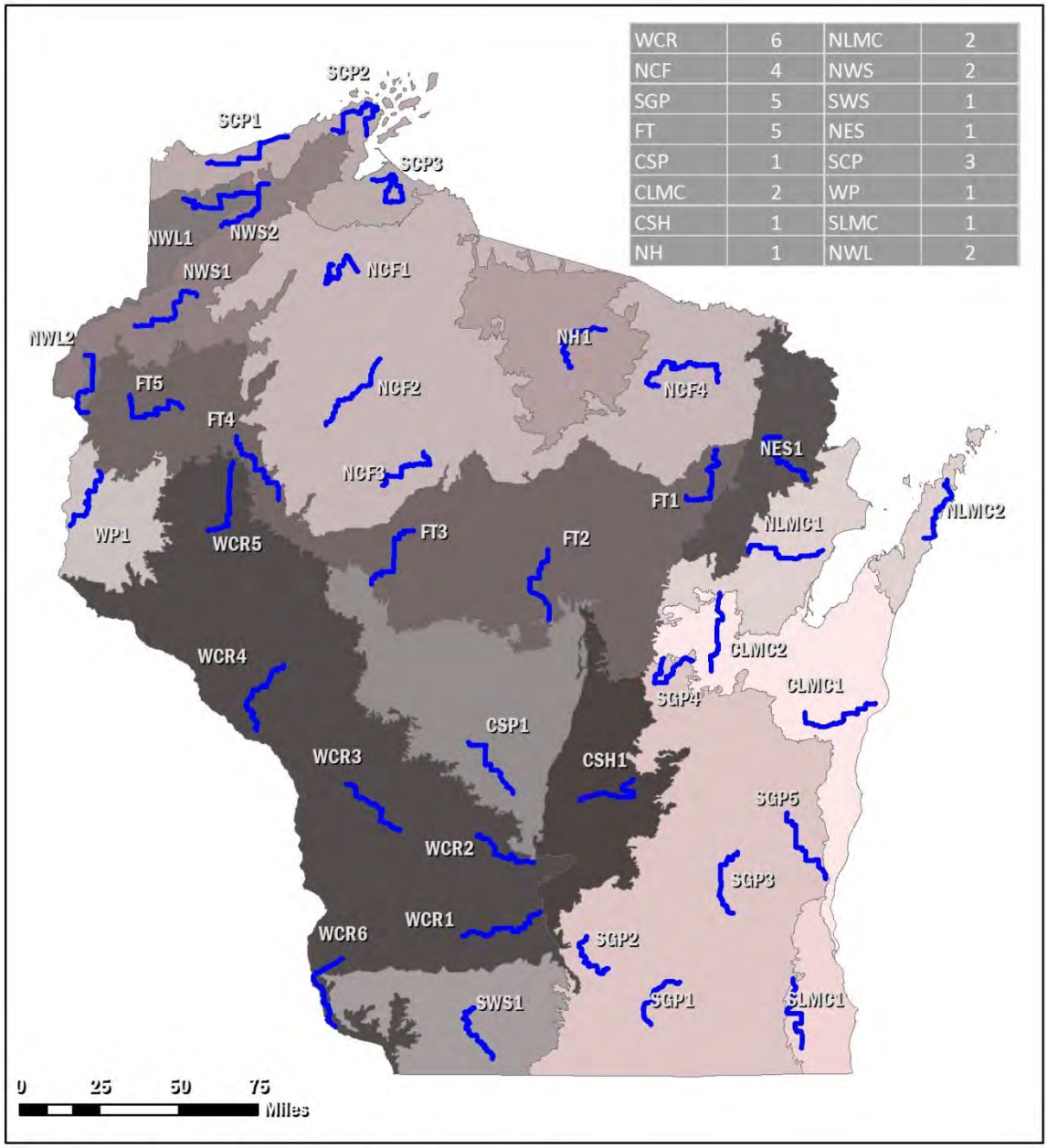
Roche, N., Langton, S., Aughney, T., Russ, J. M., Marnell, F., Lynn, D. and Catto, C. 2011. A car-based monitoring method reveals new information on bat populations and distributions in Ireland. Animal Conservation, 14: 642–651.

Wisconsin Department of Natural Resources. 2015. The ecological landscapes of Wisconsin: an assessment of ecological resources and a guide to planning sustainable management. Chapter 9, Central Sand Hills Ecological Landscape. Wisconsin Department of Natural Resources, PUB-SS-1131 2015, Madison.

Whitby, M. D., T. C. Carter, E. R. Britzke, and S. M. Bergeson. 2014. Evaluation of Mobile Acoustic Techniques for Bat Population Monitoring. Acta Chiropterologica 2014 16 (1), 223-230.

USGS National Wildlife Health Center, Bat White-Nose Syndrome (WNS)/Pd Surveillance Submission Guidelines Winter 2017/2018 (November-May) https://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/NWHC%20Winter%202017-2018%20Bat%20submission%20Guidelines.pdf

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

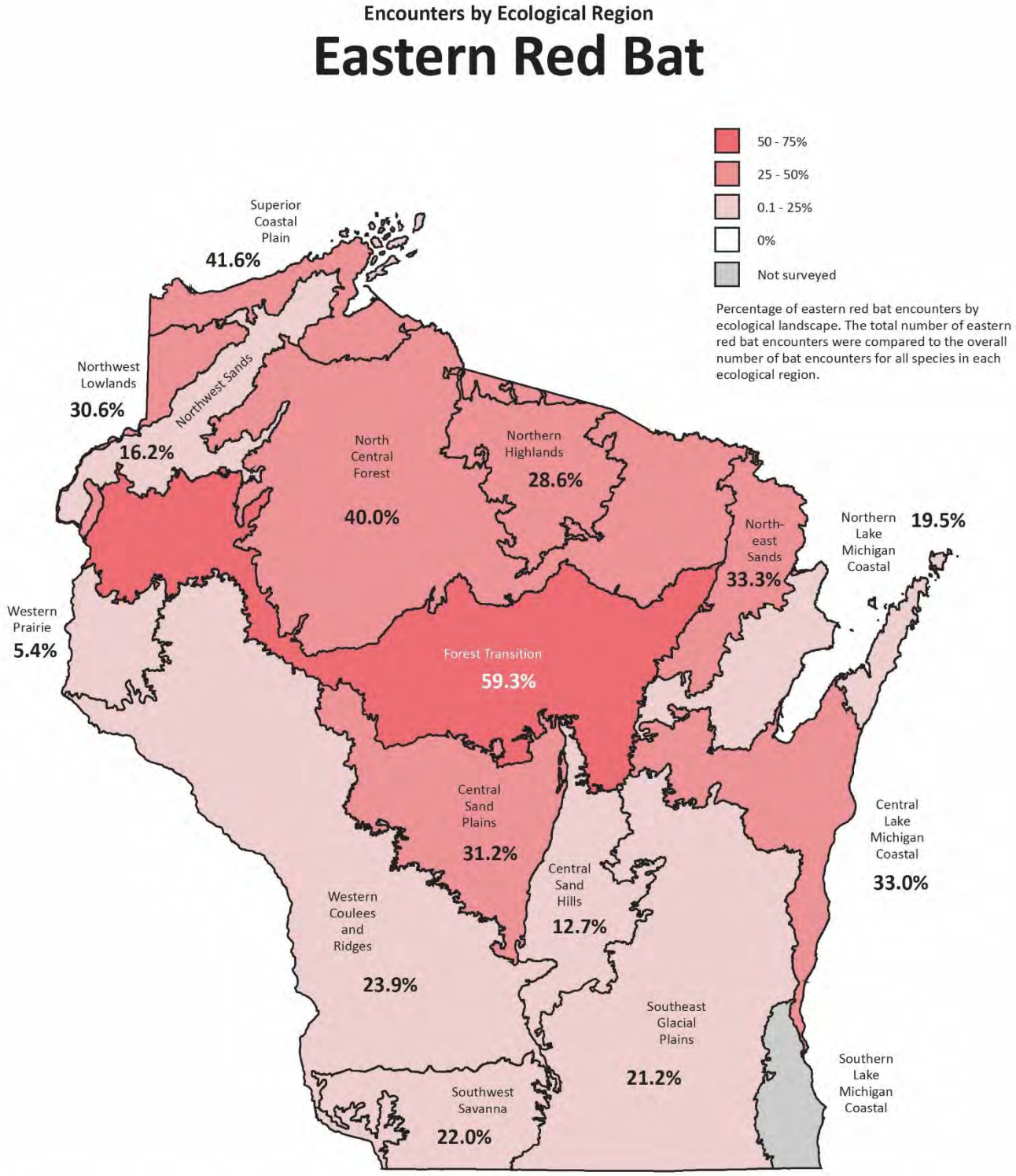


Figure 9. The eastern red bat encounters accounted for 30.1% of all recorded bat passes during driving surveys in 2017.

Encounters by Ecological Region

Hoary Bat

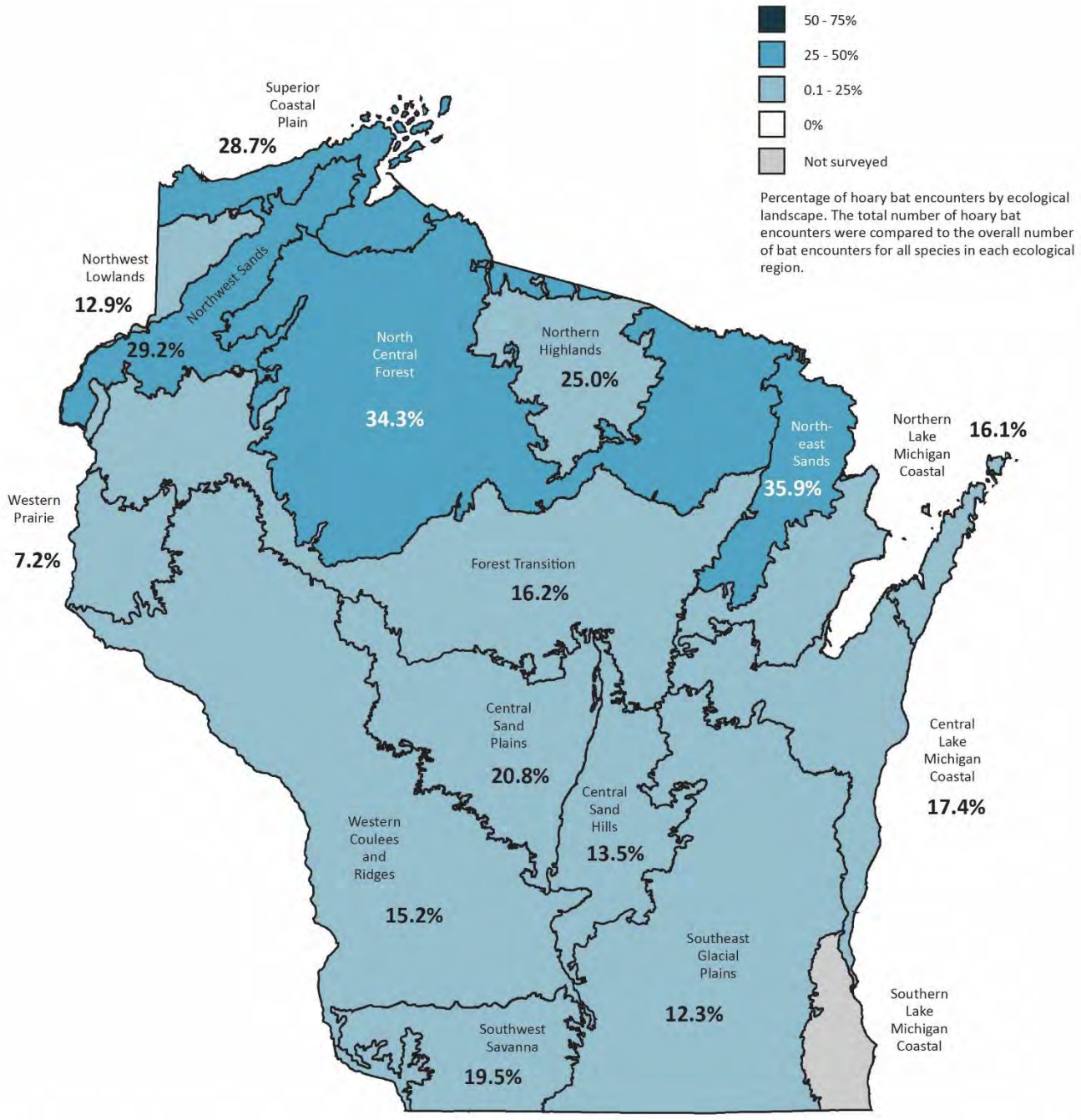


Figure 10. The hoary bat accounted for 20.2% of all bat encounters recorded during driving surveys in 2017.

Encounters by Ecological Region

Silver-haired Bat

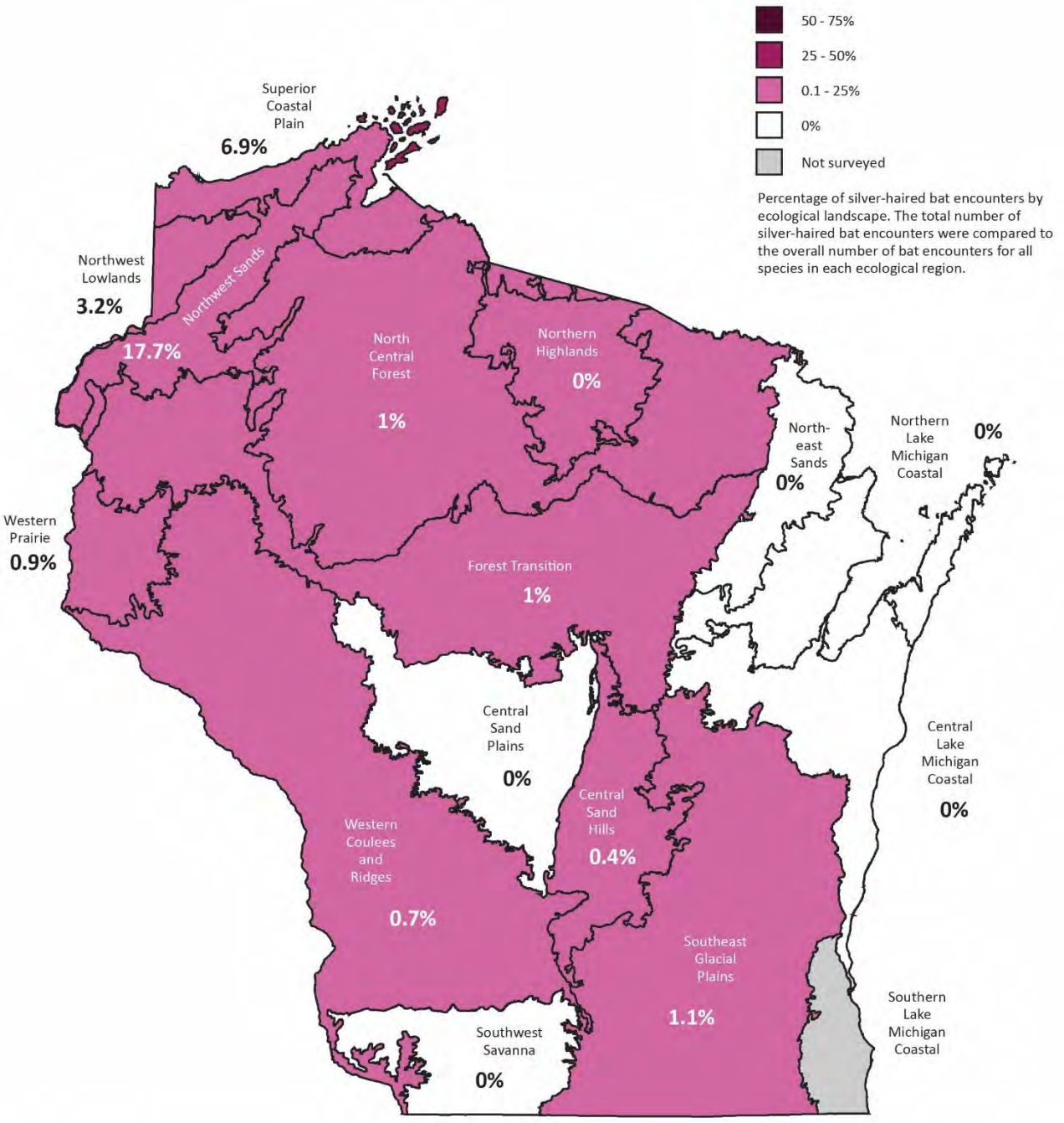


Figure 11. Silver-haired bat encounters accounted for 1.9% of all encounters recorded during driving surveys in 2017.

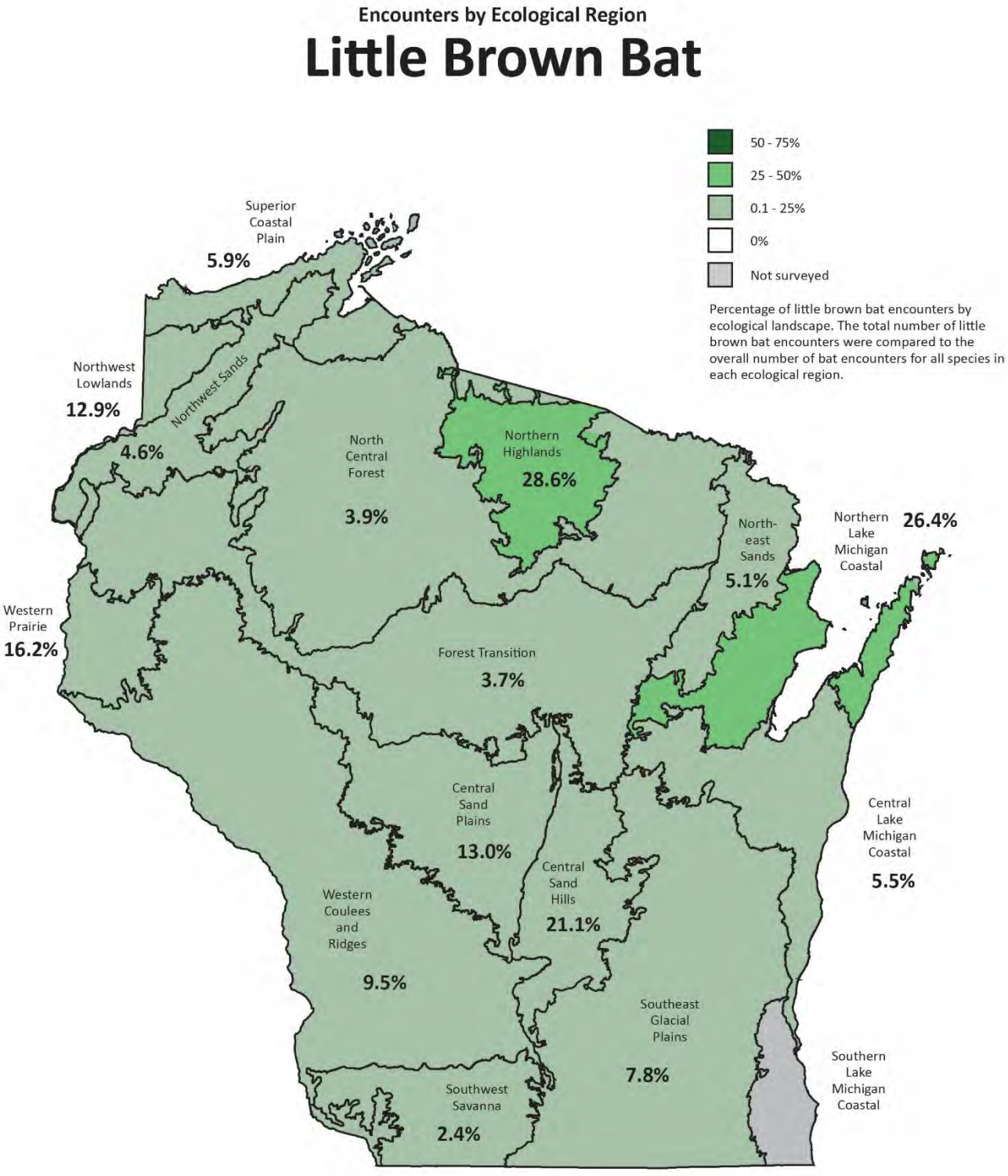


Figure 12. The little brown bat encounters accounted for 9.2% of all bat encounters recorded during driving surveys in 2017. Of note, little brown bat comprised 34.3% of all encounters in 2013 driving surveys.

Figure 13. The big brown bat had the highest encounter rate (69.4%) in Western Prairie region, and comprised 38.3% of all bat encounters during driving surveys in 2017.

Encounters by Ecological Region

Eastern Pipistrelle

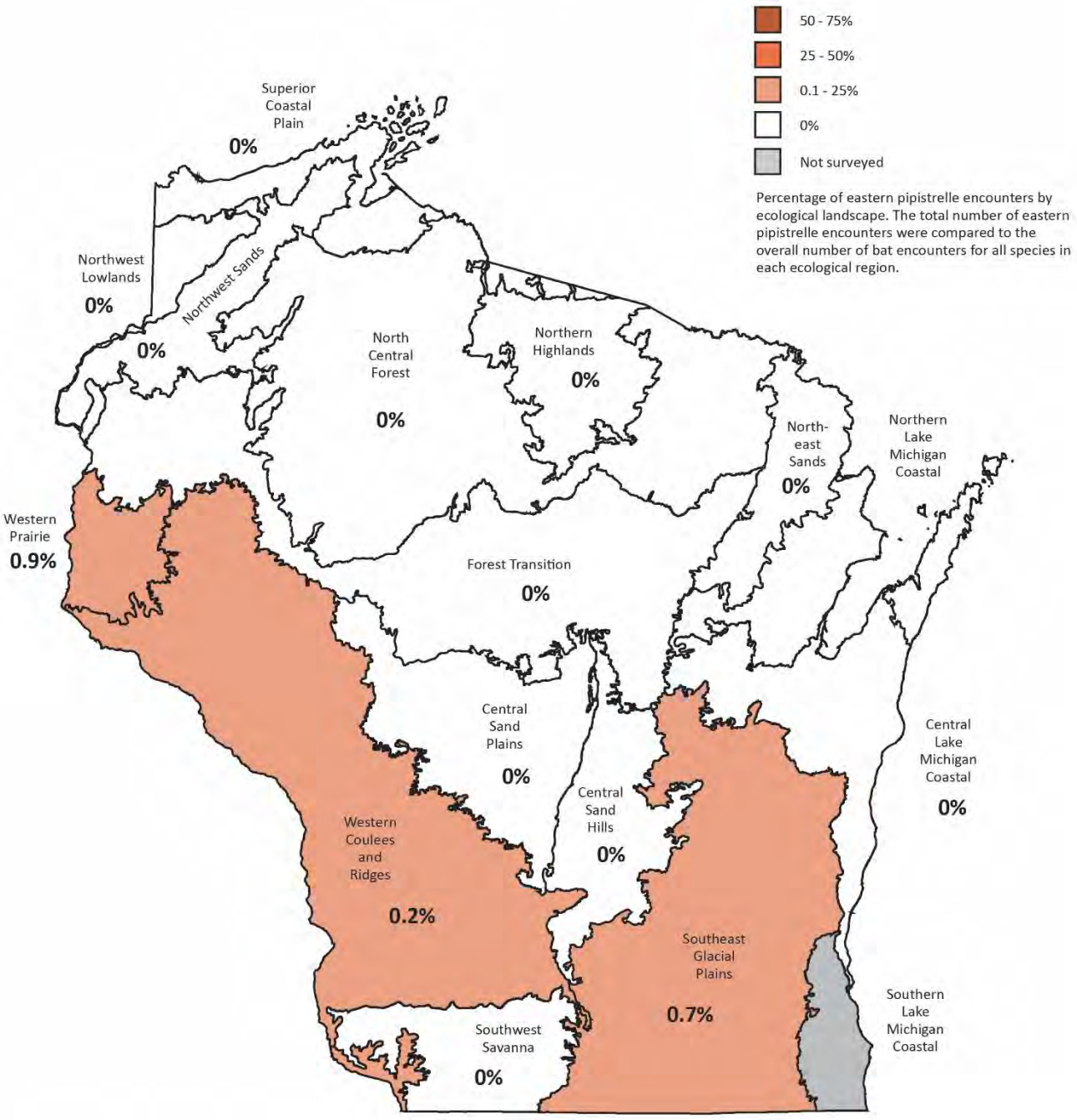


Figure 14. The eastern pipistrelle was recorded in the Western Coulees and Ridges region, Southeast Glacial Plains region and Western Prairie region. Eastern pipistrelle accounted for 0.2% of all recorded bat passes during driving surveys in 2017.

Encounters by Ecological Region

Northern Long-eared Bat

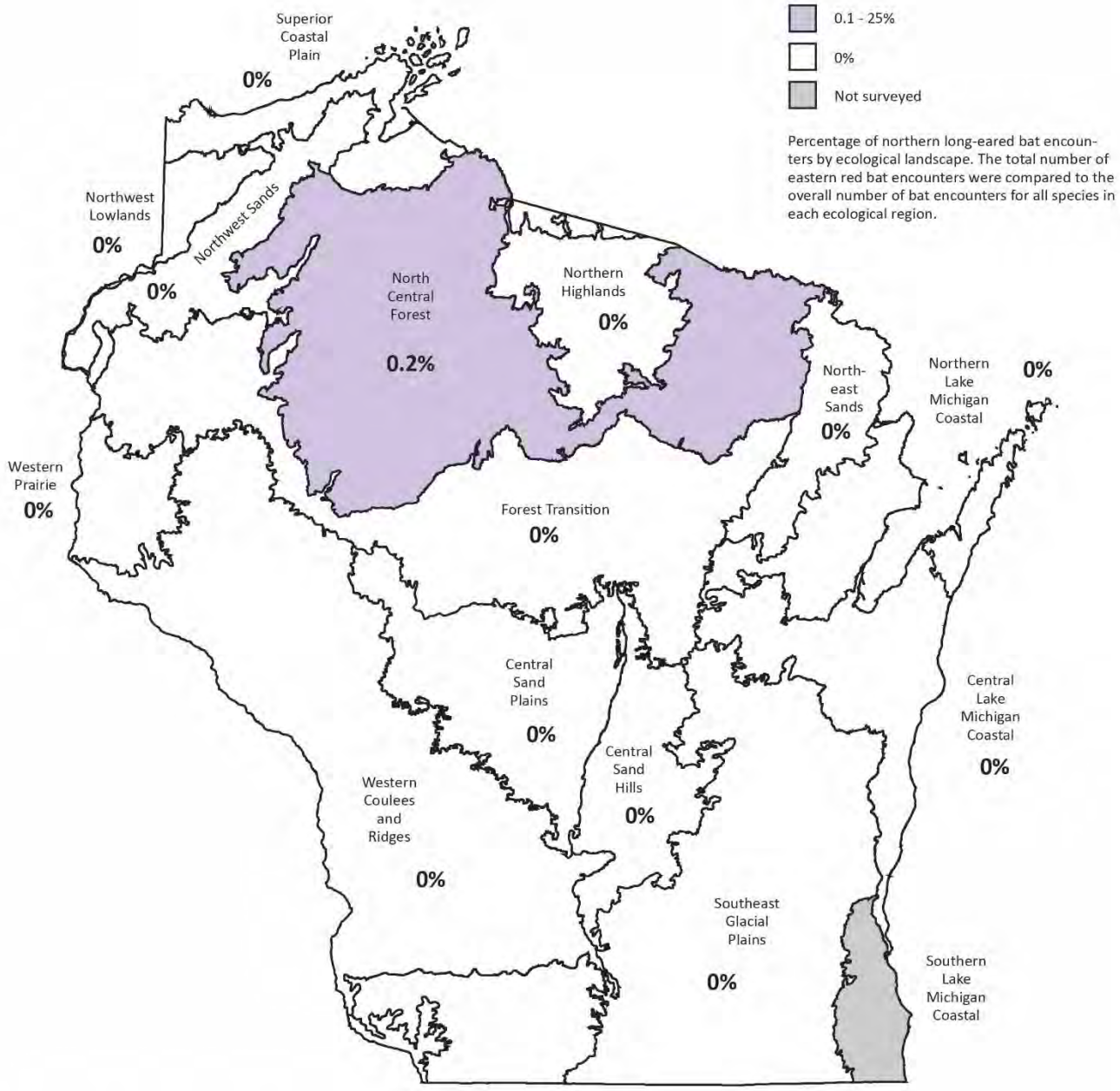


Figure 15. The northern long-eared bat was observed only in the North Central Forest during acoustic driving surveys in 2017.

Appendix 3 Table 3. Driving acoustic bat surveys (n=92) conducted in Wisconsin, June-July 2017. Incomplete survey (n=1) 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	88.4	254	4.2	1.4	23.9	103	29.5	24.3
CLMC 2	2	65.0	236	3.9	2.0	14.4	88	32.5	22.8
CSH 1	4	118.8	366	6.1	1.5	20.6	465	39.7	76.1
CSP 1	3	83.7	285	4.8	1.6	17.9	121	28.4	25.4
FT 1	3	92.6	323	5.4	1.8	15.5	324	30.9	60.1
FT 2	2	63.8	191	3.2	1.6	20.4	106	31.9	32.5
FT 3	3	90.1	274	4.6	1.5	20.9	86	30.0	18.8
FT 4	3	104.1	323	5.4	1.8	17.4	65	34.7	12.1
NCF 1	3	70.7	279	4.7	1.6	18.7	253	23.6	55.2
NCF 2	3	99.6	275	4.6	1.5	23.1	88	33.2	19.7
NCF 3	3	94.0	324	5.4	1.8	15.6	290	31.3	53.6
NCF 4	3	136.3	476	7.9	2.6	10.5	320	45.4	39.7
NES 1	1	31.1	84	1.4	1.4	25.6	59	31.1	42.1
NH 1	3	89.5	347	5.8	1.9	12.9	51	29.9	8.9
NLMC 1	2	69.8	194	3.2	1.0	19.3	71	29.8	19.2
NLMC 2	2	59.6	219	3.7	1.6	14.4	70	29.8	19.2
NWL 2	3	87.6	318	5.3	1.8	16.5	119	29.2	23.6
NWS 1	2	62.6	201	3.4	1.7	18.0	121	31.3	35.9
NWS 2	2	59.1	199	3.3	1.7	17.7	122	29.5	35.2
SCP 2	3	110.1	400	6.7	2.2	12.1	120	36.7	17.7
SCP 3	1	27.8	113	1.9	1.9	12.6	91	27.8	48.3
SGP 1	6	161.5	515	8.6	1.4	21.9	224	26.9	25.8
SGP 2	3	75.7	290	4.8	1.6	15.6	82	25.2	17.1
SGP 3	3	83.8	243	4.1	1.4	26.3	75	27.8	19
SGP 4	3	82.4	263	4.4	1.5	20.7	102	27.5	23.1
SGP 5	1	32.4	80	1.3	1.3	29.3	46	32.4	34.5
SWS 1	3	85.9	242	4.0	1.3	25.5	64	28.6	15.8
WCR 1	3	101.5	309	5.2	1.7	18.9	181	33.8	36.2
WCR 2	3	99.5	323	5.4	1.8	18.4	105	33.2	20.4
WCR 3	3	87.4	257	4.3	1.4	28.2	210	29.1	45.7
WCR 4	3	90.7	308	5.1	1.7	19.1	119	30.2	26.1
WCR 5	3	88.8	324	5.4	1.8	14.8	72	29.6	13.2
WCR 6	1	33.9	110	1.8	1.8	16.3	50	33.9	27.3
WP 1	3	94.0	321	5.4	1.8	17.1	249	31.3	47.2
Total	**92**	**2822**	**9266**	**152**			**4712**		
Mean	**2.7**	**83.0**	**272.5**	**4.6**	**1.7**	**18.8**	**138.6**	**31.1**	**30.6**