Impact of Weather Conditions and Proximity to Water on Bat House Occupancy in the Beaverhill Natural Area

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Abstract

Bats are an essential part of many ecosystems. However, their natural habitats are in a steady state of decline in many areas. In an attempt to mitigate habitat loss and supplement roosting sites, artificial roosts known as bat houses have been installed in targeted areas. Many factors must be considered when creating an ideal bat house, such as colour, size, installation location, the material of construction, and overall design. Several studies have identified that weather conditions can also influence occupancy rates in bat houses.

Several peer reviewed studies have noted the importance of microclimatic and weather conditions as an influence on bat house occupancy. However, the specifics of what aspects of microclimatic and weather conditions were never identified.

Staff, volunteers, and student interns at Beaverhill Bird Observatory (BBO) have been monitoring and studying bat house occupancy in the Beaverhill Natural Area (BNA) since 2016.

In this study, weather conditions, including average temperature during sampling and humidity were documented and compared to preferred bat roosting locations. Additionally, the proximity to water relating to bat house locations was considered part of the scope of this study.

Interpretation of the data collected suggested that there was a low correlation between bat house occupancy, temperature, and humidity. When reviewing data related to bat house locations and proximity to water, the study revealed a strong correlation to bat house occupancy (R^2 = 62%).

Introduction

Bats (Order: Chiroptera) provide a variety of important ecosystem functions such as insect pest control, pollination, and seed dispersal (Ramírez-Francel et al., 2022). For example, regarding pest control, a single Little Brown Bat (*Myotis lucifugus*) can consume one thousand or more mosquito-sized insects in one hour (Tuttle et al., 2013; Riccucci & Lanza, 2014; Whitby et al., 2020). Bats also play a significant but understudied role in pollination and seed dispersal (Ramírez-Francel et al., 2022). It has been indicated that arguably, one of the most important ecosystem services that bats provide is their consumption of pests. For example, a recent study indicates that Little Brown Bats regularly consume 160 known species of agricultural pests and disease vectors (Maslo et al., 2022).

Bats are also useful bioindicators to gauge environmental conditions, due to their mobility, long lifespan, and small size (Fenton, 1997). Despite significant ecological functions served by bats, populations continue to decline around the world (Pennisi et al., 2009) partly due to a loss of natural roost sites (Weier et al., 2019). To combat the loss of natural roosting sites artificial roosts known as bat houses have been installed in areas where suitable natural roosting sites are not available (White, 2004) or to manage displaced bat maternity colonies (Brittingham & Williams, 2000).

Another major factor in the population decline of bats in North America is the fungal disease known as White Nose Syndrome (WNS), which was first detected in North America in 2006 - 2007 (Hoyt et al., 2021). WNS affects hibernating bats and has resulted in the death of millions of bats in the United States and Canada since the winter of 2007-2008 (United States National Wildlife Health Centre, 2022). Installation of bat houses is considered a top priority action to aid bats in recovery from WNS (Wilcox and Willis, 2016).

To offset a decline in bat populations, the installation of bat houses in strategic locations can play a significant role in supplementing available roost sites (Meiring and Chambers, 2014). This aids conservation efforts, especially in the face of climate change-driven habitat loss (Fontaine et al., 2021,). Several studies have focused on how different aspects of bat house design and placement can influence bat house occupancy rates (e.g., Long et al., 2007; Meiring and Chambers 2014; Rueegger et al., 2019; Fontaine et al., 2021). For example, Fischer (2014) found that bat houses placed on the side of buildings instead of trees were more likely to support maternity colonies. Several studies have considered the influence of weather and environmental factors on bat house occupancy rates (Brittingham & Williams, 2000; Dodd et al., 2022). When considering factors impacting bat house occupancy, variables most often considered in studies in the context of attracting bats were: house type and mount location. Few studies measured height or studied microclimatic or weather factors (Mering & Chambers, 2014).

Studies have indicated that weather conditions, including humidity as well as the thermal limits for bats' roost temperature, are important factors that influence occupancy rates, especially for maternity colonies (Weaver et al., 2015; Crawford & O'Keefe, 2021). The upper heat tolerance of temperate bats appears to be around 40 degrees celsius. (Crawford and O'Keefe, 2021), Bats often move to cooler regions of the roost when temperatures exceed this limit.(Weaver et al., 2015).

Distance to water has also been identified as an important factor as it has been indicated that water access is extremely important for bats **(**Adams & Hayes, 2021). Bats often frequent aquatic habitats for drinking and feeding purposes (Salvarnia, 2016). As global water sources decline, competition for habitat in proximity to water will increase (Adams & Hayes, 2021). This demand will impact bats during the reproductive season as well as impacting overall long-term bat populations (Adams & Hayes, 2021).

The species of bat targeted in this study is the Little Brown Bat, which is the most common bat species in bat houses within the Beaverhill Natural Area (BNA). The Little Brown Bat is widely distributed across North America (B.C. Conservation Data Centre., n.d.). The species is currently listed as federally endangered and is part of the species at risk act, due to the impacts of WNS (B.C. Conservation Data Centre., n.d.). They forage low over water on flying insects, especially chironomids (Barclay, 1991). Most of the Little Brown Bat's diet consists of aquatic insects, such as Mayflies (*Ephemeroptera*) and non-biting midges (*Chironomid Diptera*) (Belwood & Fenton, 1976; Clare et al., 2011). The Little Brown Bat's preference for aquatic insects would be consistent with its preference to select roosting locations near water **(**Adams & Hayes, 2021), thus suggesting these bats prefer to roost closer to water to ensure they are closer to their primary food source. A 2021 study found that Little Brown Bats preferred to roost closer to water sources (Lehrer et al., 2021).

Biologists at Beaverhill Bird Observatory began deploying bat houses in the BNA in 2016. They introduced multi-chambered bat houses in 2020. All houses were distributed across different habitat types (open, edge, clearing, and interior) to determine whether bat house occupancy in the region was influenced by differences in habitats. Each year, student interns have monitored population numbers in these bat houses and investigated how different factors, such as bat house size and general design (multi-chambered vs single-chambered, bat house paint colour, etc.) would influence bat house occupancy rates. Results from previous internships indicate that female bats prefer larger multi-chamber bat houses for maternity colonies (Waldron & Burke, 2021; Gualter & Halajian, n.d.). Several of the previous reports also studied the influence of maximum daily temperature and habitat type (Low, 2017; Waldron & Burke, 2021); however, the results for these factors were inconsistent between years in these studies.

The inconsistency of results from previous studies did not allow for an accurate assessment of the effect of weather conditions on bat house occupancy. For this study, a more holistic approach was taken. Data from the past three years were combined to provide a more robust analysis of the importance of weather conditions on bat house occupancy.

The scope of this study includes the following:

- Assessment of overall bat occupancy at the BBO over the last three summers to determine whether overall population numbers in the region have increased, remained stable, or decreased; and
- Evaluate how weather conditions (outside humidity and average temperature during sampling) influence bat house occupancy; and
- Explore how roost distance to water may affect bat house occupancy in the BNA.

Methods

Study Area

The study was in the Beaverhill Natural Area (BNA) (53.3672220, -112.54170) located 7.8 km east of Tofield, Alberta (Figure 1). The BNA comprises 410 hectares (1,013.1 acres) of aspen parkland and marshlands (Alberta Government, 2022) and is situated in the Aspen Parkland Ecoregion (National Ecological Framework for Canada, 1995). The region is characterised by an annual average temperature of 1.5°C; with cool and short summers (mean: 15°C) and long cold winters (mean: -12.5°C). Precipitation levels in the area range from 400 to 500 mm annually. The area is highly populated by a mix of trees and shrubs including Balsam Poplar (*Populus balsamifera*), Trembling Aspen (*Populus tremuloides*), Beaked Hazelnut (*Corylus cornuta*), Bebb's Willow (*Salix bebbiana*), Fire Cherry (*Prunus pensylvanica*) and Snowberry (*Symphoricarpos spp.*) (Nature Conservancy Canada, 2019).

Data Collection

A total of 38 bat houses along a 2.3 km route were positioned in the BNA as part of a long-term bat house monitoring program. Of the 38 bat houses, 32 were monitored over the course of this study. Four, previously installed bat houses, were taken down due to being too far from the observatory (bat houses 4, 5, 6, 7, and 13). Data from two other bat houses (bat houses 37 and M8) are sporadic, and these bat houses were excluded from this study. The bat houses installed in the BNA are a variety of sizes and colours. Two bat houses are single-chambered green boxes, three boxes are multi-chambered blue boxes, five boxes are medium-large single-chambered brown boxes, 17 are small single-chamber red boxes, and five are large brown, multi-chamber boxes (see Figures 2 and 3 for locations). The houses are distributed in four habitats within the BNA. These habitats include edge, interior, clearing, and open habitats (see Figure 4). These four habitats are: edge which comprises treed areas within 200 m of water bodies, interior, comprising forested areas, clearing, which comprises open areas surrounded by trees, and open habitats consisting of open grasslands.

Bat counts and weather conditions at bat house locations were completed weekly for a total of 17 weeks between May 16 and September 11, 2022. Only data collected between May through August were considered for analysis as part of this report due to lack of historic data after August in previous years.

Weather data were collected at the commencement of each study day including wind speed (km/hr), average temperature during sampling (C°), and percent humidity (%). Weather data were sourced from Weather Canada and The Weather Network, both of which collect weather data from a weather station located at Elk Island National Park located 40 km northwest of the BNA. Weather measurements were taken just before the first bat house was checked and it was also taken after the last bat house was checked. The average between the two temperatures (before and after) was used in the study data. Weekly surveys typically commenced before sunset on Monday evenings. Occupancy numbers were determined by conducting visits to each bat house. Verification of bat numbers was done using a flashlight to illuminate the interior of each bat house. A head count was then conducted, with counts done in an expedited manner to minimise disturbance to resident roosting bats (see Figure 5). A consistent route was taken to count bat numbers in bat houses during each weekly visit. The route was completed in a clockwise direction, from the BBO center to Robin's Route to bat house 12, then continuing down Flicker Freeway, to Harrier Highway and finally to Warbler Way (see Figure 6).

Coordinates for each bat house were collected using the Apple Compass application. The coordinates were established by recording the Apple compass GPS coordinates from directly under each bat house. The distance from each bat house to the water's edge was measured by determining the shortest straight line distance between the bat house and the water's edge (water sources include Sora pond, and Lister lake) using the Google Earth application version 9.154.0.2.

In relation to proximity to water data, each bat house was placed into a 'distance category' for ease of analysis. Five distance categories were created which are the following: 0-100m, 200-300m, 300-400m, 400-500m, and 500-600m. Bat houses were grouped into which category their proximity to water fell. Distance category 100-200m was removed because only one bat house (27) fell into that category.

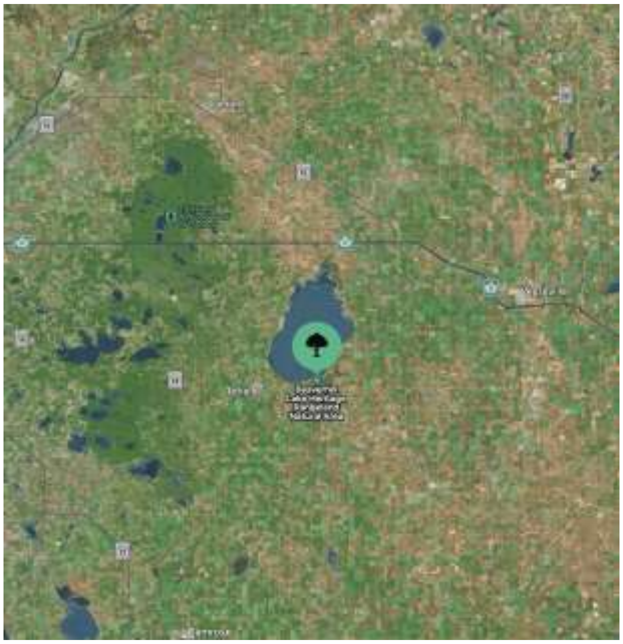

Figure 1: Beaverhill Natural Area (BNA) - from the Google Maps application version 6.40.4.

Figure 2: Bat house distribution in the BNA- (M stands for Maternity box) from the Google Earth application version 9.154.0.2. A green marker indicates a large single chamber box. Red indicates a small box, and yellow indicates a large multi chamber box.

Figure 3: Bat house types found in the BNA. Top left is a blue multi chamber house. Top right is a large single chamber house. The middle is a green single chamber house. The bottom left is a large brown multi chamber house. The bottom right is a small red house) Photos by Hailey Lewicki.

Figure 4: The habitat types in the BNA. Top left is the open habitat. Top right is the edge habitat. Bottom left is the interior habitat. The bottom right is the clearing habitat. Photos by Hailey Lewicki.

Figure 5: Conducting bat house counts during weekly site visits. Photo by Monica Lewicki

Figure 6: Trail map of the BNA trails. (Beaverhill Bird Observatory, 2020)

Data Analysis

Following the collection of all the data between May and September 2022, a thorough review and interpretation of the results was undertaken. All data were formally tabled and statistically analysed and any trends or patterns were documented. The coefficient of determination (R^2 value) of each parameter was calculated, and graphs and overall patterns were provided for each. Data collected from this study can be referenced in the Appendix.

Results

Three Year Overall Analysis

The bat observation program at the BBO was introduced to encourage bats to roost in the area. Data were consistently collected between 2020 and 2022 with a 240% increase in bat numbers observed. A 42% increase was observed between 2021 and 2022. With significant increases in bat populations since bat counts began in 2020, it could be concluded that efforts to increase bat populations through the installation of artificial roosts is having a positive influence on the bat populations at the BNA (Appendix 1b).

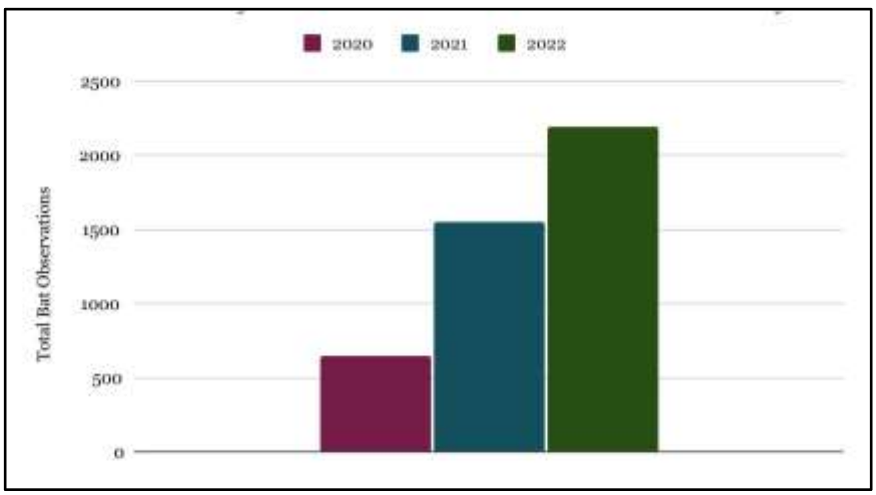

Figure 7: A bar graph depicting the increase in bat occupancy over a three year period.

Influence of Weather Conditions on Bat House Occupancy

A review of available data was completed, which included average temperature during sampling and humidity. Humidity and temperature measurements were taken each week before bat data collection began, as well as after data collection was completed. The average of the two values was used for the study. Humidity has one year of data (2022) and average temperature during sampling analysis consists of three years of data (2020, 2021 and 2022).

The coefficient of determination (R^2 value) for humidity was calculated to be 12.6% suggesting that humidity has very little influence on bat occupancy numbers (Appendix 4).

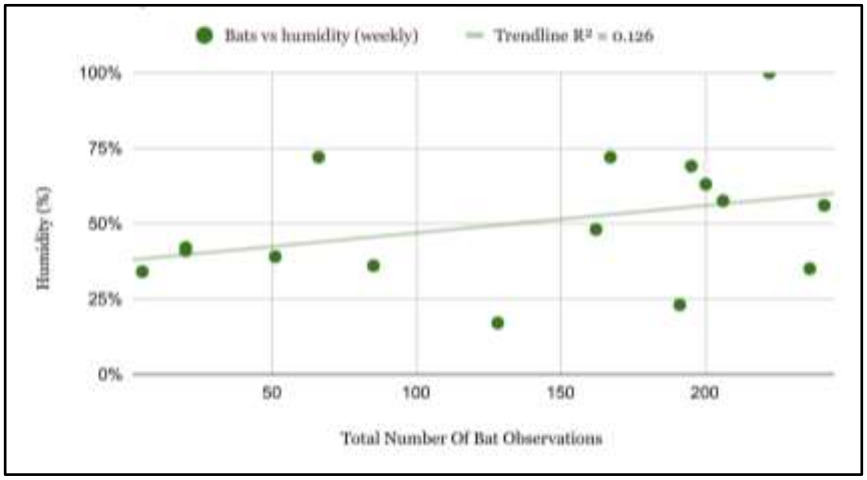

Figure 8: Humidity (2022 data) in comparison to the number of bat observations.

Temperature measurements were taken before and after data collection with the average value being used for study purposes. This is the average temperature during sampling. An R^2 value of 5.4% was calculated suggesting that daily temperatures do not significantly influence bat house occupancy (see Appendix 3).

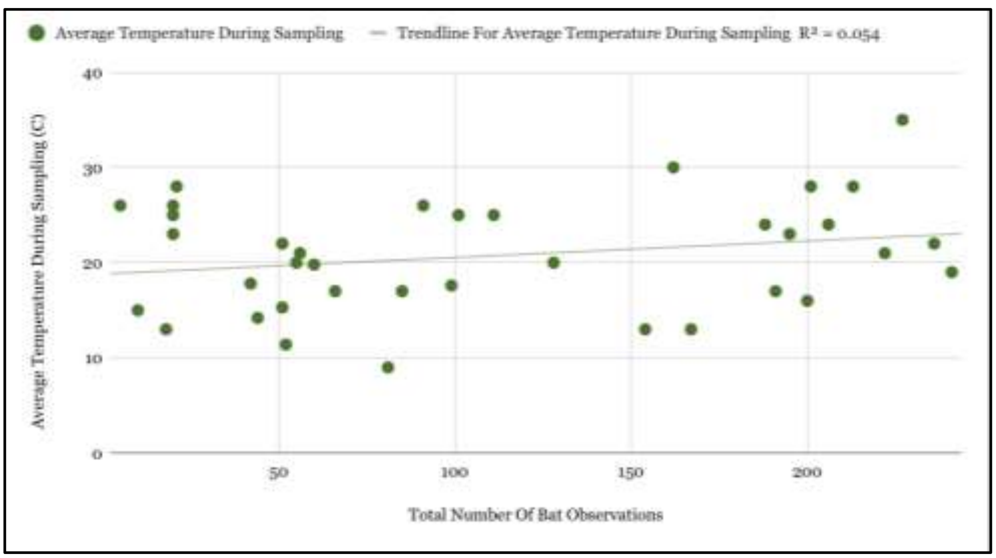

Figure 9: average temperature during sampling vs total number of bat observations- over a three year period (2020, 2021 and 2022).

<u>Bat House Proximity to Water</u>

Bat house distance to water was calculated, and bat observations over three years (2020, 2021 and 2022) were analysed. An R^2 value of 62.4% was calculated, suggesting a significant correlation between bat occupancy numbers and the roost distance to water. Houses 27 and M41 were removed from the distance to water calculations due to an extreme skew they caused in the data (see Appendix 2). House M41 had an extremely high occupancy rate so it was excluded.

House 27 was excluded as it was the only house in its distance category and therefore an inaccurate representation of occupancy was anticipated in that category (see Appendix 2).

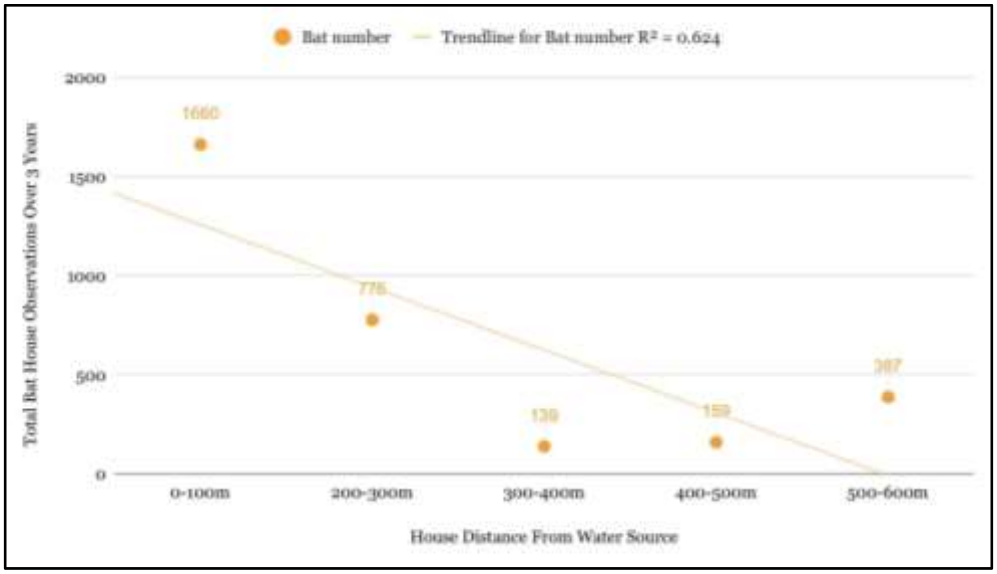

Figure 10: Total bat observations over three years (2020, 2021 and 2022) vs. house proximity to water. Bat numbers (for each house) in each distance category were grouped together.

Discussion

This study focused on how weather conditions (average temperature during sampling and humidity) and bat house proximity to water affect bat house occupancy numbers. The results suggest that average temperature during sampling and humidity do not play a significant role in bat house occupancy, whereas proximity to water results displayed significance.

Three-Year Overall Analysis

The overall bat occupancy numbers over three years were included to assess the effectiveness of the bat house occupancy project in the BNA. Results suggest that the installation of artificial roosts has been extremely effective. Previous trend data could suggest that overall bat numbers will continue to rise in future years.

In the early years of the bat program (2017 to 2019), maternity boxes were not installed in the BNA which likely impacted bat occupancy numbers. In 2020, six maternity bat houses were installed at the BNA. These maternity bat houses have proven effective and have attracted more bats to the area.

Influence of Weather Conditions on Bat House Occupancy

Other studies have suggested that weather conditions are an important factor that affects bat house occupancy (Lourenço & Palmeirim 2004; Weier et al., 2019). Weather conditions have been suggested to play a large role in occupancy rates. The results from this study suggest that humidity and average temperature during sampling are not significant factors. Although, this analysis may prove different in other regions. However, weather activity was monitored for the area as a whole, not at each individual bat house, which may have skewed results.

For a more accurate gauge of the importance of average temperature during sampling, three years of data were reviewed. The data suggest that average temperature during sampling does not appear to be significant. Internal bat house temperatures have been found to be more significant as they are more accurate than external temperatures. Internal temperature is extremely important when raising pups and the survival of the bats (Crawford & O'Keefe, 2021). Bat house colour has also been identified as important due to how it may impact the interior temperatures of the bat houses (Low, 2017). Internal house humidity has also been identified as an important factor, as it can possibly affect the temperature in the house (Lourenco & Palmeirim, 2004). In future studies, the collection of data from inside the bat houses that includes environmental parameters such as internal temperature and humidity would be important to gain further clarity on bat house occupancy. Eighteen temperature data loggers were installed in some bat houses throughout the 2022 season, but this data is being analysed and not available at this time.

Bat House Proximity to Water

Bat house proximity to water is an understudied area in bat house research (B.C. Conservation Data Centre). Results from this study indicate a strong relationship between distance to the nearest water source and bat house occupancy numbers over a three-year period (2020, 2021, and 2022) at the BNA. This suggests that proximity to water may be more important than the location of bat houses in different habitat types. This result is not surprising since some studies have found that the Little Brown Bat depends on a nearby body of water as its food source (Clare et al., 2011). This would be consistent with a preference for roosting sites closer to water (Clare et al., 2011). The majority of a Little Brown Bat's diet consists of aquatic insects, including non-biting midges (*Chironomid Diptera*) and Mayflies (*Ephemeroptera*) (Belwood & Fenton, 1976; Clare et al., 2011).

Limitations

Weather parameters were collected from a weather station located over 40 km northwest of the BNA which may have resulted in discrepancies in weather-related data used in the study. Any discrepancies in weather data could have skewed the study results. In terms of bat house locations in proximity to water bodies, bat houses were not evenly distributed in each distance category which could sway the results in favour of one category over another. For example, only four houses are located in the 200-300m category, whereas sixteen bat houses are located in the 0-100m category.

Recommendations For Future Bat Studies In The BNA

Bat studies in the BNA could be improved for future studies by creating a consistent set of data. Specifically, it is important to address the uneven number of bat houses of each size and colour. Having the same number of brown, green, blue, and red houses, as well as the same number of small, medium, and large houses would greatly improve the accuracy of results. Maternity boxes (large multi chamber houses) have significantly better occupancy rates, regardless of the colour and size of the house.

It also would be beneficial, for further proximity to water research, to distribute houses evenly in each 100 metre distance category.

In future studies, collecting data from inside the bat houses (e.g., internal temperature and humidity) would be important to gain further understanding of factors affecting bat house occupancy.

Conclusion

This study found that weather conditions, including average temperature during sampling, and humidity were not significant factors influencing bat house occupancy. However, the proximity of bat houses to the nearest water source had a significant impact on bat house occupancy.

Based on data collected in the BNA for this report during the 2022 season and studies completed in previous years (2020 and 2021), the highest occupancy rates were found in bat houses that were constructed as multi-chamber boxes, painted a dark colour on the exterior, placed on a tree and near a natural water source.

This study highlights the importance of monitoring bat house occupancy on a long-term basis as more data allows for a clearer, more reliable understanding of patterns and trends that could influence bat populations. The study also highlights the importance of water proximity to bat house locations. Finally, the overall increase in total bat observations in the BNA over the last three years is a testament to the utility and success of providing artificial roosts for bats, which could significantly aid bat conservation efforts in Alberta, especially for the endangered Little Brown Bat.

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Appendix

Appendix 1. Raw 2022 bat house metadata and numbers. Information included pertains to each individual bat house: its distance to water in metres, the 100m distance category the house falls into, the habitat each house is located in and the house size. The bat numbers for each house in each month (2022) is also noted here; as well as the yearly total of bats in each house.

Bat House #	Distance to wate	Distance categor	Habitat	House Type	Bat # may	June	July	August	Total
2	581	500-600m	Interior	Large	0	4	5	3	12
3	300	200-300	Interior	Large	0	2	6	14	22
9	338	300-400	Interior	Small	0	0	1	3	4
10	302	300-400	Interior	Small	10	0	0	1	11
11	501	500-600	Clearing	Large	9	29	62	17	117
12	525	500-600	Open	Large	0	0	4	6	10
14	439	400-500	Clearing	Large	4	7	16	19	46
15	364	300-400	Interior	Large	8	3	13	12	36
16	537	500-600	Interior	Large	15	19	18	3	55
M17	280	200-300	Edge	XL	41	67	13	7	128
18	230	200-300	Edge	Small	0	0	2	1	3
M19	203	200-300	Edge	XL	65	103	66	2	236
20	18.1	0-100	Edge	Small	0	0	0	1	1
21	2	0-100	Edge	Small	1	0	1	4	6
M22	30.1	0-100	Edge	XL	91	194	82	0	367
23	4	0-100	Edge	Small	0	0	0	0	0
M24	37.3	0-100	Edge	XL	41	134	96	0	271
25	66	0-100	Edge	Small	0	0	0	4	4
26	74.8	0-100	Edge	Small	0	0	2	3	5
27	101	100-200	Edge	Small	0	0	1	1	2
30	49.5	0-100	Edge	Small	0	0	3	1	4
32	72.7	0-100	Edge	Small	0	0	4	4	8
33	50.7	0-100	Edge	Small	0	0	3	4	7
35	43.8	0-100	Edge	Small	0	0	4	0	4
36	48.3	0-100	Interior	Small	0	0	1	1	2
38	301	300-400	Interior	Small	0	0	0	7	7
39	509	500-600	Clearing	Small	0	0	0	1	1
M41	582	500-600	Clearing	XL	119	248	146	0	513
M44	51.7	0-100	Edge	Medium	0	3	42	24	69
M45	60.4	0-100	Edge	Medium	0	18	120	0	138
M46	43.3	0-100	Edge	Large	0	13	74	19	106

Appendix 1b. Bat numbers over three years 2020, (highlighted in dark pink) 2021 (highlighted in dark purple) and 2022 (highlighted in bright green). Each date has the total number of bats observed in all bat houses that day.

dates:	Bat Numbers
Friday, May 08, 2020	6
Thursday, May 14, 2020	10
Saturday, May 23, 2020	32
Saturday, May 30, 2020	15
Friday, June 05, 2020	51
Thursday, June 11, 2020	44
Sunday, June 21, 2020	51
Tuesday, June 30, 2020	57
Monday, July 06, 2020	60
Tuesday, July 21, 2020	116
Monday, July 27, 2020	99
Tuesday, August 04, 2020	42
Wednesday, August 12, 2020	52
Wednesday, August 19, 2020	10
Sunday, May 16, 2021	56
Tuesday, May 25, 2021	81
Tuesday, June 01, 2021	91
Sunday, June 06, 2021	154
Sunday, June 13, 2021	111
Tuesday, June 22, 2021	201
Tuesday, June 29, 2021	227
Saturday, July 03, 2021	188
Wednesday, July 14, 2021	213
Saturday, July 24, 2021	101
Tuesday, July 27, 2021	55
Tuesday, August 03, 2021	20
Friday, August 13, 2021	21
Tuesday, August 17, 2021	10
Tuesday, August 24, 2021	18
Monday, May 16, 2022	85
Monday, May 23, 2022	128
Monday, May 30th 2022	191
Monday, June 6th, 2022	167
Monday, June 13, 2022	236
Monday, June 20, 2022	241
Monday, June 27, 2022	200
Monday July 4th, 2022	222
Monday, July 11th, 2022	206
Monday, July 18th, 2022	195
Wednesday, July 27, 2022	162
Tuesday, August, 2nd, 2022	66
Sunday, August, 7th, 2022	51
Monday, August 15, 2022	20
Monday, August 22, 2022	20
Monday, August 29, 2022	5

Appendix 2. A table depicting distance to water and it's related data. Each house has it's distance to water in metres, the total bats in each house in 2020, 2021 and 2022. It also has which 100m distance category each house falls into. Grey highlight indicates removed houses- due to skews and ones that were removed between years.

House Number	Distance To Water (M)	Total bats 2020	Total bats 2021	Total Bats 2022	Distance categor
20	18.1	0	0	1	0-100
21	2	3	8	6	0-100
23	4	0	0	0	0-100
25	66	1	2	4	0-100
26	74.8	5	2	5	0-100
30	49.5	2	3	4	0-100
32	72.7	3	1	8	0-100
33	50.7	3	9	7	0-100
35	43.8	1	5	4	0-100
36	48.3	2	1	2	0-100
M22	30.1	34	324	367	0-100
M24	37.3	8	251	271	0-100
M44	51.7	0	0	69	0-100
M45	60.4	0	0	138	0-100
M46	43.3	0	0	106	0-100
27	101	2	0	2	100-200
3	300	10	15	22	200-300
18	230	6	9	3	200-300
M17	280	107	52	128	200-300
M19	203	29	159	236	200-300
9	338	0	3	4	300-400
10	302	0	0	11	300-400
15	364	20	47	36	300-400
38	301	7	4	7	300-400
14	439	88	25	46	400-500
11	501	19	44	117	500-600
12	525	11	9	10	500-600
16	537	10	53	55	500-600
39	509	3	32	1	500-600
2	581	5	6	12	500-600m
M41	582	189	302	513	500-600
4		0	0	0	
5		0	0	0	
6		5	2	0	
7		3	17	0	
13		13	12	0	
37		3	5	0	
M8		53	145	0	

Appendix 3. A table depicting Average temp during sampling for 2020, 2021 and 2022. Bat number refers to the amount of bats on the corresponding day as well as the Average temp during sampling for that date.

Date	Bat Number	Av Temp During Sampling
Friday, May 08, 2020	6	
Thursday, May 14, 2020	10	
Saturday, May 23, 2020	32	
Saturday, May 30, 2020	15	
Friday, June 05, 2020	51	15.3
Thursday, June 11, 2020	44	14.2
Sunday, June 21, 2020	51	
Tuesday, June 30, 2020	57	
Monday, July 06, 2020	60	19.8
Tuesday, July 21, 2020	116	
Monday, July 27, 2020	99	17.6
Tuesday, August 04, 2020	42	17.8
Wednesday, August 12, 2020	52	11.4
Wednesday, August 19, 2020	10	
Sunday, May 16, 2021	56	21
Tuesday, May 25, 2021	81	9
Tuesday, June 01, 2021	91	26
Sunday, June 06, 2021	154	13
Sunday, June 13, 2021	111	25
Tuesday, June 22, 2021	201	28
Tuesday, June 29, 2021	227	35
Saturday, July 03, 2021	188	24
Wednesday, July 14, 2021	213	28
Saturday, July 24, 2021	101	25
Tuesday, July 27, 2021	55	20
Tuesday, August 03, 2021	20	23
Friday, August 13, 2021	21	28
Tuesday, August 17, 2021	10	15
Tuesday, August 24, 2021	18	13
Monday, May 16, 2022	85	17
Monday, May 23, 2022	128	20
Monday, May 30th 2022	191	17
Monday, June 6th 2022	167	13
Monday, June 13, 2022	236	22
Monday, June 20, 2022	241	19
Monday, June 27, 2022	200	16
Monday July 4th, 2022	222	21
Monday, July 11th, 2022	206	24
Monday, July 18th, 2022	195	23
Wednesday, July 27, 2022	162	30
Tuesday, August, 2nd, 2022	66	17
Sunday, August, 7th, 2022	51	22
Monday, August 15, 2022	20	26
Monday, August 22, 2022	20	25
Monday, August 29, 2022	5	26

Appendix 4. Raw humidity data from 2022. Depicted are the number of bats on each date, as well as the humidity on each day.

Date	Bat Number	Humidity (%)
Monday, May 16, 2022	85	36%
Monday, May 23, 2022	128	17%
Monday, May 30th 2022	191	23%
Monday, June 6th 2022	167	72%
Monday, June 13, 2022	236	35%
Monday, June 20, 2022	241	56%
Monday, June 27, 2022	200	63%
Monday, July 4th, 2022	222	100%
Monday, July 11th, 2022	206	57.50%
Monday, July 18th, 2022	195	69%
Wednesday, July 27, 2022	162	48%
Tuesday, August, 2nd, 2022	66	72%
Sunday, August, 7th, 2022	51	39%
Monday, August 15, 2022	20	42%
Monday, August 22, 2022	20	41%
Monday, August 29, 2022	5	34%