North American Bat Monitoring Program

Alberta 2020 Final Report

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Executive Summary

Nine species of bat occur in Alberta with at least five species considered to be susceptible to population decline due to either disease (white-nose syndrome; WNS) or fatalities at wind energy facilities. Since 2015 Alberta has been a part of the North American Bat Monitoring Program (NABat) to gather data on current provincial bat distributions and relative abundances, predominantly through passive and mobile acoustic surveys. There was a huge increase in NABat grid cells surveyed in 2020, compared to previous years. In 2020, passive acoustic surveys were conducted at 101 stations within 63 NABat grid cells; between one and four detectors surveyed each grid cell with a total of 1472 nights of passive acoustic surveys. Mobile surveys were conducted at 20 grid cells (10 of which did not have accompanying passive surveys) over 37 nights, two nights at the 14 mobile transects in the Upper Peace Region (conducted by the Alberta Biodiversity Monitoring Institute) and in Elk Island National Park, and a single night for the remaining 5 transects. For the passive surveys, sites were surveyed a mean of 15.2 nights (range of 1-96 nights).

There was a total of 99,727 bat call sequences recorded during the passive surveys, with the majority (56,353 or 57%) not identified to a species/species group. Of the call sequences identified to species / species group, similar to previous years, they were most often identified as *Lasiurus cinereus,* Myotis 40k, or *M. lucifugus* (15,545 or 36%, 8175 or 19%, and 7451 or 17%, respectively), as well as EPFU-LANO (7282 or 17%). The mobile surveys recorded 645 bat call sequences, with over three-quarters (500 or 78%) identified to species / species group, predominantly attributed to *M. lucifugus* (208 or 32%). The majority of the NABat passive acoustic surveys occurred prior to 10 July 2019 and mean nightly bat activity was highly variable, both in time and space, with some species having discrepancies in mean nightly activity between detectors within the same grid cell.

As in previous years, these findings have serious implications for the conservation and maintenance of Alberta's bat populations with the increasing and emerging threats of WNS and wind energy development. In Alberta NABat surveys have been regularly conducted in five of the six provincial Natural Regions with the majority of surveys in the Boreal, consistent surveys in the Foothills, Grasslands and Rocky Mountain, increasing surveys in the Parklands and limited surveys in the Canadian Shield. Future surveys should aim to fill gaps in the provincial distribution of surveys, particularly in the Canadian Shield Natural Region and the north-west of the province. As well, surveys should be concentrated in areas where populations are expected to decline, from either WNS (potential threat from south-west as WNS expands out from Washington State) or wind fatalities (wind belt of southern Alberta).

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Introduction

Nine species of bat occur in Alberta (Table 1). A tenth species, *Myotis californicus*, is suspected of occurring, likely along the Rocky Mountains as it has been observed just across the border in south-eastern British Columbia (Cori Lausen, *pers comm*) and has been detected acoustically in Waterton Lakes National Park (Burgar 2017a, 2018) and possibly in Jasper National Park and the foothills, near Switzer (Burgar 2018, 2019, 2020). Of confirmed bat species in Alberta, two (*Myotis lucifugus* and *M. septentrionalis*) were listed as Endangered on Schedule 1 of the Species At Risk Act in 2014 due to the impending threat of the fungal disease white-nose syndrome (WNS) (Environment Canada 2015). Three additional species (*Lasiurus borealis*, *L. cinereus*, and *Lasionycteris noctivagans*) may experience population declines due to increasing wind development.

As of spring 2020, WNS has confirmed occurrences in seven Canadian provinces, as far west as Riding Mountain National Park in Manitoba (Figure 1). The confirmed WNS occurrences in Washington State put south-western British Columbia within the 250 km setback buffer. Since first being detected in one bat in Washington State in 2016, WNS has now been confirmed from bats at three locations in Washington State, in addition to the fungus (*Pseudogymnoascus destructans*) being present at three additional locations in Washington and one in California, suggesting WNS is spreading from the west as well as the east. If not already present in western Canada, WNS is expected to occur within western Canada generally, and Alberta specifically, within a few years. The majority of wind energy developments linked to bat fatalities in Canada occur in south-western Alberta and it is projected that *L. cinereus* populations may decline as much as 90% across North America over the next five decades (Frick et al. 2017).

In response to these threats, in 2014 the province of Alberta initiated a pilot project to expand the North American Bat Monitoring Program (NABat) into Alberta to document current provincial bat distributions and indices of abundance at multiple scales. NABat's purpose is to create a continent-wide program to monitor bats at local to range wide scales (https://www.nabatmonitoring.org/) (Loeb et al. 2015). Since 2015 Alberta has conducted NABat monitoring through acoustic surveys (mobile and passive) at multiple locations across the province, including within all of the national parks. In addition, Alberta has been conducting annual monitoring at the largest known winter hibernaculum and efforts are also focusing on locating new roosts —another mandate of NABat is monitoring winter hibernaculum and summer maternity colonies.

For consistent bat species identification across sites, an Alberta based bat call automation model was developed (Burgar 2017b) and has been used to analyse provincial bat acoustic data. *Myotis* species can be difficult to distinguish acoustically; one of the five confirmed *Myotis* species occurs province wide while four have some geographic separation that can aid in identification of *Myotis* calls based on geography (Table 1, maps in Burgar 2018). *Myotis evotis* occurs in the southern half of the province while *M. septentrionalis* occurs in the northern half; *M. volans* is poorly documented and likely only occurs in the Rocky Mountain and Grassland natural regions; and *M. ciliolabrum* occurs in the badland habitats of the Red Deer, South Saskatchewan, and Milk River valleys and adjacent coulees (Cory Olson, *pers comm*).

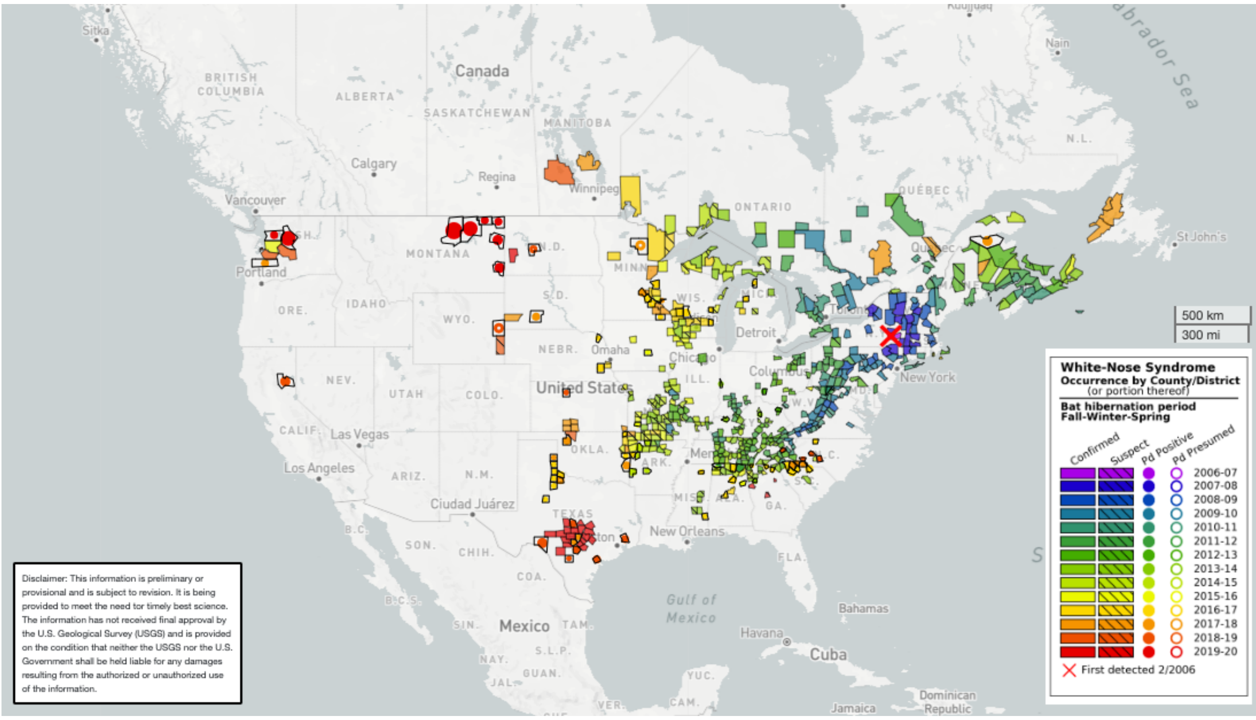

Figure 1. Map showing extent and spread of white-nose syndrome (WNS) up to the spring of 2020, downloaded from https://www.whitenosesyndrome.org/where-is-wns.

Table 1. Bat species known, and likely, to occur in Alberta.

Common name - NABat	Scientific name	Code	Distribution	Likely Occurs
Big brown bat	*Eptesicus fuscus*	EPFU	Province-wide	
Eastern red bat	*Lasiurus borealis*	LABO	Province-wide	
Hoary bat	*Lasiurus cinereus*	LACI	Province-wide	
Silver-haired bat	*Lasionycteris noctivagans*	LANO	Province-wide	
California myotis	*Myotis californicus*	MYCA	Unconfirmed	Mountains
Western small-footed myotis	*Myotis ciliolabrum*	MYCI	South	
Long-eared myotis	*Myotis evotis*	MYEV	South	
Little brown bat	*Myotis lucifigus*	MYLU	Province-wide	
Northern myotis	*Myotis septentrionalis*	MYSE	North	

Long-legged myotis	*Myotis volans*	MYVO	Unclear	Mountains & Grasslands

This report summarizes the findings of the NABat surveys conducted and submitted to Alberta Environment and Parks in 2020. This report includes passive acoustic surveys that were conducted following NABat protocols but not necessarily for NABat monitoring (i.e., outside the typical NABat temporal window). The methods provide details on the study design, processing of the calls through *Alberta eBat* (Burgar 2017b), and statistics summarising NABat bat acoustic activity within the province. The results provide overall calls and mean nightly calls for each grid cell, and by volancy period for Natural Region and land use type (groupings reflect NABat categories), as well as nocturnal activity patterns for species / species groups pre- and post-volancy pooled across the province. The discussion touches on analysis limitations and future recommendations, as well as implications of the findings in the context of wind energy development and WNS. In addition, the discussion provides brief highlights of the multi-year acoustic data analysis commissioned by Parks Canada: this analysis examined six years of NABat passive acoustic data spatially, temporally, and by key landscape attributes to summarise (1) bat survey locations and efforts, (2) bat activity patterns by landscape attribute and temporal niche partitioning, and (3) bat community and species / species group occurrences as functions of space, time and landscape attributes (Burgar 2021). The appendix provides comprehensive site specific survey details (site map, datasheet, environmental and site details, graph and tabular output of recorded bat call sequences per detector/night/site) for each NABat sampling grid surveyed, akin to the processed acoustic data and associated site metadata to be uploaded to the international NABat database.

Methods

Study Design & Survey Methods

NABat uses a probability-based sampling design to ensure valid statistical inference of bat population trends over the continent (Loeb et al. 2015). To do so NABat adopted a grid-based finite-area sampling frame with 10 km by 10 km (100 km^2) grid cell sample units. All 100 km^2 cells were assigned a spatially balanced and randomized ordering using the generalized random-tessellation stratified (GRTS) survey design algorithm. The benefit of the GRTS design is its flexibility and robustness to adding/dropping survey sites as resources and logistical conditions change over time. Alberta comprises 6422 full grid cells and 437 partial cells; each full grid cell sampling unit is further broken down into four quadrants, identified by their cardinal direction (e.g., NE for north-east).

Please note that this year sampling grid cells are referred to using their GRTS ID, as per the NABat hierarchical naming convention, assigning individual stations a name based on which GRTS grid cell and quadrant they fall within. For example, Jasper National Park's Tekarra Marsh acoustic survey station has been renamed as "23146_NE_01" as it falls within the north-east quadrant of GRTS grid cell 23146. The '01' refers to the station number as some quadrants contain more than one station and/or a survey location may be moved between years.

Passive surveys consisted of deploying one to four detectors within each grid cell, preferably with one in each quadrant. NABat recommends conducting passive surveys over multiple consecutive days, with a four night minimum, prior to the emergence of volant young. Mobile surveys consisted of mounting detectors on moving vehicles and driving transects within the cell. NABat recommends driving each (25-48 km) transect at least twice in one week and, where applicable, conducting both the passive and mobile surveys during the same week. To optimize trend detection NABat recommends conducting acoustic surveys of the same grid cells annually, for a minimum of five years. See Loeb *et al.* (2015) for comprehensive details on the NABat sampling design and survey protocols and the appendix for passive survey details specific to each grid cell.

Bat Call Analysis

For the passive surveys, grid cells were surveyed using either full spectrum (WAV; Song Meter SM2+ BAT or SM4 BAT, Wildlife Acoustics Inc, MA USA; or Anabat Swift, Titley Scientific, MO USA) or frequency division zero-cross (ZC; AnaBat Express, Titley Scientific, MO USA) detectors with omni-directional microphones. Mobile surveys were recorded using both full spectrum and frequency division recorders with directional microphones, mounted on motor vehicles. Detectors recorded in either WAV or ZC format onto SD cards.

Once recorded, files were processed using *Alberta eBat* (www.albertaebat.ca) (Burgar 2017b). For full spectrum (WAV) and zero-cross (ZC) files, *Alberta eBat* is able to process and automatically identify multiple nights of recordings per site. A survey night begins at sunset and ends at sunrise on the following date; for example, all calls recorded with date-time stamps between 28-06-2020 23:00:00 and 29-06:2020 04:59:00 were considered the survey night of 28-06-2020. At this time Anabat Express output files (ZCA) are not able to be processed directly through *Alberta eBat* and require the first step of converting the ZCA file to nightly ZC files using the converter function in Anabat Insight (Version 1.9.1, Titley Scientific, MO USA).

All analyses were conducted in R (version 3.6.1; 2019), within RStudio (version 1.2.5033) using rmarkdown (version 2.1; Allaire et al. 2020) for reproducible results. Unless otherwise noted, results are reported as the mean ± 1 SE.

Results

Survey Effort

In 2020 acoustic monitoring data was contributed from 73 sampling grids. Passive acoustic surveys were conducted at 101 unique stationary points (i.e., stations) in 63 grid cells within five Natural Regions (Boreal, Foothills, Grassland, Parkland, and Rocky Mountain), comprising 42 grid cells outside National Parks and 21 grid cells in four National Parks (Banff, Elk Island, Jasper, and Waterton Lakes) (Table 2 and Figure 2). Mobile acoustic surveys (mobile surveys, along transects) were conducted in 19 grid cells in Banff National Park, Jasper National Park, North Saskatchewan River Region, Upper Athabasca Region, and the Upper Peace Region. Ten mobile surveys were in grid cells without accompanying passive surveys.

Table 2. The number of stations and NABat grid cells passively surveyed in Natural Regions and Land Units (i.e., National Parks or Land-use Framework Regions). Land Unit abbreviations are as follows: BANP = Banff National Park, EINP = Elk Island National Park, JANP = Jasper National Park, WBNP = Wood Buffalo National Park, WLNP = Waterton Lakes National Park, LOAR = Lower Athabasca Region, LOPR = Lower Peace Region, NOSR = North Saskatchewan Region, REDR = Red Deer Region, SOSR = South Saskatchewan Region, UPAR = Upper Athabasca Region, and UPPR = Upper Peace Region

National Park	Natural Region	Land Unit	Total Grid Cells	Total Stations	NABat Stations
In	Boreal	EINP	1	4	4
In	Parkland	WLNP	1	1	0
In	Rocky Mountain	BANP	10	12	3
In	Rocky Mountain	JANP	2	6	6
In	Rocky Mountain	WLNP	7	12	3
Out	Boreal	LOPR	2	6	6
Out	Boreal	NOSR	5	11	6
Out	Boreal	REDR	2	2	0
Out	Boreal	UPPR	1	2	2
Out	Foothills	UPAR	3	7	7
Out	Foothills	UPPR	5	11	11
Out	Grassland	REDR	6	6	0
Out	Grassland	SOSR	6	7	7
Out	Parkland	NOSR	4	4	0
Out	Parkland	REDR	5	5	0
Out	Rocky Mountain	UPPR	3	5	5

For the passive surveys, each grid cell had a mean of 1.6 ± 0.1 (1 SE) stations, with between 1 (91 stations) and 4 (1 station) stations per quadrat. The average minimum distance between stations was 11.3 ± 1.7 km. Within 10 km of a station, there were an average of 2 ± 0.2 neighbouring stations. There were 19 stations where the next nearest station was >10 km away. While most (i.e., 60 or 59%) stations were surveyed specifically for NABat monitoring, some (i.e., 42 or 41%) stations were surveyed following similar NABat protocols but not for NABat monitoring per se (e.g., outside of the recommended survey temporal window or for other objectives such as monitoring migratory routes [RDR] or to collect WNS baseline data [BNP, WLNP]).

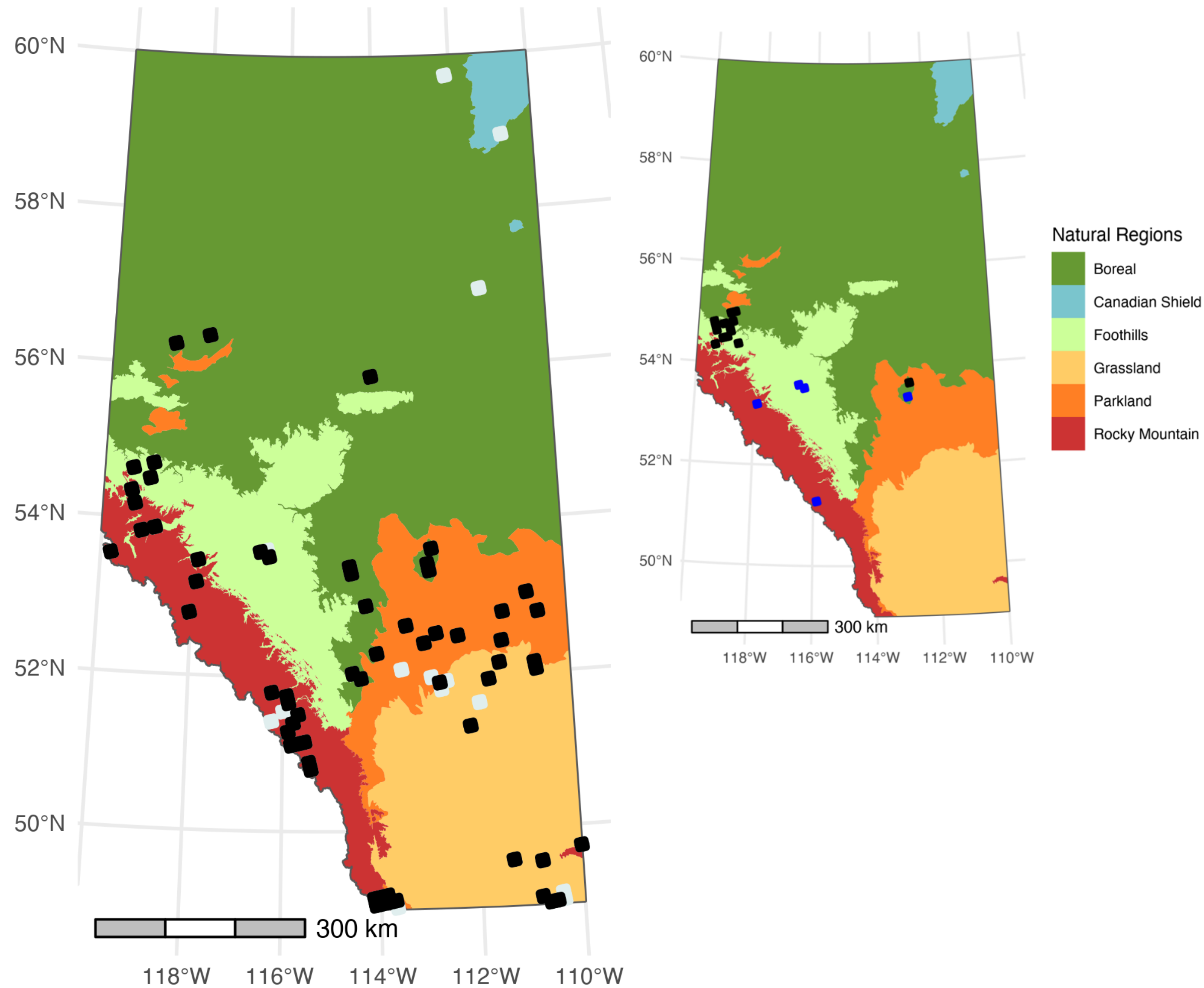

Figure 2. Passive surveys (left map) were conducted at 101 stations and within 63 NABat sampling grids in Alberta 2020: in the Boreal, Foothills, Grassland and Rocky Mountain Natural Regions of Alberta. The black polygons represent NABat sampling grids surveyed in 2020 while the grey polygons represent NABat grids surveyed in previous years, but not 2020. For mobile surveys (smaller right map), 15 transects were surveyed on two nights (black polygons) while five transects were only surveyed once (blue polygons).

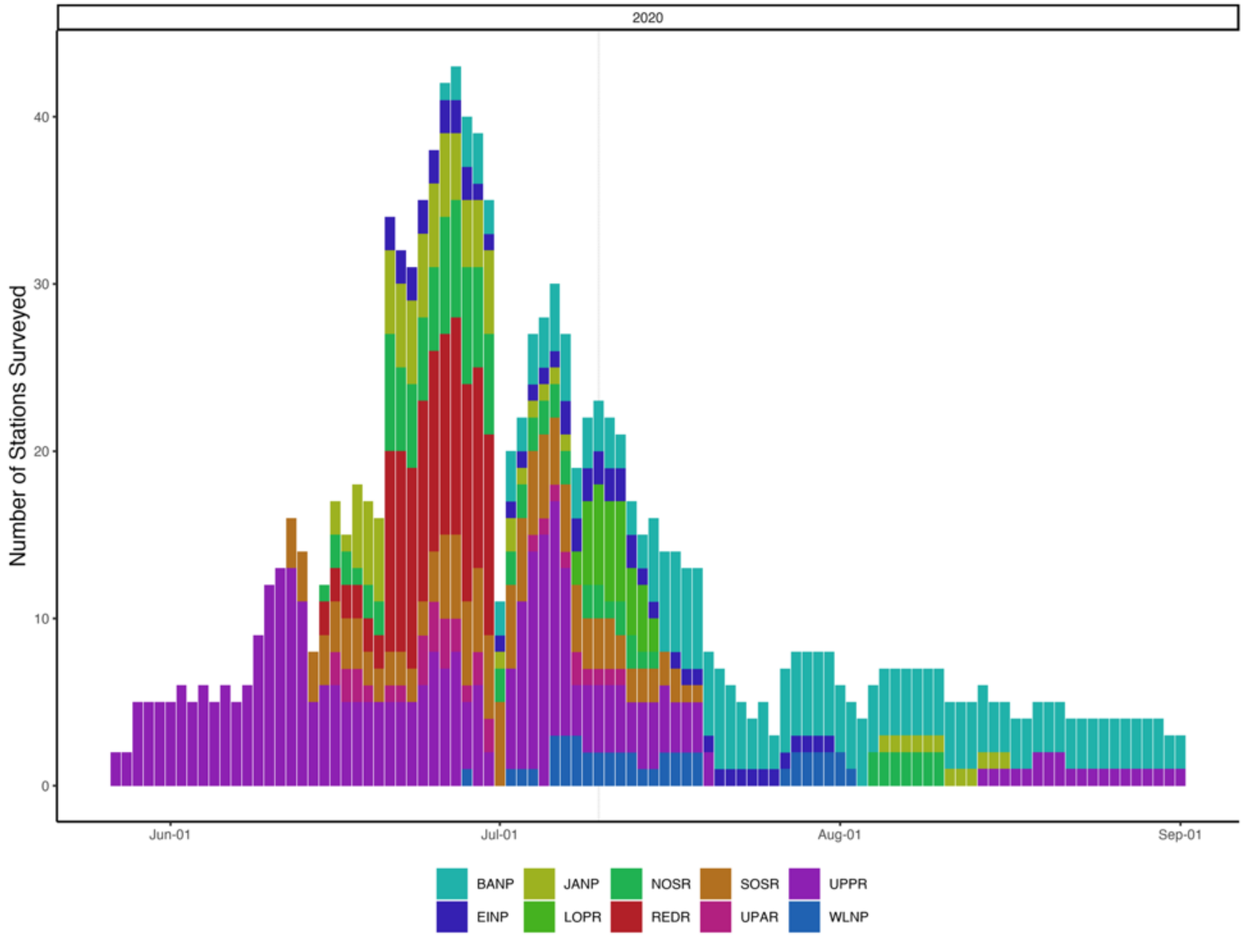

Figure 3. Number of stations surveyed within each Land Unit (see Table 2 for Land Unit abbreviations) between 1 May and 1 September, 2020. The dashed horizontal line is July 10, the general date of volancy. Some stations were surveyed outside of this temporal window but that data was considered as too far outside the NABat monitoring window to be included in this report.

Mobile surveys were conducted between 9 June and 15 July, inclusive. Two transects (grid cells: 89754 – Edson2; 267463 – Pocahontas) were monitored on the same night using two different detectors, presumably to examine the agreement between detectors of different models, recording side by side. The results for both detectors are provided.

Passive Survey Results

Nightly Overall Bat Call Summaries

There were 99,727 bat calls recorded at 101 stations from 1 May to 1 September 2020, over 1476 survey nights. Of these calls, 57% were classified as unknown. Mean nightly bat calls were higher in the Boreal, compared to any other Natural Region (Figure 4). More calls were recorded each night post-volancy in the Boreal and Foothills Natural Regions, compared to pre-volancy. In contrast, the Parkland Natural Region had more nightly calls recorded pre-volancy, compared to post-volancy. Recall a general volancy date of July 10 was applied across the province.

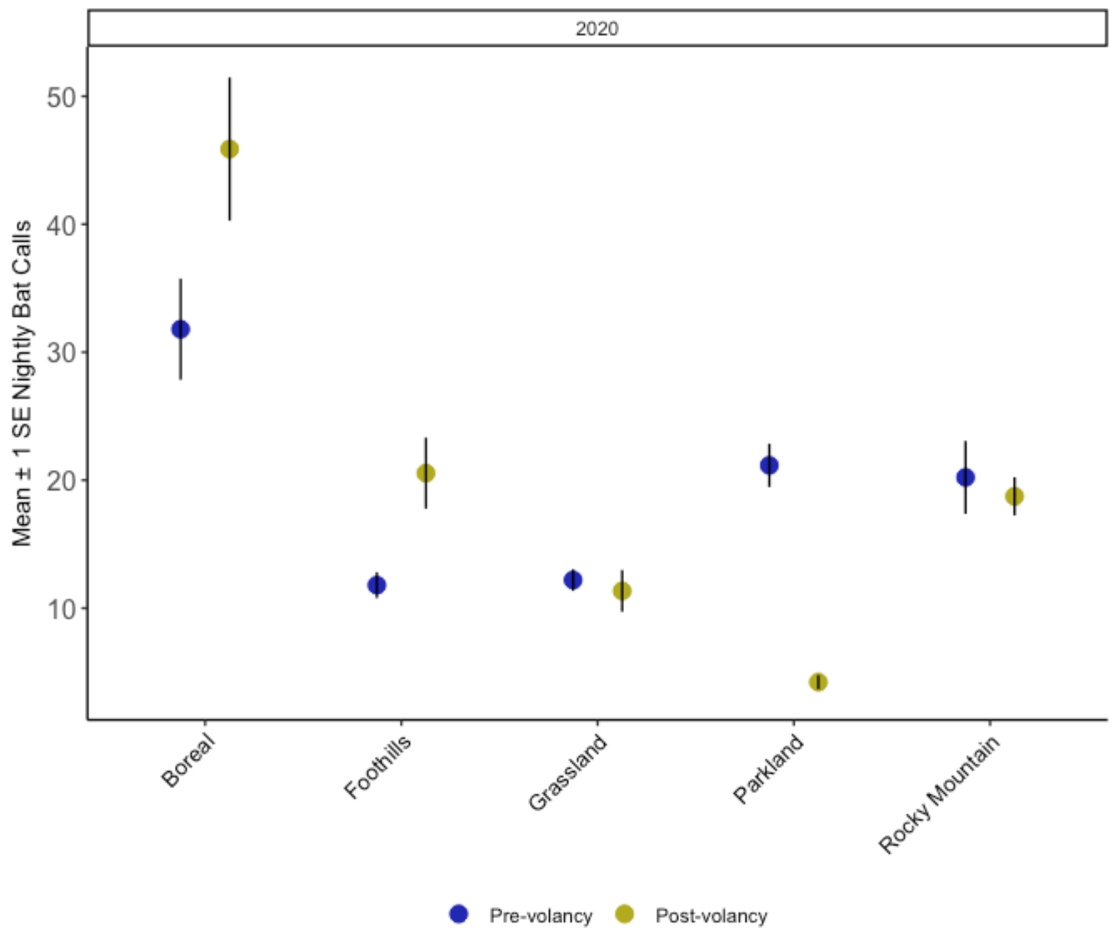

Figure 4. Mean nightly bat calls for each Natural Region, by volancy period.

Overall, mean nightly bat calls were higher within Agricultural and Forest-deciduous land use types (Figure 5). More bat calls were recorded each night post-volancy, compared to pre-volancy, in the Agricultural, Forest-conifer, and Water land use types; all other land use types had similar mean nightly call rates regardless of temporal window.

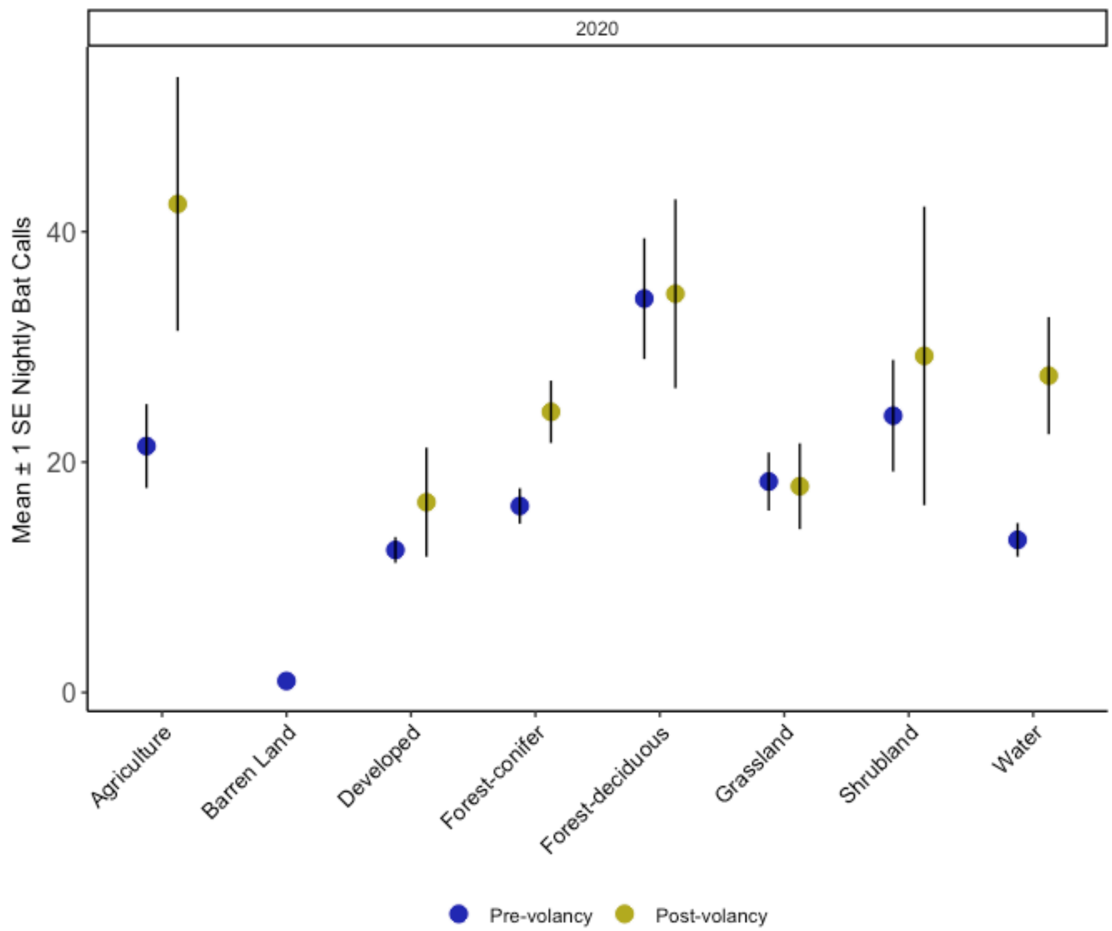

Figure 5.Mean nightly bat calls for each land use type, by volancy period.

There was substantial variation in the number of bat calls recorded per night, both within and between NABat grid cells (Figure 6). Mean nightly calls ranged from <5 in some grid cells to over 100 in other grid cells, although most grid cells recorded ~ 25 bat calls per night. Variation was also high between nights within a grid cell and/or station with some stations recording twice as many calls in one night, compared to a previous survey night. One grid cell in each the LOPR, UPPR and WLNP had substantially higher mean nightly bat activity, and variation between nights in activity, compared to the other grid cells.

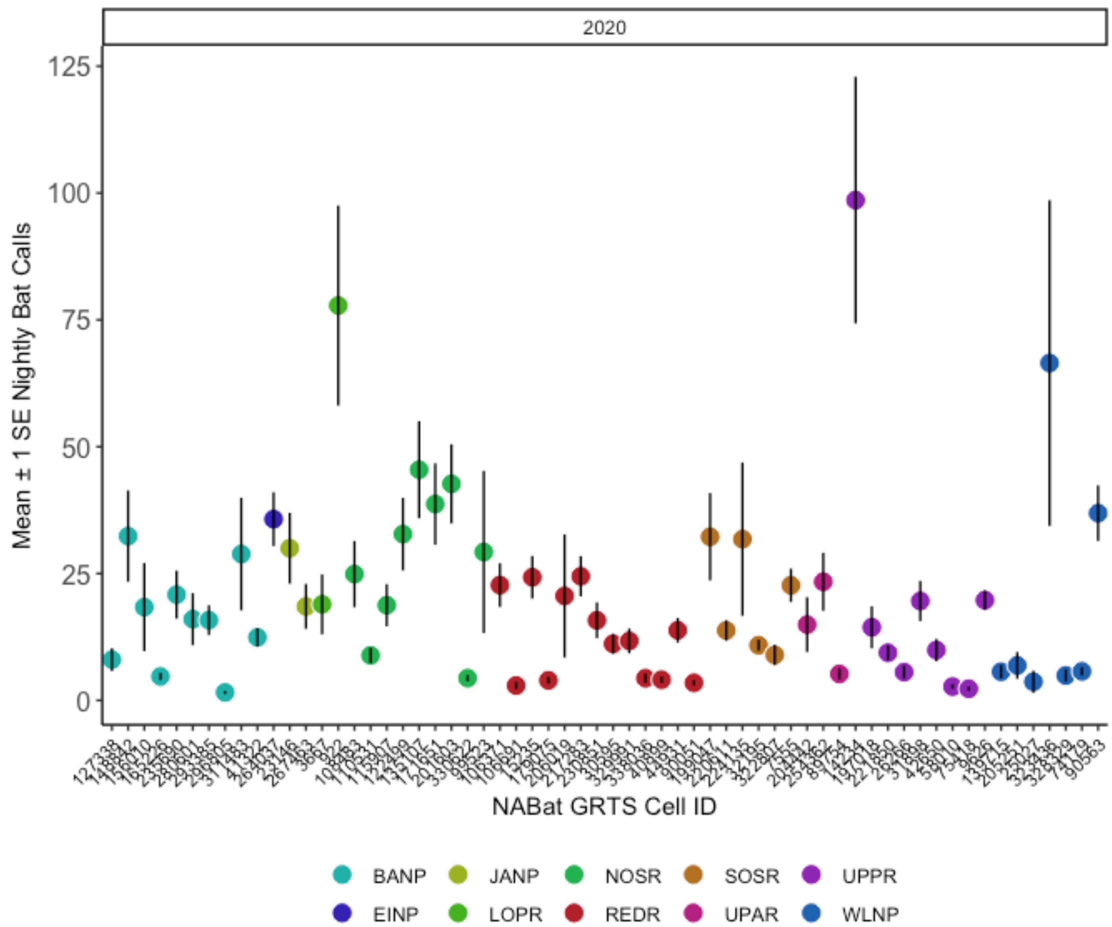

Figure 6. Mean nightly bat calls for each NABat grid cell.

Nightly Bat Call Summaries by Species / Species Group

For the 43% of bat calls identified to a species / species group, the overwhelming majority (16%) were identified as *Lasiurus cinereus*, then nearly equal proportions of Myotis 40k (8%), *M. lucifugus,* and the species group EPFU-LANO (7% each) (Table 3).

Table 3. Overall bat call count, percentage, and calls per night for 101 stations surveyed between 1 May and 1 September, 2020.

Species / Species Group	Call Count	% of Calls	Calls per Night
EPFU	861	1	0.58
EPFU-LANO	7282	7	4.93
LANO	1206	1	0.82
LACI	15545	16	10.53
LABO	273	0	0.18
LABO-MYLU	2425	2	1.64
MYLU	7451	7	5.05
MYCA	72	0	0.05
MYCI	16	0	0.01
MYEV	5	0	0.00
MYEV-MYSE	12	0	0.01
MYSE	8	0	0.01
MYVO	43	0	0.03
Myotis 40k	8175	8	5.54
unknown	56353	57	38.18

The proportions of species / species group and unknown calls recorded in Natural Regions and land use types was fairly consistent between categories (Figure 7). The 72 possible *M. californicus* calls were detected in the Foothills and Rocky Mountain Natural Regions, similar to previous acoustic survey findings (Burgar 2018, 2019, 2020). Please note that not all stations had Natural Region and land use type metadata i.e., missing for EINP and BANP baseline sites), thus the discrepancy between the total number of calls in Table 3 and Figure 7. This is particularly evident for *L. cinereus* and *M. lucifugus*.

There were more mean nightly calls of EPFU-LANO, *L. noctivagans* and *M. lucifigus*, and unknown bat calls recorded in the post-volancy, compared to the pre-volancy period (Figure 8).

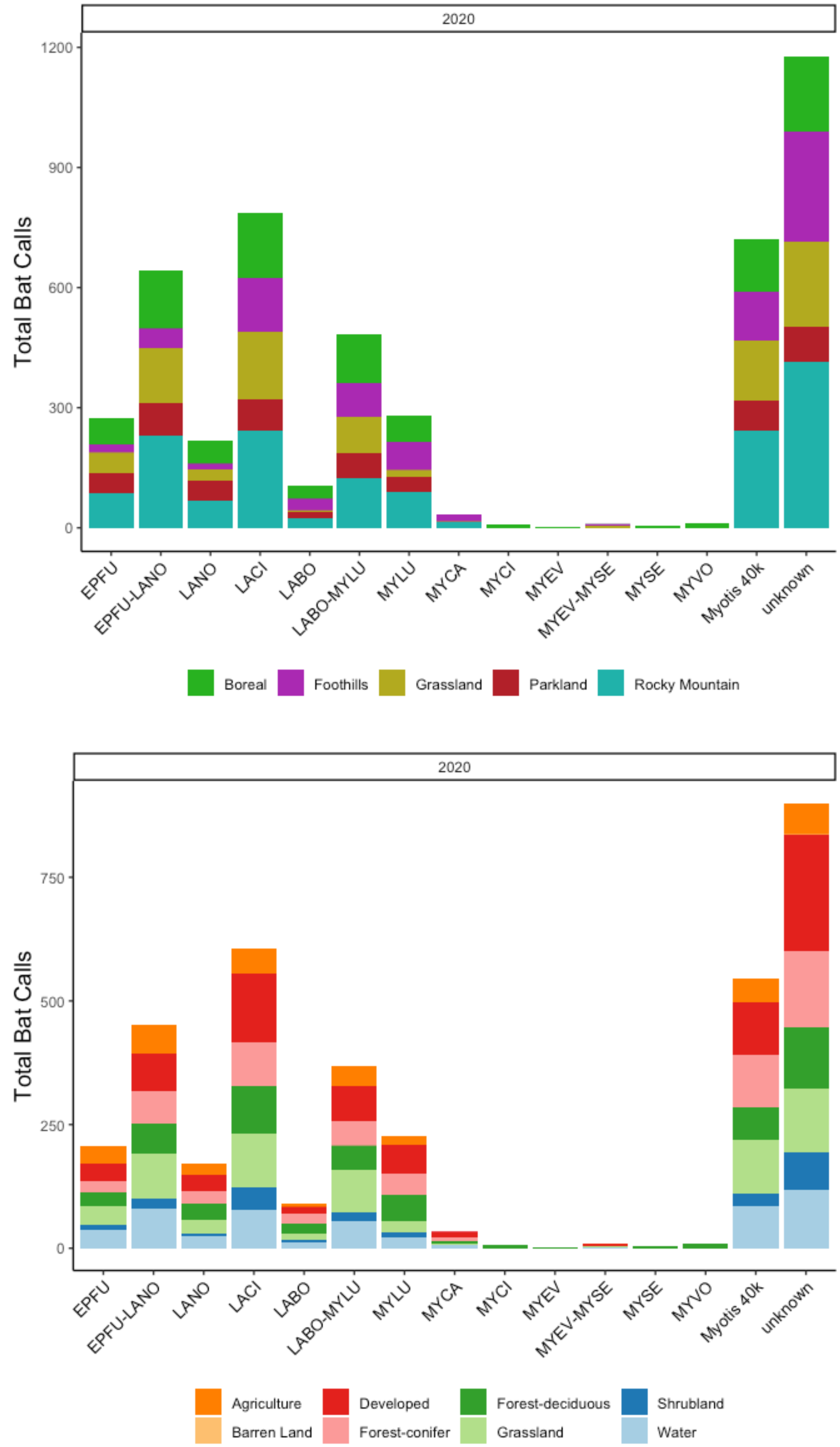

Figure 7. Total bat calls for species / species group by Natural Region (top) and land use type (bottom).

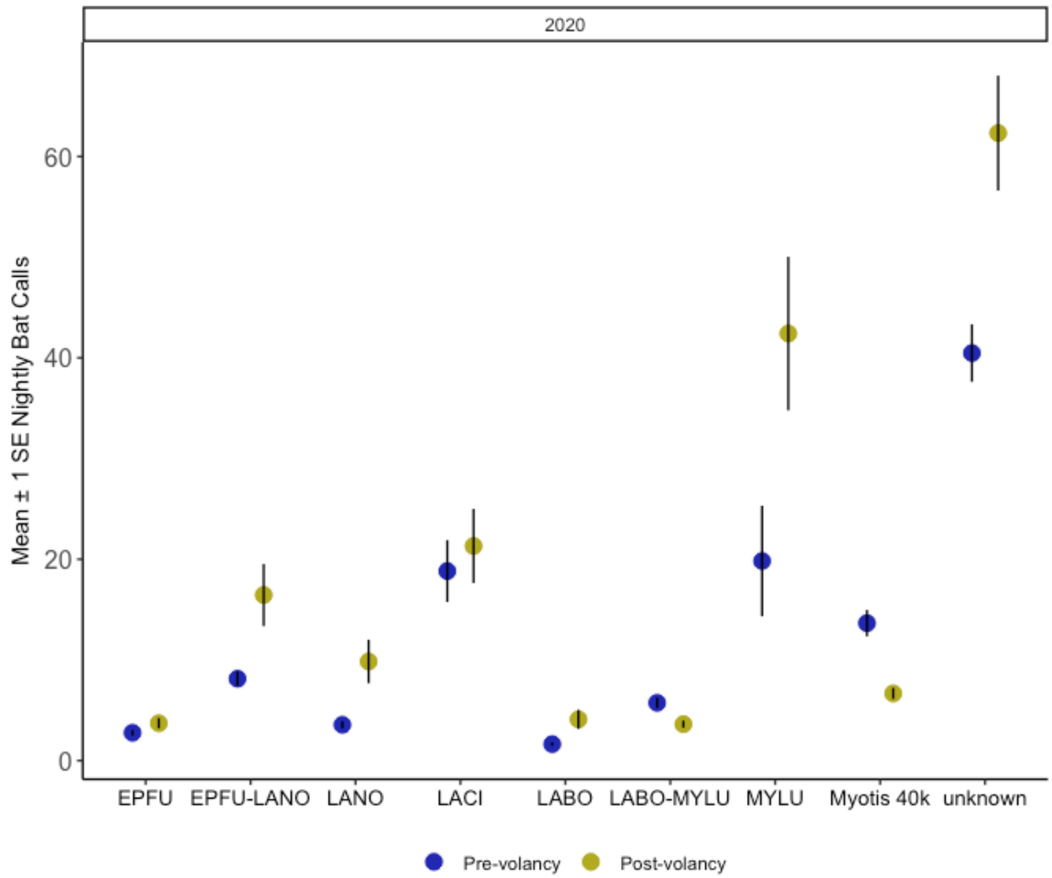

Figure 8. Mean nightly bat calls for each species / species group by volancy period.

For nocturnal activity patterns, volancy was again set as 10 July but with truncated data such that pre-volancy groups comprised calls recorded up to one month before July 10 while post-volancy groups comprised calls recorded for one month on or after July 10. *Eptesicus fuscus* nocturnal activity was quite peaked after sunset with a second, minor peak pre-sunrise; this pattern was clear both pre- and post-volancy but with a shift earlier in the post-volancy period (i.e., initial peak at ~10 pm compared to midnight) (Figure 9). In contrast *L. noctivagans* exhibited a more muted activity pattern with a smaller initial peak after sunset and a slightly larger second peak before sunset, and generally the same pattern regardless of temporal window. *Lasiurus cinereus* and *M. lucifigus* also exhibited a bi-modal activity pattern with more activity post-sunset and a second, smaller peak pre-sunrise (Figures 10 and 11). *Lasiurus cinereus* also had a small shift to earlier activity, whereas *M. lucifugus* had a much more pronounced second peak pre-sunrise, post- compared to pre-volancy. *Lasiurus borealis* had one very strong peak of activity ~ midnight pre-volancy compared to more consistent activity throughout the night, post-volancy (Figure 11). Unsurprisingly, species group patterns were a mix of the two contributing species (Figures 9 and 11).

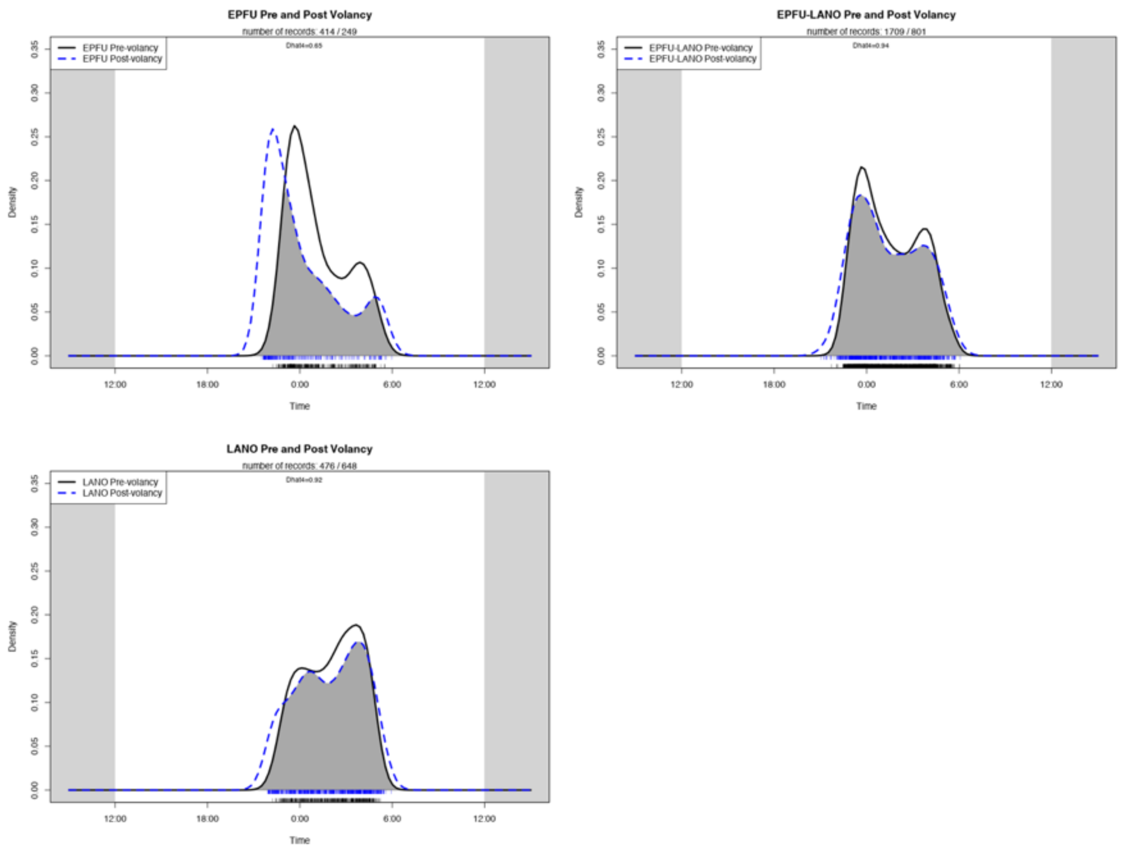

Figure 9. Nightly activity overlap one month pre- and post-volancy for EPFU, LANO and EPFU-LANO.

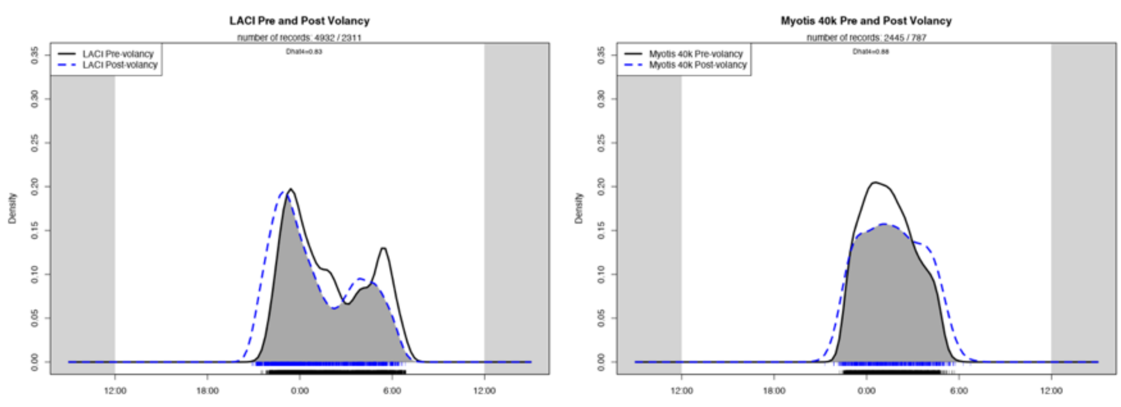

Figure 10. Nightly activity overlap one month pre- and post-volancy for LACI and Myotis 40k.

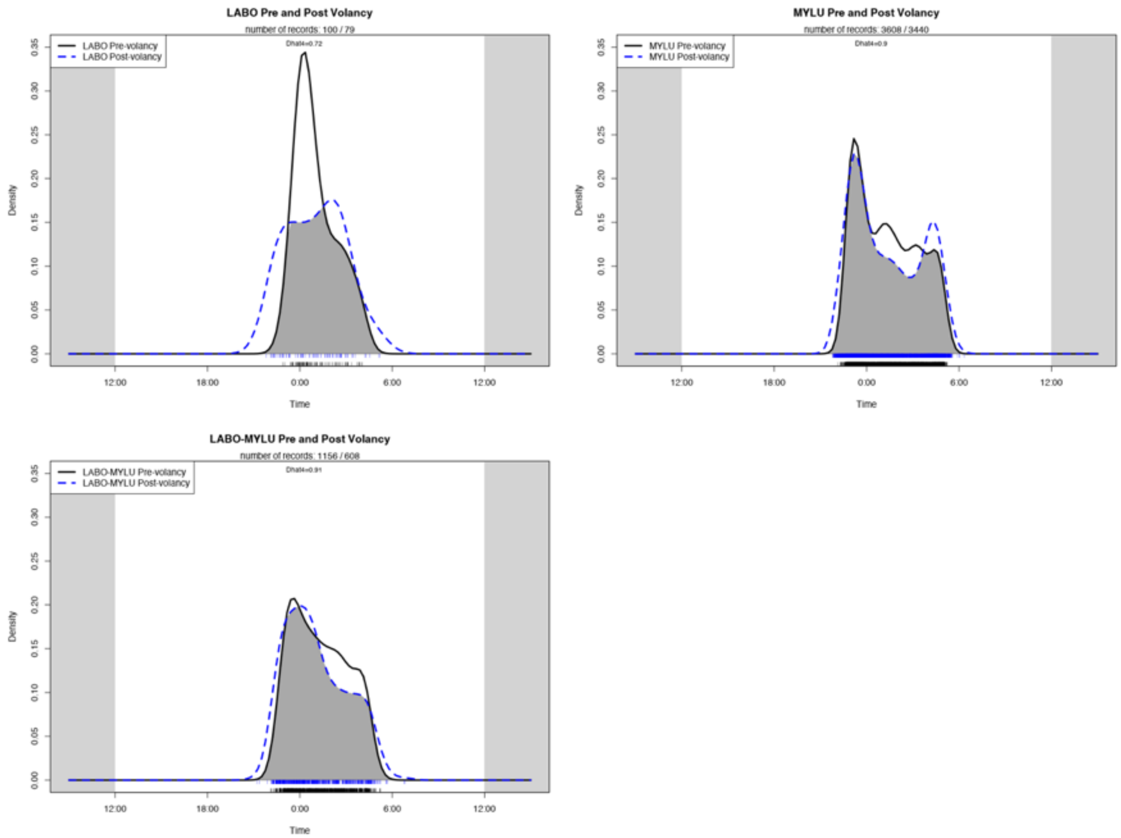

Figure 11. Nightly activity overlap one month pre- and post-volancy for LABO, MYLU and LABO-MYLU.

Mobile Survey Results

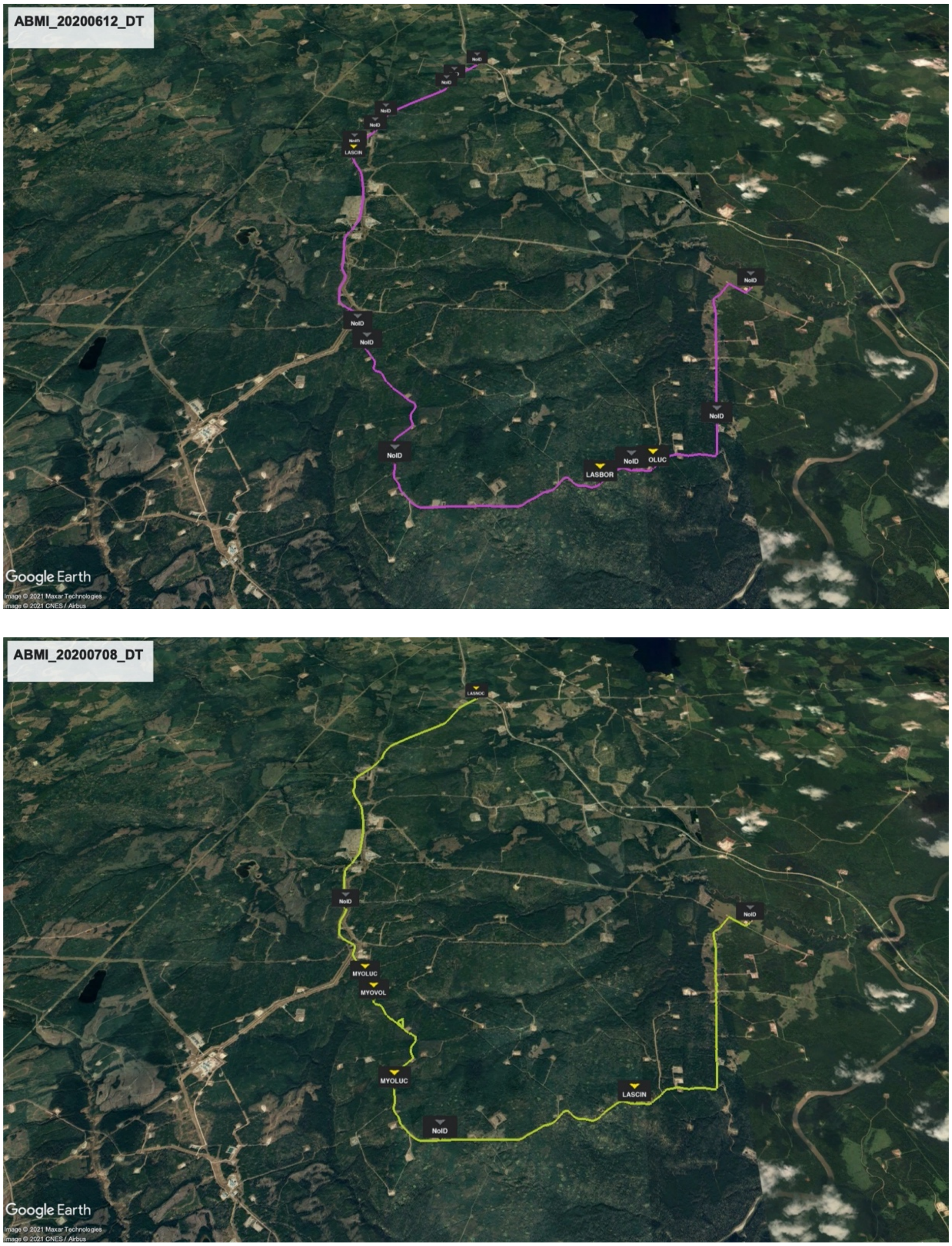

Figure 12. An example of spatial variation in calls between nights for mobile transect 120474, surveyed 12 June (top) and 8 July (bottom). Each bat silhouette represents a point where a bat call was recorded.

Nightly Bat Call Summaries by Species / Species Group

There was a total of 645 bat calls recorded during mobile surveys in 2020 (Table 4). Over three-quarters (500 or 78%) were identified to species / species group with *M. lucifugus* as the most frequently detected species (208 or 32%). Mobile surveys also yielded highly variable bat activity between and within grid cells (Figure 13), ranging from <5 calls recorded on some surveys (e.g., 296805, 328699) to >30 calls for a single species on other surveys (e.g., *M. lucifugus* in 264037).

Table 4. Overall bat call count, percentage, and calls per night for 20 mobile transects surveyed once or twice between 9 June and 15 July, 2020.

Species / Species Group	Call Count	% of Calls	Calls per Night
EPFU	47	7	1.27
EPFU-LANO	69	11	1.86
LANO	32	5	0.86
LACI	30	5	0.81
LABO	15	2	0.41
LABO-MYLU	52	8	1.41
MYLU	208	32	5.62
MYCA	3	0	0.08
Myotis 40k	41	6	1.11
unknown	148	23	4.00

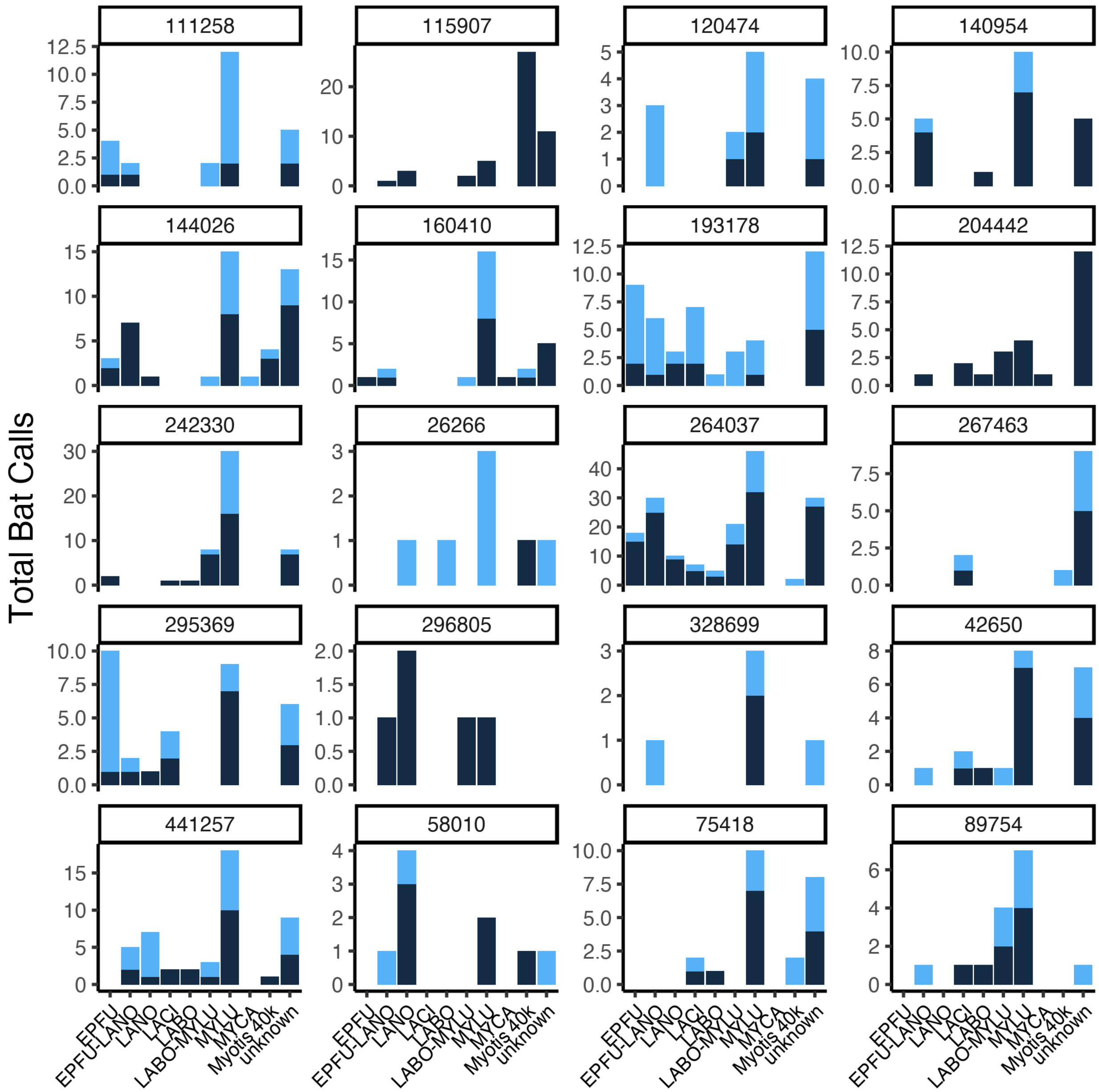

Figure 13. Total bat calls recorded per mobile transect for each night surveyed or for the two detectors in the instances of grid cells 267463 (Pocahontas) and 89754 (Edson2), which were surveyed twice on the same night. Please note the different y-axes. The dark blue denotes the first night a transect was monitored and the light blue the second, if applicable.

Discussion

This year the Alberta Parks Canada commissioned a multi-year analysis to analyze and report on passive acoustic bat data collected as part of NABat in Alberta from 2015-2020, within a provincial and landscape context (Burgar 2021). This depth of data allowed the modelling of simultaneous statistical inferences at the bat community and species /species group level, accounting for species interactions in explaining species occurrences across the province and through time (i.e., hierarchical modelling of species communities or HMSC). The HMSC analysis found that model predictors (grouped as temporal, landscape, local, survey effort, and random site-specific) accounted for between 27% to 63% of the occurrence of a species / species group at a station (Figure 14). The variance partitioning varied considerably between specific species / species groups, highlighting the importance of modelling species responses jointly rather than pooling all bat call data as one single response variable.

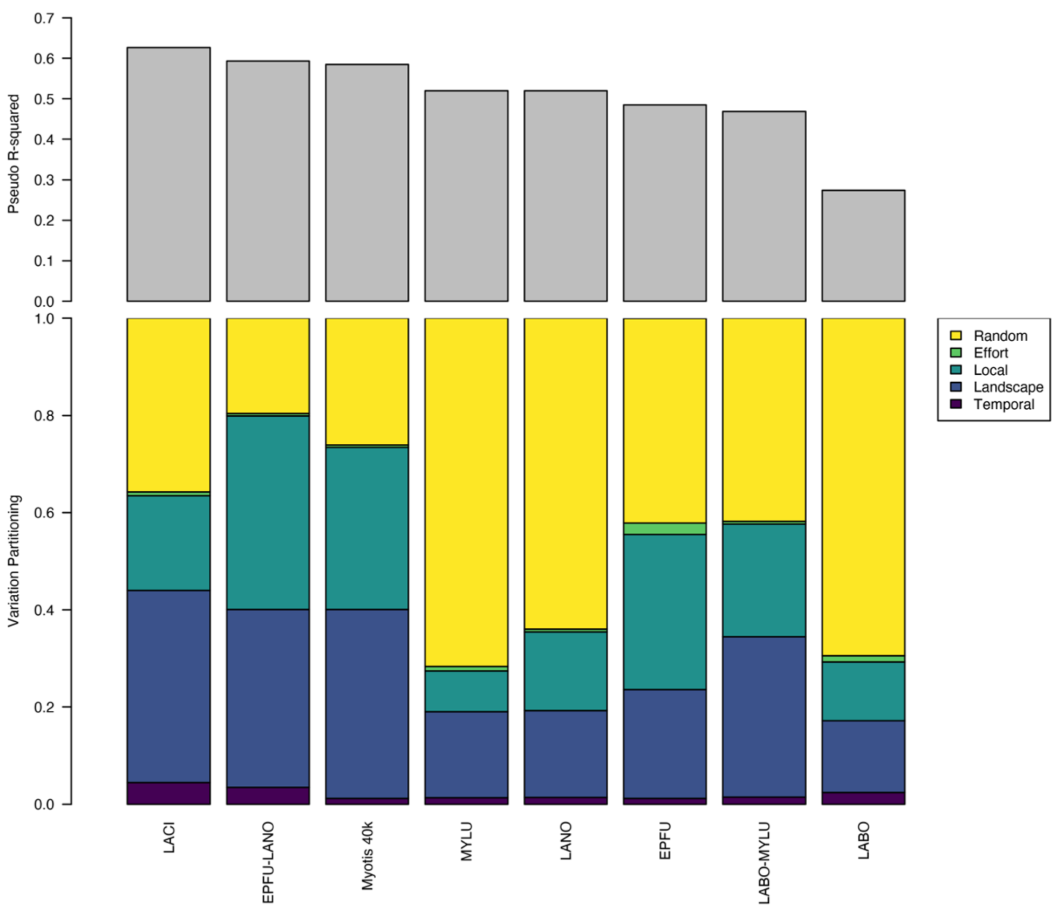

Figure 14. The amount of variation explained (i.e., pseudo-R2 value, top graph), and the proportion of explained variance by predictor group (bottom graph), for each species / species group included in the HMSC model. Figure taken from Burgar (2021).

Specifically, the analysis found that bat species were mostly positively associated with predictors (Figure 15). Most species / species groups had more calls in the Boreal, Foothills, and Parkland, compared to the Rocky Mountain Natural Region. More bat calls were recorded east of Slave Lake (i.e., a longitude of -114.7776° W) and fewer were recorded north of Red Deer (i.e., a latitude of 52.1123° N). *Myotis lucifugus* and *L. noctivagans* had fewer calls outside of National Parks, compared to within parks. Where significant, local features (i.e., distance to road, distance to water and the type of water feature) had positive associations with bat calls. Although the effect was not as strong, model results suggest *M. lucifugus* and *L. borealis* calls increased over time, across years and within a year. *Lasionycteris noctivagans* calls also increased across years while *Eptesicus fuscus* calls increased within a year. *Lasiurus cinereus* and EPFU-LANO calls decreased across years. Lastly, as survey effort increased so did the number of bat calls recorded for all species / species groups; underscoring the importance of including this variable, to account for the variation in sampling effort across stations and within survey weeks.

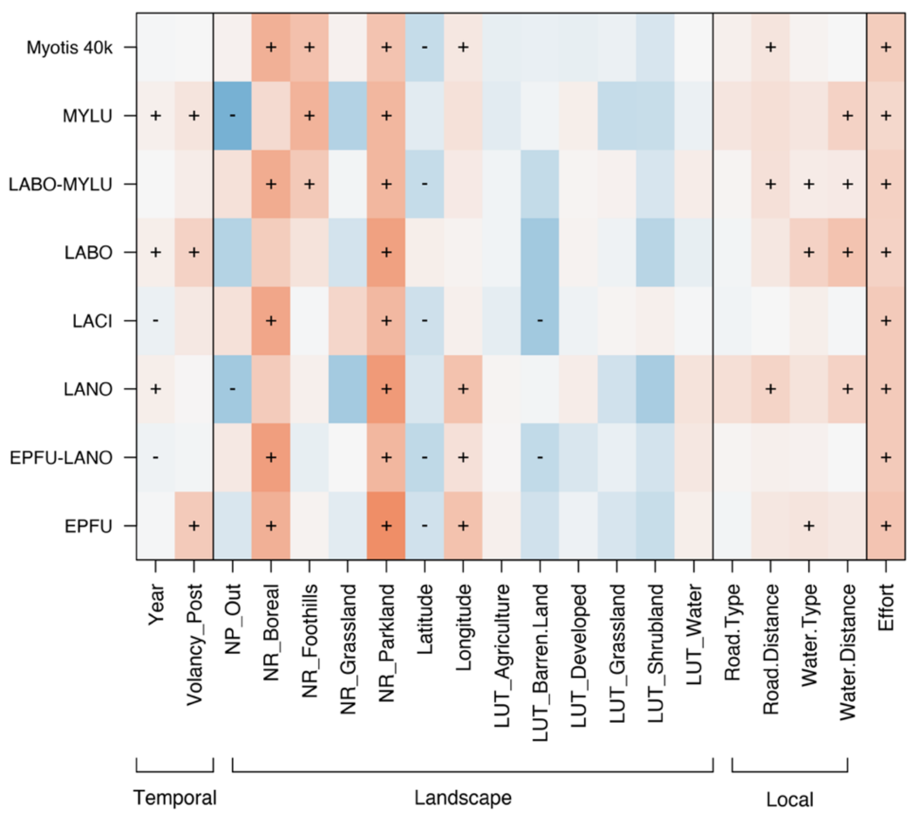

Figure 15. Heatmap depicting how species respond to predictors. Colours denote the estimate covariance between standardized effect size and direction; red and '+' symbols denote positive credibility intervals which do not span zero; blue and '-' symbols denote negative credibility intervals which do not span zero. Figure taken from Burgar (2021).

The findings from the multi-year analysis generally, and the 2020 results specifically, highlight the importance of continued and consistent acoustic monitoring. Bat activity is highly variable across space and time; the NABat survey guidelines should be taken as minimum survey standards with the aim for more survey nights at a station (i.e., aim for 7 rather than the minimum of 4) and >1 survey for each mobile transect. Even if the aim of the monitoring is species detected / not detected (e.g., for NABat occupancy modelling), these findings show that some species may be using a site but are not detected on every survey night. This is of particular importance for monitoring less common species such as *M. californicus*. Interestingly, *M. californicus* has been consistently recorded in the Rocky Mountain and Foothills Natural Regions, albeit with very low numbers, suggesting that this species may indeed be present in south-west Alberta and extending its range as far north-east as Switzer. It is also important to note that different detectors and changes in equipment may well alter the species recorded during a survey, underscoring the importance of calibrating equipment between surveys and following consistent survey standards to minimise the human / technology effect on detecting species present during a survey.

This year nine stations in the UPPR were surveyed with completely random placement of detectors within a selected grid cell, rather than the typical survey protocol of selecting a 'bat friendly' location for a detector near to a randomly generated and/or logistically feasible location. These nine stations recorded significantly fewer bat calls than any other station, to the point that it seemed as the equipment malfunctioned upon review. To maximise species detections and maintain consistency with other NABat surveys, it is recommended to locate detectors in such a way to maximise bat detections while minimising echolocation call interference from nearby clutter (e.g., vegetation, water or buildings).

Similar to past years, bat calls were most often identified as Myotis 40k, *M. lucifugus*, or *L. cinereus,* yet again highlighting the serious implications for the conservation and maintenance of Alberta's bat populations with the emerging and increasing threats of WNS and wind energy development. The high percentage of EPFU-LANO calls (7%) compared to either *E. fuscus* or *L. noctivagans* (1% each) is more pronounced, but a similar pattern, to previous years. This, alongside the majority (57%) of calls being unidentified to bat species, underscores the importance of manual verification (to reduce both false negatives and false positives) and/or improvements to Alberta eBat with respect to the underlying call library. This report aimed for consistency in processing, electing to use Alberta eBat as the sole bat call identification engine. Unfortunately, this aim for consistency invariably reduced the accuracy of species identifications, available in the cases where biologists submitted their manually verified results alongside the raw acoustic data. The sheer magnitude of surveys (73 grid cells surveyed in 2020 compared to 14 in 2019) and calls recorded did not allow for manual verification of Alberta eBat output. Whenever possible, manual verification should review species identification from any automated processor, especially when interested in rare or soft amplitude species.

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References

Allaire, J., Y. Xie, J. McPherson, J. Luraschi, K. Ushey, A. Atkins, H. Wickham, J. Cheng, W. Chang, and R. Iannone. 2020. rmarkdown: Dynamic Documents for R. R package version 2.1.

Burgar, J. M. 2017a. North America Bat Monitoring Program, Alberta 2016. Edmonton, Alberta, Canada.

Burgar, J. M. 2017b. Alberta eBat - Version 1.0 Technical Report. Edmonton, Alberta, Canada.

Burgar, J. M. 2018. North America Bat Monitoring Program, Alberta 2017. Edmonton, Alberta, Canada.

Burgar, J. M. 2019. North America Bat Monitoring Program, Alberta 2018. Edmonton, Alberta, Canada.

Burgar, J. M. 2020. North America Bat Monitoring Program, Alberta 2019. Edmonton, Alberta, Canada.

Burgar, J. M. 2021. North America Bat Monitoring Program Multi-year Acoustic Data Analysis and Reporting.

Environment Canada. 2015. Recovery strategy for Little Brown Myotis (Myotis lucifugus), Northern Myotis (Myotis septentrionalis), and Tri-colored Bat (Perimyotis subflavus) in Canada [Proposed]. Species at Risk Recovery Strategy Series. Ottawa, Canada.

Frick, W. F., E. F. Baerwald, J. F. Pollock, R. M. R. Barclay, J. A. Szymanski, T. J. Weller, A. L. Russell, S. C. Loeb, R. A. Medellin, and L. P. McGuire. 2017. Fatalities at wind turbines may threaten population viability of a migratory bat. Biological Conservation 209:172–177.

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.

R Development Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.