CONSERVING AND MONITORING LITTLE BROWN BAT (*MYOTIS LUCIFUGUS*) COLONIES IN YUKON:

2014 – 2015 ANNUAL REPORT

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Summary

Context

- Little brown bats (*Myotis lucifugus*) are currently assessed in Canada as an *Endangered* species. The key threats are disease, climate change, loss of roosting habitat, and persecution by property owners and managers.

Aims

- The main goal of our 2014 work was to pilot emergence counts and mark-recapture methods as means to inventory little brown bat colonies.
- In addition, we visited colonies to band individuals and determine colony demographics.
- We conducted a pilot study on the feasibility of using emergence counts for estimating population size; for this work, three colonies were surveyed multiple times.
- We also collected biological samples (hair, feces, DNA) for analyses of diet, migratory movements, and population genetics.

Key Results

- We captured, measured, and banded 940 bats in 2014 (compared to 1,111 and 1,035 bats in 2013 and 2012, respectively). Biological samples were taken from a subsample of these bats.
- Population estimates were modeled from mark-recapture data from Squanga Lake. The models produced large estimates that may be inaccurate because the population failed to satisfy the key assumption of a closed population. The efficacy of mark-recapture methods requires further work.
- Emergence counts produced population size estimates that appeared to be more realistic. This technique may prove to be best for inventorying bat colonies that use bat houses. However, some work is necessary to test assumptions of population closure.
- Several bat houses erected in previous years remain unoccupied. New ones are planned.
- Three papers based on work conducted in previous fiscal years were subject to external peer review and published in scientific journals.

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Introduction

Little brown bats (*Myotis lucifugus*) are currently assessed in Canada as an *Endangered* species. The fungal disease, white nose syndrome, is the main threat to populations across North America (Frick *et al.* 2010, Foley *et al.* 2011). While the fungus is not yet recorded in western Canada, it is anticipated to affect little brown bat populations across the continent in the near future. In addition, the distribution and abundance of little brown bats is likely determined to a large degree by climate, and changes in climate may have large consequences for little brown bats in northern regions (Humphries *et al.* 2002). Other threats to little brown bats include loss of roost-sites and roost exclusion (eviction) by humans of maternity colonies in buildings.

Monitoring of bat houses in Yukon by local biologists for the collection of scientific data began in the late 1990s (Slough and Jung 2008). Environment Yukon began monitoring bat houses in 2004 and established a limited number of bat houses in key locations beginning in 2007. Bats are long-lived mammals, with maximum reported life spans of 30 – 40 years; consequently, long time series of data are needed to assess changes in population size and demographic parameters (Jung *et al.* 2014). By developing a time series of data on bat colonies at key locations, we can track changes in colony size, reproduction, and survival. These data are crucial for developing conservation plans for bats in the region (Jung *et al.* 2014), and may be used to assess the conservation status and demographic response of little brown bats to changes in weather and climate. Indeed, the little brown bat time series data in southern Yukon is among the most valuable in western Canada, where the species has generally been less monitored than in eastern North America.

For this reporting year (2014 – 2015), our main goal was to pilot emergence counts as a means to estimate population size. We also sought to increase our sample size of banded bats and to add to our time series of data on little brown bat survival and reproduction, and conduct a mark-recapture population estimate of the Squanga Lake bat colony. These data may form the basis of a broader analysis on the population ecology of little brown bats in northwestern Canada, and are invaluable with regards to informing conservation status assessments, and recovery and management planning for the species (Jung *et al.* 2014).

In addition to the main goals of our work this year, we collected biological samples from captured bats for analyses in specialized laboratories. Specifically, we aimed to contribute samples to larger-scale studies investigating little brown bat diet, migration, contaminants, and population genetics and connectivity.

Methods

Colonies Studied

Our work in 2014 was conducted at 7 maternal bat colonies in southern Yukon: Chadburn Lake, Dalton Post, Drury Creek, Little Atlin Lake, Salmo

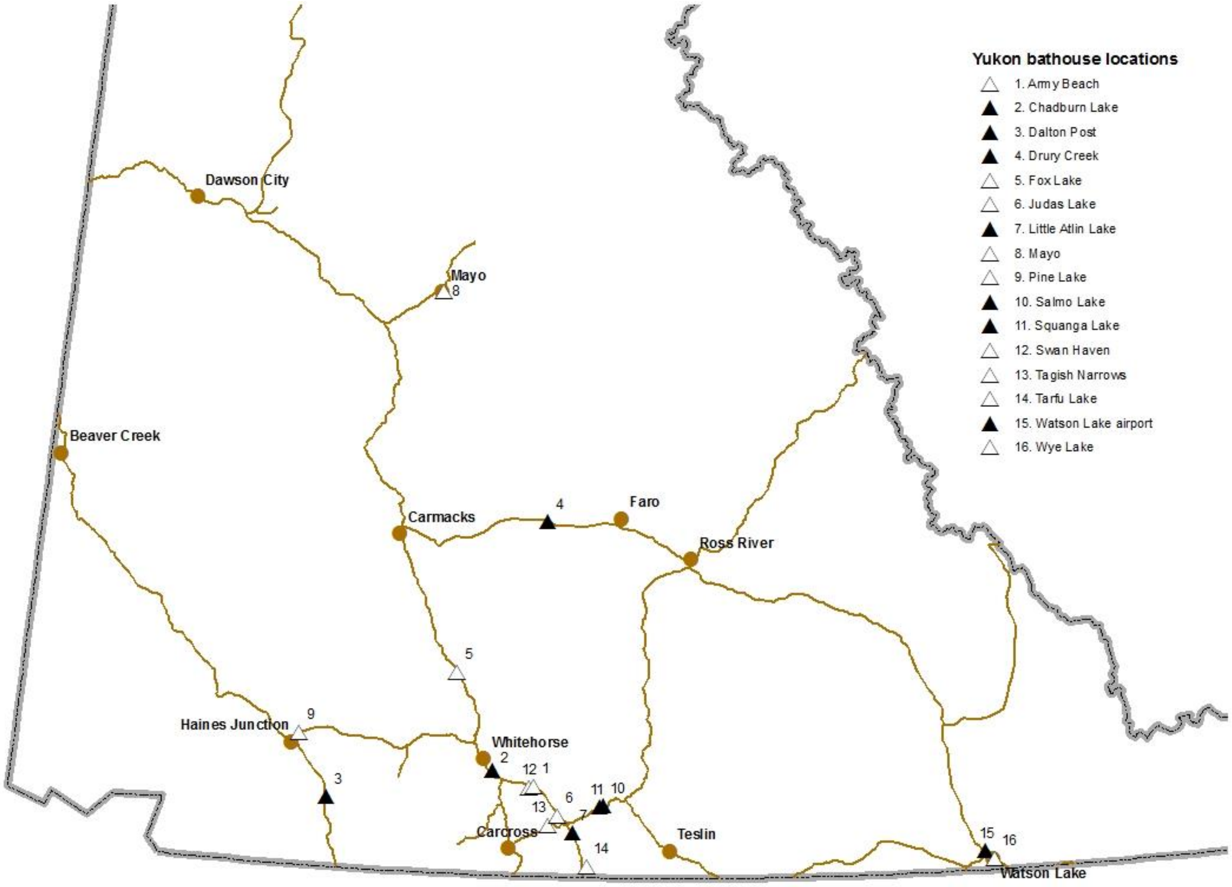

Figure 1. Location of bat houses in Yukon, Canada. Closed (black) triangles represent the bat colonies that were the focus of our monitoring in summer 2014.

Lake, Squanga Lake and Watson Lake (Figure 1). Most of these colonies roost in bat houses that were established to offer alternative roosts for bats that roosted in nearby buildings where they were not wanted or were excluded (see Slough and Jung 2008, Jung and Kukka 2013).

Bat Captures, Banding, and Sample Collection

We used harp traps (Kunz and Anthony 1977; Figure 2) to capture bats from bat houses at dusk. The colony at the Watson Lake airport was trapped with mist nets, because the roost is located in the air traffic control tower and cannot be effectively trapped with a harp trap. Captured bats were measured, and the sex, age-class, and reproductive condition were determined, where possible. Each individual was banded with a uniquely numbered forearm band (2.9 mm lipped alloy band; Porzana Limited, Icklesham, United Kingdom). The band identification numbers of previously banded bats were recorded. Mass (± 0.1 g) and forearm length (± 0.1 mm) were obtained with a digital scale and digital calipers, respectively. The reproductive status of adult female bats was determined

Figure 2. A harp trap set to a bat house near Salmo Lake, Yukon, provides an ideal site to monitor little brown bat (*Myotis lucifugus*) populations.

from palpation and/or visual inspection of the teats (non-reproductive, pregnant, lactating, post-lactating, or unknown).

We collected a small tuft of hair from 14 – 28 bats at each colony to provide samples for stable isotope analysis, with the goal of using these samples to provide information on diet and, possibly, migration routes. We collected fecal (guano) samples to provide information on diet, by placing a guano trap (Brigham *et al.* 2002) underneath the bat house and collecting the contents 1 – 2 weeks thereafter. In addition, we collected DNA samples from the Watson Lake colony by taking a small (2 mm) biopsy of tissue from each wing. Research shows that in most cases the tissue heals within 12 days (Faure *et al.* 2009).

We captured bats more frequently at the Squanga Lake colony (5 capture sessions) in order to calculate mark-recapture population estimates.

A matrix of encounter histories (0 = not captured, 1 = captured) for each capture session (n = 5) for each bat captured ≥1 times in 2014. Program Density (ver. 5) was used to develop varying models of population size, based on the complete matrix of encounter histories. We used ΔAIC to assess the relative rank of the various population models.

As a pilot study, we conducted emergence counts at four colonies (Squanga Lake, Salmo Lake, Chadburn Lake and Drury Creek). The aim of this work was to examine the efficacy of a non-invasive and less labour intensive means of assessing the size of colonies than mark-recapture surveys. We counted bats for 50 minutes after the first bat flew out of the roost (most bats exit the roost within 30 minutes after the first bat) either directly in person or from a video recording. We conducted the surveys in the early season (3 June – 15 July) before juveniles contributed to the population. We used GoPro units at Salmo Lake and Chadburn Lake, and Sony Handycam HDR-CX430 at Squanga Lake. We conducted the surveys in the early season (3 June – 15 July) before juveniles contributed to the population. We also documented the temperature and weather conditions. Emergence counts have been used to monitor population trends elsewhere (e.g. Warren and Witter 2002), including in monitoring programs based on citizen-science (e.g. Community Bat Programs BC in British Columbia). We used a bootstrap analyses to derive randomized (n = 5000 iterations) means and 95% confidence intervals from the emergence count data. Bootstrap analysis was conducted using Ecological Methodology (ver. 7).

In addition to our focused work, we visited most of the remaining bat houses in our monitoring program to assess their structural condition and occupancy by bats. Structural condition of bat houses may be compromised by weather events (e.g. strong winds), human activities (e.g. vehicles, snow removal equipment, vandalism), or wildlife (e.g. woodpeckers). Other wildlife (e.g. birds; Jung and Kukka 2013) may occupy bat houses and displace bats. We assessed occupancy by knocking on the support structure and listening for bats. If there was no response we briefly shone a flashlight into the bat house to visually determine occupancy, and searched the ground underneath the bat house for guano.

Results and Discussion

Bat Captures & Banding

We visited each colony at least once between 4 June and 8 August 2014 for a total of 13 capture sessions (Table 1). Most colonies were trapped only once. We collected mark-recapture data at Squanga Lake over five trapping sessions. Chadburn Lake and Salmo Lake colonies were trapped twice (early and late season). In addition, Chadburn Lake, Miles Canyon and Wolf Creek roosts were trapped several times by Brian Slough (an independent researcher).

Altogether, we captured and processed 940 bats in 2014, compared to 1,111 bats in 2013 and 1,035 in 2012 (Jung and Kukka

Table 1. Summary results of little brown bat (*Myotis lucifugus*) captures at 7 maternal colonies in Yukon, Canada, summer 2014.

Colony	Capture Date (2014)	Total Number of Bats Captured	Number and Percent of Individuals Newly Captured	Number and Percent of Individuals Recaptured	Percent of Adult Females that were Reproductively Active (%)
Chadburn Lake	8 July	35	13 (37%)	22 (63%)	53
	8 August	12	7 (58%)	5 (42%)	100
Dalton Post	14 July	23	20 (87%)	3 (13%)	65
Drury Creek	16 July	152	143 (94%)	9 (6%)	59
Little Atlin Lake	26 June	129	70 (54%)	59 (46%)	88
Salmo Lake	24 June	114	24 (21%)	90 (79%)	85
	7 August	122	18 (15%)	104 (85%)	28
Squanga Lake	4 June	64	10 (16%)	54 (84%)	unknown
	16 June	61	14 (23%)	47 (77%)	unknown
	23 June	52	12 (23%)	40 (77%)	unknown
	10 July	63	17 (27%)	46 (73%)	58
	29 July	63	39 (62%)	24 (38%)	69
Watson Lake	31 July	50	50 (100%)	0 (0%)	55

2013). The largest number of bats per session (n = 152) was handled at the Drury Creek colony. The number of previously banded bats varied between colonies. Bats at Squanga Lake and Salmo Lake colonies, which have been banded intensively over the years (Slough and Jung 2008), had recapture rates from 38% to 85% (Table 1). In contrast, only 6% of bats at the Drury Creek colony were recaptures from the previous year; 2013 was the first year of banding at this colony.

Reproductive status of adult females in late June and July ranged from 53% to 88%, depending on the colony. Juvenile bats appeared in our captures in late July and August. The sex ratios of juveniles at the Squanga Lake, Watson Lake and Salmo Lake colonies were 0.8, 0.5 and 0.7 males per 1 female, respectively.

Sample Collection

We collected DNA samples (wing punches) from 21 bats at the Watson Lake airport colony. These samples were sent to a university-based researcher for analysis and contribution to a larger scale project on population genetics and gene flow in little brown bats in northwestern North America. The other colonies were sampled for DNA in 2013.

We collected hair and fecal samples at each colony. These samples were shipped to a university-based researcher where they will be used to examine diet, and possibly migration, of little brown bats in Yukon and Alaska.

Table 2. Summary results of little brown bat (Myotis lucifugus) roost emergence counts in Yukon, Canada, summer 2014.

Colony	Date	Number of Bats	Temp. (C°)	Weather
Chadburn Lake	3 June	50	9	cloudy
	10 June	45	12	partly cloudy
	19 June	36	11	partly cloudy
Salmo Lake (includes two bat houses)	18 June	270 (144 + 126)	3	clear
	23 June	255 (107 + 148)	12	partly cloudy
	26 June[a]	150 (64 + 86)	6	partly cloudy
	1 July	232 (68 + 164)	14	partly cloudy
	2 July	226 (64 + 162)	16	cloudy
	3 July[a,b]	109	13	steady heavy rain
	9 July[a]	241 (86 + 155)	17	cloudy
	10 July	276 (125 + 151)	10	clear
Drury Creek	15 July	190	11	partly cloudy
Squanga Lake	9 June	118	7	partly cloudy
	18 June	65	3	clear
	22 June	125	12	very light rain
	25 June	62	9	clear
	1 July	98	14	partly cloudy
	2 July	96	16	cloudy
	3 July	78	13	steady heavy rain
	9 July	142	17	cloudy

[a] an underestimate; problems with the recording equipment. Data not used in analysis.
[b] only 1 bat house was monitored on 3 July. Data not used in analysis.

Emergence Counts

We conducted 27 bat emergence counts at five roosts (Chadburn Lake cabin, Drury Creek bat house, Squanga Lake bat house and two bat houses at Salmo Lake; Table 2). The counts at Chadburn Lake and Squanga Lake were done in person and with a video camera (double count), whereas the emergence from Salmo Lake bat houses was observed from a video recording only. Drury Creek roost was double-counted by two people. The emergence typically occurred half hour after sunset (32 ± 9 min).

Chadburn Lake roost was surveyed three times. The direct counts ranged from 36 – 50 bats. Bats at this roost tended to exit and enter the roost several times during the survey, which made the count challenging. Consequently, we did not re-count the bats from the video recording. Emergence count may not be a suitable method for monitoring this colony. The Squanga Lake bat house was surveyed eight times. The video recording yielded higher counts than the direct counts. This highlights the efficacy of video recording emergence for later analysis. The highest count for the Squanga Lake roost was 142 bats (9 July). Salmo Lake bat houses were surveyed eight times. The highest count was 276 bats for both bat houses (10 July). The Drury Creek bat house was surveyed only once. We counted 190 bats at this roost, which is the largest number of bats in one bat house during our emergence surveys this year. The weather varied among the survey dates from cool and clear to warm and rainy, and most likely affected bat behaviour at emergence.

The bootstrapped mean (n = 5000 iterations) for Salmo Lake was 245.7 bats (95% confidence limits = 229.6 – 261.2), and for Squanga Lake it was 109.4 bats (95% confidence limits = 97.6 – 120.8).

Overall, we believe that emergence counts may hold significant promise as a means to monitor bats in Yukon. Further work, however, is required to determine: a) the assumption of population closure, b) how many counts are needed to develop a mean population count with reasonable confidence limits, c) how does weather impact emergence counts, and d) what is the power of emergence counts to detect change. Radio-telemetry would be the best means to look at population closure. Closure may occur at the site (bat house) level, or for a meta-population of bats using the same foraging area and roosting together in a fission-fusion fashion throughout the summer. The other questions may be answered by obtaining a large sample of emergence counts at the same roost, during the same season. This is a key piece of information that is necessary to plan how and when to do emergence counts to obtain reliable information.

Squanga Lake Population Estimate Pilot Study

In 2014, we captured and banded 210 individual adult females 272 times, over 5 capture sessions at Squanga Lake. In 2012, we captured and banded 174 individual adult females 196 times, over 4 capture sessions at the same colony. In both years, capture probabilities were low (0.0701 – 0.2197; Table 3). For both years, the Huggins model had the most support, as indicated by AICc (Table 3); however, in both 2012 and 2014 the ΔAIC for the Darroch model was ≤2 from the top-ranked Huggins model, indicating that it too was well supported.

The Huggins model population estimate for 2014 at the Squanga Lake colony was 419 ± 40.3 bats. This represents a decline of approximately 200 bats compared to the population estimate of 617 ± 114.2 bats obtained using the same methodology in 2012.

At this time, we are unsure how to interpret the mark-recapture results. Based on our regular visits to the Squanga Lake colony over the past 4 – 5 years, a population estimate of 400 – 600 bats seems much too high for this colony. Based on our banding operations, where we guesstimate that we capture >80% of the bats in the colony each capture session, we had initially “ball-park” estimated

Table 3. Mark-recapture based population estimate models for the Squanga Lake bat colony during 2012 and 2014.

Year / Model	Population Estimate ± SE	95% Confidence Intervals	Capture Probability	Log Likelihood	k	AICc	ΔAICc	Rank
2012 [a]								
M(0) Null	617 ± 114.2	444 – 922	0.0794	-320.796	4	645.7	8.8	4
M(t) Darroch	605 ± 111.5	436 – 903	0.0810	-314.063	2	638.5	1.6	2
M(b) Zippin	not calculable						–	
M(h) 2-point finite mixture	698.5	481 – 69853	0.0701	-317.858	3	643.9	7.0	3
Huggins	621 ± 115	446 – 910	0.0789	-317.462	1	636.9	0	1
2014 [b]								
M(0) Null	417 ± 39.9	351 – 512	0.1305	-521.632	4	1047.3	8.5	4
M(t) Darroch	413 ± 39.3	348 – 506	0.1317	-514.079	2	1040.6	1.8	2
M(b) Zippin	295 ± 32.4	251 – 402	0.2197	-519.026	3	1044.1	5.3	3
M(h) 2-point finite mixture	469	372 – 46905	0.1160	-520.496	5	1049.2	10.4	5
Huggins	419 ± 40.3	354 – 514	0.1297	-518.387	1	1038.8	0	1

[a] 1 session with 4 trapping occasions; 196 captures of 174 individuals.
[b] 1 session with 5 trapping occasions; 272 captures of 210 individuals.

that the colony was about 120 adult females. Of note, our *a priori* ball-park estimate is very close to the bootstrapped mean obtained by our emergence counts (109.4, 95% confidence limits = 97.6–120.8).

We believe that our mark-recapture models may not be accurate, likely because the population is open, not closed during the pup-rearing time as we had previously assumed. The low capture probabilities provide some evidence this is the case. Considering that we captured 210 individual adult females in summer 2014, but only had 62 recaptures of these individuals, it seems plausible that there was considerable interchange between colonies during our census period. Indeed, our banding data do suggest some exchange between individuals between colonies (Slough and Jung, unpublished data). Jung (2013) suggested that the Squanga Lake and Salmo Lake bat colonies may form a metapopulation. Alternatively, it may be that individual bats are not associated with a particular house and instead use multiple roosts in a common foraging area throughout the season. This is what Jung (2013) assumed when he developed population estimates for the Squanga and Salmo Lake bat colonies as a 'meta-population'. Clearly, further work is needed to evaluate the efficacy of mark-recapture techniques to estimate bat maternity colony size. As noted above for emergence counts, a small radio-telemetry study is needed to examine fission-fusion dynamics in little brown bat colony attendance in Yukon.

Bat House Monitoring

Bat houses provide key habitat for maternity colonies of little brown bats (Brittingham and Williams 2000). During the 2014 summer season, we visited all bat houses in our monitoring program, except those at Tarfu Lake and Mayo (Figure 1). The bat houses at Pine Lake and Dezadeash Lake remain unoccupied. The bat houses at Tagish Narrows, Judas Lake, Army Beach, Swan Haven, Fox Lake, Watson Lake airport and Wye Lake had some evidence of use as temporary roosts (based on a few pellets of guano), but they do not have established maternal colonies. Bats are unlikely to move to a new location if their traditional roost remains available. For example, the bat house at Watson Lake airport probably remains unoccupied, because the colony is settled in the air traffic control tower. Similarly, the bats at Army Beach continue to use the picnic shelter, rather than the bat house. We will continue to monitor use of bat houses in summer 2015. We also plan to establish a new bat house near Kookatsoon Lake Recreation Site, which is nearby to a large maternity colony that was evicted from its roost in summer 2014.

Outreach and Deliverables

Bat viewing events were organized on 16 June 2014 at Squanga Lake and 8 August 2014 at Chadburn Lake, as part of the wildlife viewing program's events.

Scientific papers subjected to peer-review and published in scientific journals in 2014 – 2015 were published as part of a special issue on bats in northwestern Canada and Alaska (Olson and Jung 2014), and included: 1) documentation of first records of two species (Hoary Bat, *Lasiurus cinereus*, and Long-legged Myotis, *Myotis volans*) in Yukon (Slough *et al.* 2014; Appendix A); 2) a description of roost sites and movements of little brown bats in southwestern Yukon (Randall *et al.* 2014; Appendix B), and 3) a prospectus on research needs for bats in northwestern North America (Jung *et al.* 2014; Appendix C).

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APPENDIX 1   PEER REVIEWED PUBLICATIONS

ACOUSTIC SURVEYS REVEAL HOARY BAT (LASIURUS CINEREUS) AND LONG-LEGGED MYOTIS (MYOTIS VOLANS) IN YUKON

Below is the citation and abstract of the above paper peer-reviewed and published in the scientific journal Northwestern Naturalist. The paper may be found at: http://www.bioone.org/doi/abs/10.1898/13-08.1

ABSTRACT—The bat fauna of Alaska and northwestern Canada remains poorly known, principally due to a lack of dedicated surveys. To better assess the diversity of bats in the region, we conducted full-spectrum acoustic surveys at several sites in Yukon, Canada. During our surveys we obtained the 1st acoustic records of hoary bat (*Lasiurus cinereus*) and long-legged myotis (*Myotis volans*) in Yukon. Neither species had been documented previously in the territory, but one or both species were known from adjacent Alaska, British Columbia, and Northwest Territories. Characteristics of certain echolocation calls of hoary bats and long-legged myotis are difficult to confuse with other species that might also occur in the region. In addition, we made other noteworthy recordings; however, species identification for these other echolocation calls was ambiguous. These 1st records significantly increase our knowledge of the ranges of these bat species in Yukon, Canada. Further acoustic surveys, coupled with live captures, will help us further understand the diversity and distribution of bats in Yukon.

CITATION: Slough, B.G., T.S. Jung, and C.L. Lausen. 2014. Acoustic surveys reveal hoary bat (*Lasiurus cinereus*) and long-legged myotis (*Myotis volans*) in Yukon. Northwestern Naturalist 95: 176–185.

ROOST-SITE SELECTION AND MOVEMENTS OF LITTLE BROWN MYOTIS (MYOTIS LUCIFUGUS) IN SOUTHWESTERN YUKON

Below is the citation and abstract of the above paper peer-reviewed and published in the scientific journal Northwestern Naturalist. The paper may be found at: http://www.bioone.org/doi/abs/10.1898/13-02.1

ABSTRACT—Diurnal roost sites are a critical resource for bats. Despite their importance, we know little about the roosting habits of little brown myotis (*Myotis lucifugus*) in the boreal forest of northwestern Canada and Alaska. To locate diurnal roost sites and determine minimum distances to foraging areas, we radio-tagged 10 little brown myotis (7 adult females, 3 adult males) in the boreal forest of southwestern Yukon, Canada. All of the females roosted in a single building, with 1 using a bat house for 2 nights. In contrast, the males used a variety of roost sites, including buildings, rock cliffs, and trees, and switched roosts periodically. We observed sex-biased movements, with adult males traveling a significantly shorter distance between their diurnal roost sites and a key foraging area than adult females. Males tended to roost near a key foraging area, whereas radio-tagged females flew >5 km from their diurnal roosts to forage. Our data are some of the first obtained via radio-telemetry for little brown myotis in the boreal forest and confirm that the roosting behavior of the sexes is different. That all of the radio-tagged females primarily used 1 roost site in town and flew relatively far to a key foraging area suggests that these critical resources may be somewhat limiting in our study area.

CITATION: Randall, L.A., T.S. Jung, and R.M.R. Barclay. 2014. Roost-site selection and movements of little brown myotis (*Myotis lucifugus*) in southwestern Yukon. Northwestern Naturalist 95: 312-317.

CONCLUDING REMARKS: WHAT DO WE NEED TO KNOW ABOUT BATS IN NORTHWESTERN NORTH AMERICA?

Below is the citation and abstract of the above paper peer-reviewed and published in the scientific journal Northwestern Naturalist. The paper may be found at: http://www.bioone.org/doi/abs/10.1898/95-3.1

ABSTRACT—After being virtually ignored, bats in northwestern Canada and Alaska have recently been subject to increasing attention by scientists, resource managers, and the public. We review recent advances in bat research in the region and identify key priorities for future research, including what we believe is needed to provide a more coordinated approach to filling in these knowledge gaps. Our knowledge of the diversity and distribution of bats has improved considerably as a result of dedicated survey efforts. Scientists have provided a tantalizing glimpse into the natural history and ecology of bats in far northwestern North America and some of the unexpected adaptations they exhibit in response to the challenges imposed by northern environments. Despite these recent advances, further work is required to document the distribution of bats in the region; identify key summer roosting habitats and hibernacula; assess population status and trends; evaluate the impact of anthropogenic change and develop mitigation strategies; and better understand the natural history ecology of bats in the region. Improving our knowledge of these aspects of bat biology will be useful for informing conservation planning initiatives and environmental impact assessment processes. To ensure that new information is reliable and accessible, we strongly recommend that researchers strive to meet minimum evidentiary standards; deposit data, samples and voucher specimens in appropriate repositories; coordinate monitoring efforts and data collection; and publish or otherwise report results. We hope that our concluding remarks will help guide bat research in northwestern Canada and Alaska, and that the hard-earned results obtained in future studies will impart a positive impact on bat conservation in the region.

CITATION: Jung, T.S., K.M. Blejwas, C.L. Lausen, J.M. Wilson, and L.E. Olson. 2014. Concluding remarks: What do we need to know about bats in northwestern North America. Northwestern Naturalist 95: 318-330.