Bat Survey of Nahanni National Park Reserve and Surrounding Areas, Northwest Territories

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ABSTRACT

Using mistnets and AnaBat ultrasound detector systems, bats were surveyed within the South Nahanni River Watershed, Northwest Territories (NWT) from 16 - 31 July and 3 - 5 August, 2006. The acoustic component of this survey took place over 19 nights, and mistnetting was carried out on 15 nights. Most of the survey took place within the current Nahanni National Park Reserve (NNPR) boundary; four nights of sampling occurred outside the park. This was the first formal survey of bats in the Northwest Territories. Previous to this survey, two species of bats were known from the NNPR: *Myotis septentrionalis*, the northern long-eared bat (Carbyn and Patriquin 1976), and *M. lucifugus*, the little brown bat (Fenton et al. 1972). This survey confirmed the presence of these two species and added the following five bat species: *Myotis evotis*, the western long-eared bat, *M. volans*, the long-legged bat, *Eptesicus fuscus*, the big brown bat, *Lasiurus cinerus*, the hoary bat, and *Lasiurus borealis*, the eastern red bat. Four species were captured in mistnets (*M. septentrionalis, M. lucifugus, M. evotis* and *M. volans*), and one species was detected acoustically with several visual identifications of bats in flight (*E. fuscus*). Two species were detected acoustically only (*L. cinereus, L. borealis*), and will require capture to verify their presence; a sighting of "an orange bat" in the vicinity of *L. borealis* acoustic detections one month after the survey, lends support to the presence of this species. *L. cinereus* had been previously documented elsewhere in the NWT (sight record) prior to this survey.

Both sexes of bats were captured; the only species found to be raising young in the park was *M. lucifugus*. This is the most northerly record (61^{o} latitude) of *M. evotis* and *M. volans* in North America, extending their range approximately 300 km. The identification of all captured species was confirmed through genetic analysis. With seven species of bats now known to occur

in the NWT, this territory has the greatest bat diversity in the Canadian and American north, followed by Alaska with six species (Parker et al. 1997).

Five additional days of acoustic monitoring took place opportunistically outside of the South Nahanni Ecosystem, at Fort Simpson on the snye running between the Mackenzie and Liard Rivers, and at Samba Deh Territorial Park along the Trout River. Bats were detected, but no new species.

Use of the South Nahanni Watershed / Greater Nahanni Ecosystem by bats is not well understood, but this survey provides a foundation upon which to base future work. Of the seven species identified in NNPR, five are nonmigratory (*M. evotis, M. volans, M. septentrionalis, M. lucifugus, E. fuscus*), meaning that they hibernate for the winter. These five species typically hibernate in caves or rock crevices; the latter species is considered extremely cold tolerant. The year-round habitat usage of the bats in NNPR is not known and will require further study; however, that seven bat species may be roosting, raising young, and hibernating in the park increases the likelihood that parts of the entire watershed and greater ecosystem are important for bats and this should be taken into consideration in the future park boundary expansion.

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INTRODUCTION

Documenting biodivesity in protected areas is an ongoing process, and establishing baseline data is important for managing parks in a conservation context. With the exception of the bat component in an impact assessment (Carbyn and Patriquin, 1976) and a survey of caves (Fenton et al., 1972) there had been no formal survey of bats in Nahanni National Park Reserve (NNPR) until now. Only two species of bats had been documented in the park prior to this survey: *M. lucifugus*, the little brown bat, and *M. septentrionalis*, the northern long-eared bat. This latter specimen was originally labelled as *M. keenii* (Keen's bat), but taxonomic review since this time revised the classification of long-eared bats.

A total of three bat species, *M. lucifugus, M. septentrionalis,* and *Lasiurus cinereus,* the hoary bat, had been documented in the Northwest Territories (NWT; Northwest Territories Species Infobase, accessed 20 Sept. 2005) prior to this survey; I predicted additional species would likely occur in the NWT, and specifically in NNPR, based on records of other bat species captured in NE B.C. (Wilkinson et al. 1995; Bradbury et al. 1997; Vohnof et al. 1997).

In addition to providing fundamental management information for bat conservation in NNPR, baseline bat biodiversity data were collected in an effort to help in determining the most beneficial boundaries for park expansion. Protection of habitat for bat species currently in the NWT, and for species shifting northward (e.g. climate change), can be accomplished with park expansions such as the one currently being considered for the NNPR (Nahanni Expansion Working Group, MOU between Parks Canada and Dehcho

First Nations, 2004). Understanding what bat species are present in the NNPR, would allow an evaluation of habitat likely to be important for bats in the greater Nahanni Ecosystem, potentially providing additional information for consideration in the negotiation of boundary expansion.

Understanding the northern limits of species is becoming increasingly more important as a way of monitoring climate change and its impact on wildlife. Climate change models for the little brown bat, *M. lucifugus* (Humphries et al. 2002), predict that this species' hibernation distribution will dramatically shift north in Canada in the future. NNPR is currently north of where conditions for *M. lucifugus* are thought marginally suitable for hibernation; the climate-physiology model (Humphries et al. 2002) predicts the NNPR region will be highly suitable within 80 years. Knowing what landbase to protect now, and what habitats will be important for wildlife in a future of climate change, is challenging, and starts with baseline data. Bats may serve as important indicators of climate change due to their vagility (able to move long distances relatively quickly) and temperature-regulated physiology. Documenting the impact of climate change on wildlife requires establishing these baseline data, making the survey of bats in northern areas high priority.

METHODS

This survey was conducted in three main locations in southwest NWT (Figure 1): 1. Along the South Nahanni River from Rabbitkettle Lake, within the existing Nahanni National Park Reserve, to the Splits, just outside of the park boundary; 2. In the limestone cave Nahanni North Karst area between the Ram Plateau and Tundra Ridge; 3.

Outside of the South Nahanni Watershed at the confluence of the Liard and Mackenzie Rivers, in Fort Simpson, and on the Trout River near the Mackenzie Highway.

This survey involved the capture of bats using mistnets and recording of bat ultrasound using AnaBat detectors (Titley Electronics, Australia). While some species of bats are difficult to capture, their presence can be detected using echolocation detectors. Not all bats are identifiable through echolocation analysis, therefore, using both acoustic and capture techniques was necessary to ensure a thorough survey. Some species produce echolocation calls with diagnostic characteristics that allow for species identification through use of acoustics only.

River Survey

Travel was by raft along the South Nahanni River starting in the park at Rabbitkettle Lake, and ending in the Splits outside the park, a total river distance of approximately 330 km. In total 15 nights of sampling took place along the river (15 July – 31 July); mistnetting occurred on 12 of these nights (Figure 1; Table 1) and acoustic sampling took place each night. One night of acoustic survey on the river occurred outside the park (in the Splits).

Nahanni North Karst Survey

Three additional nights of mistnetting (3 – 5 Aug.) and acoustic sampling were carried out in the Nahanni North Karst region (Figure 1). Four areas were sampled: Raven Lake, First Polje, near Moraine Lake, and an area 2.5 km northeast of Third Polje adjacent to the Ram Plateau (Table 1). Access was by helicopter.

Outside South Nahanni Ecosystem

Four additional nights of acoustic recordings took place outside of the South Nahanni Watershed and Karst regions, at Fort Simpson (3 nights, 7 – 9 Aug.; approx. N 61.85400^{o} W 121.33800^{o}) and Trout River (1 night, 10 Aug.; Sambaa Deh Falls Territorial Park; approx. N 61.13770 ^{o}, W 119.81040 ^{o}). A female volant juvenile *M. lucifugus* was also retrieved from a house in Fort Simpson on 8 August. The degree of ossification of the metacarpal-phalangeal joint was determined by measuring the epiphyseal gap (Hamilton 1996); in other words, the degree with which the cartilage was replaced by bone in the finger joints was used to provide a relative estimate of age in this juvenile bat.

Capture

Bats were captured using mistnets of various lengths (2.6 – 18 m). Each net was 2.6 m high but often nets were strung such that one net was above the other, creating a large "wall" of net (net details provided in Table 4 of results; see below) across the flyway. Mistnets were open by "civil twilight" light levels, which was earlier each night of the survey (~1:50 am at start of survey, ~0:10 at end of survey). Nets were kept open all night until morning twilight (~3:30 am at start of survey; ~4:50 at end of survey) unless temperatures became excessively cold and/or bats were not heard on the handheld Pettersson bat detector (Model D100).

Captured bats were removed from nets immediately and after measuring and identifying, they were released on site. Forearm measurements were taken with calipers, and in some cases ear pinna length was measured using a translucent ruler placed into the base of the ear. For all measurements three independent readings were taken and the mean value is calculated. Ear tragus shape was noted, and presence or absence of a keel (membrane protrusion near ankle) was determined to facilitate species identification. Mass was taken using a calibrated digital scale accurate to 0.01 g, and in most cases (otherwise noted) the animal was held for one hour to void the digestive tract and achieve an accurate weight. Relative age (adult or juvenile) was determined by examining the degree of ossification of a finger joint making up the wing (metacarpal-phalangeal joint); adults are fully ossified (Anthony 1988). Within the adults, age was estimated further by classifying the degree of toothwear on a scale of 2 – 7 (toothclass, Holroyd 1993). Reproductive status was determined in males by examining the testes, and in females by gently palpating the abdomen, checking for worn hair around the teats, and trying to express milk from worn teats.

A small (2mm diameter) biopsy of wing tissue was taken from each captured individual (Lausen 2005); two fragments of the 16S ribosomal subunit gene in the mitochondrial DNA were sequenced by J. Zinck (Portland State University, Portland, OR; Zinck et al. 2004) to confirm species identification genetically.

Netting was conducted only in the Greater Nahanni Ecosystem (watershed and Karst); recording of ultrasound took place in all survey areas.

<u>Acoustic Identification</u>

AnaBat detectors were attached to digital compact flash ZCAIM units, which save ultrasound information digitally on compact flash cards. Units were placed near water bodies, in most cases this was rivers or creeks. During the South Nahanni River portion of the survey, one unit was placed near the river each night, and another unit was set up near the netting area, which was up to 1.5 km from the South Nahanni River. Twenty-six sites were acoustically monitored in the South Nahanni Watershed (Table 1) at 14 sampling locations (Figure 1). In a number of cases bats flew close to us and circled; therefore the AnaBat detector at the netting area may have recorded more bat passes than perhaps would otherwise have been detected.

Identification of bats through acoustic analysis requires that there be unique properties for each species' echolocation calls. Calls are visualized on a frequency versus time graph. Features of calls, such as call duration, slope of call, up-turned shape, time between calls, shape of call, etc. allow for identification (Corben 2002). An understanding of how AnaBat records data (zero-crossing) is required to interpret calls (e.g. intensity, harmonics, etc.) and such an understanding was used to analyze calls from this survey, but is beyond the scope of this report. Species assumed to be present in the study area (Table 2) were the four captured species of *Myotis* (*M. lucifugus, M. volans, M. evotis, M. septentrionalis*); additional species were acoustically detected based on acoustic criteria (see below).

Lasiurus cinereus, *L. borealis*, *M. evotis* (and long-eared bats in general) can produce visually unique calls that separate them from all other species. It is these unique call features that allowed for the acoustic identification of these species in this survey. However, not all calls produced by an individual will be the same and calls of different individuals can differ, and therefore, the unique call features are not always present; when these diagnostic calls are not present in a recorded pass, then identification is less certain. Reference calls were successfully collected from hand released *M. volans* (n = 2), *M. lucifugus* (n = 5), *M. evotis* (n = 1) and *M. septentrionalis* (n = 1). However, due to the small samples sizes, these calls were not used in the analysis of unknown calls (discriminate function analyses not performed). Bat passes were analyzed in AnaLook

4.9j (Corben 2004), and placed into “high frequency” versus “low frequency” categories. The call characteristics that allow species to be identified in high quality calls (Table 2) were used to identify species within the high and low frequency categories. This was instrumental in identifying the presence of species that were not captured. Good quality high frequency calls could be further identified into three main groups: 1. long-eared *Myotis* (*M. evotis, M. septentrionalis*), identified by their typical steep-sloped calls (Brigham et al. 2002), 2. *Myotis* not long-eared (*M. lucifugus*, *M. volans*; making the assumption that there were no other *Myotis* spp. in the study area), and 3. *Lasiurus borealis*, distinctive in their shallow slope and call shape, but still possibly confused with some *Myotis* calls. Calls in the 30-45 kHz range that were of too poor a quality to determine slope were undifferentiated and labeled as “Myotis spp.” Because *M. evotis* makes echolocation calls that are lower in minimum frequency than *M. septentrionalis*, long-eared *Myotis* calls that were <35 kHz were evidence of *M. evotis.* Within the low frequency bats, *Eptesicus fuscus*, the big brown bat, and *Lasionycteris noctivagans*, the silver-haired bat, cannot be differentiated acoustically. But because the former species has a unique flight pattern and body shape and tends to emerge at high light levels, it is easily identified in flight. *E. fuscus* was visually identified during the survey (see below), and therefore all 20-30 kHz calls could have been produced by this species; however, the presence of *L. noctivagans* cannot be ruled out given the suitability of the treed habitat. While *Lasiurus cinereus* and *E. fuscus/L. noctivagans* are generally differentiable, in some cases call characteristics overlap; *L. cinereus* are differentiated when calls are very long in duration (>17 ms) and/or minimum frequency is < 20 kHz.

RESULTS

Species Identified

Eighteen bats were captured in mistnets, for a capture average of 1.2 bats/night (Table 3). One bat escaped from the net without identification, and 17 bats were identified. All were adults and four species were captured: *Myotis septentrionalis,* the northern long-eared bat, *M. lucifugus*, the little brown bat, *Myotis evotis*, the western long-eared bat, and *M. volans*, the long-legged bat (Table 2).

An additional three species were not captured, but were acoustically detected: *Eptesicus fuscus*, *Lasiurus cinereus*, and *L. borealis* (eastern red bat). The former species was also visually identified in flight at two locations, and a visual report of the latter species came after the survey period (see Discussion below). A sight record of *L. cinereus* in NWT existed prior to this survey (Northwest Territories Government InfoBase). *Lasionycteris noctivagans*, the silver-haired bat, was not captured nor seen; however, because the South Nahanni Watershed seems to present highly suitable habitat for this tree-roosting migratory species, and because the echolocation calls of this species and *E. fuscus* cannot be distinguished (Betts 1998), the absence of *L. noctivagans* from the park cannot be assumed.

Genetic results corroborated field identifications (Table 3). A summary of bat species found at each sampling site (acoustic and capture data combined) can be found in Table 7 (see below).

Captures

Netting effort each night varied greatly depending on distance of netting site from river, and working conditions such as deep mud and excessive numbers of mosquitoes. The most successful method of capture involved using two mistnets, one above the other, to create a “wall” of net standing 5.2 m high instead of the typical 2.6 m net height. Twelve of the 18 captures were in such net constructions (Table 4).

The forearm measurements (Table 5) for all captures fall within the ranges for each species, as found by others in B.C. and Alberta (Nagorsen and Brigham 1993; Bradbury et al. 1997; C.L.L. unpublished data). While forearm measurements for NWT bats are similar to bats from more southerly locations, masses are larger for northern captures. Why this is the case is unknown; similar results were reported by Wilkinson et al. (1995) and Bradbury et al. (1997). It is possible this trend would disappear with larger sample sizes and consistency among studies regarding instrument of measure (i.e. digital scale vs. pezola spring-scales).

Nine of the 18 captures (50%) occurred at the lowest elevation sampling sites (250m) near First Canyon (Lafferty Canyon and Kraus Hot Springs). These areas also had the highest diversity of bats (5 species). High elevation sites (Rabbitkettle [600m] and the Nahanni North Karst [750m]) experienced colder night temperatures; less bat activity and lower species diversity were found at these locations.

Acoustic Detection

A total of 670 bat passes were detected during 6868 minutes of acoustic monitoring (Table 6; 5.9 passes/hour). The most common passes were of high frequency bats (627). Through further visual inspection of calls in this category, I was able to clearly identify that 64 (10%) of these were long-eared (mixed *M. evotis* and *M. septentrionalis*); however, a discriminate function analysis would likely have been able to confirm that many more of these passes were by long-eared bats. Within the long-eared passes, *M. evotis* was clearly present (due to some very steep calls having a minimum frequency of <35 kHz). Four high frequency passes appeared to be made by *L. borealis*. While *L. borealis* calls can resemble *Myotis* calls superficially, passes identified as *L. borealis* in this survey had very low call slope with an upturned end on some calls, which is characteristic of *L. borealis*. This species is being detected acoustically in increasing numbers in northern Alberta (see Discussion below).

Low frequency bat passes were relatively uncommon (43; Table 6), with most occurring in the more southern area of NNPR. Most passes were *E. fuscus/L. noctivagans* (34); 6 passes were identified as *L. cinereus* based on very long call duration (> 17 ms) and/or calls <20 kHz, diagnostic acoustic features of this species. A low frequency recording (14 kHz) occurred at Rabbitkettle Lake (RK1), but because of the poor quality of this recording, it was not been included with the *L. cinereus* count. *L. cinereus* was again acoustically detected outside of the park at Fort Simpson (see next section).

Table 7 is a summary of species of bats present (combined acoustic or capture data) at sampled areas in NNPR.

<u>Outside South Nahanni Ecosystem</u>

Acoustic data were collected at Fort Simpson and on the Trout River near the Mackenzie Highway. No new bat species were detected. In addition to *Myotis* bat passes, a pass of *L. cinereus* was recorded (at Fort Simpson). A volant (flying) juvenile female *M. lucifugus* was retrieved from a house in Fort Simpson, 8 August (Table 8).

Additional Data Collected

Because light levels remained high, significant overlap between bird and bat activity occurred. As such, several birds were captured in mistnets. Appendix A lists incidental bird captures and other noteworthy bird sightings.

DISCUSSION

This survey documented seven species of bats (*M. lucifugus, M. septentrionalis, M. volans, M. evotis, L. borealis, L. cinereus, E. fuscus*) for Nahanni National Park Reserve (NNPR) and for the NWT in general. Prior to this survey, two species of bats (*M. lucifugus, M. septentrionalis*) were known to exist in the park from specimens collected in the 1970s. In this survey, these two species and the two additional species of *Myotis* were captured using mistnets. *Lasiurus borealis, L cinereus* and *E. fuscus* were detected acoustically but not captured. The latter species was visually identified during the survey, the former species was visually identified by others after the survey, and *L. cinereus* was previously sighted outside of the park years prior to the survey (Northwest Territories Government Infobase). There are specimens of both *L. cinereus* and *L. borealis* on record from Nunavut (one specimen of each species; Northwest Territories Government Infobase).

With seven species of bats now known to occur in the NWT, this territory has the greatest bat diversity in the Canadian and American north, followed by Alaska with six species (Parker et al. 1997). That all seven species occur in NNPR, suggests that this area offers diverse bat habitat. Abundant tree and rock roosts together with ideal riparian foraging habitat make this park ideal for all species of bats (tree cavity roosting, foliage roosting, rock crevice roosting, cave roosting, solitary, colonial, etc.). In high latitude places such as this, foraging behaviour of bats is not understood; bats seem to persist despite short nights and short reproductive seasons. Conditions in NNPR may be optimal for bat survival; for example, steep canyon walls decrease light levels even when the sun remains low on the horizon, and this may be beneficial for foraging bats. Further research on bat behaviour in northern areas would be beneficial in understanding the importance of NNPR habitat to bats in the NWT, and consequently provide direction for park management as it pertains to bat conservation.

The Nahanni National Park Reserve protects approximately 14% of the South Nahanni River Watershed. This area contains highly suitable roosting and foraging habitat for foliage- and cavity- roosting bats. The abundance of trees and standing water in the area between Rabbitkettle and Virginia Falls would provide roosts, foraging and drinking habitat for all species captured in this survey. It is however higher in elevation and therefore cooler at night than the area downriver of Virginia Falls where night temperatures are warmer and abundant rock crevices in canyon walls provides an additional source of roosts Insects are abundant, especially mosquitoes (pers. obs.); mosquitoes were particularly abundant in 2006 compared to past years (Dave Hibbard, Nahanni Wilderness Adventures, pers. comm.). It is clear that prey would be extremely easy to collect and this may counter-balance the short night length; this would allow bats to survive at this latitude, and possibly raise young. Owls are predators on bats, although typically only medium-sized owls (e.g. short-eared owls) are perceived as threats by bats (e.g. Lausen 2001). Owls are present in the park (5 species; Doug Tate, Nahanni

National Park Biologist, pers. comm.), but with the exception of the small-bodied saw-whet owl call, owls were not seen, heard, or captured during this survey suggesting bat predators may be rare; this would allow bats to forage successfully during nights when light levels are high.

The Nahanni North Karst area consists of large numbers of limestone caves and other unique geological features. A few large caves from this area have been described as dry with fluctuating temperatures (Fenton et al. 1972). These conditions would not be suitable for hibernating bats, however, rock crevices and smaller caves are abundant and may provide important hibernation habitat (Lausen and Barclay 2006). During the early August period when the survey took place in this region, it seemed that the Nahanni North Karst did not host much bat activity. Nights were cold, perhaps due to high elevation, and bats that were detected were out earlier at higher light levels than expected, perhaps to forage early while insects are still flying. Only males were captured and this may indicate that the Nahanni North Karst area is not suitable for raising young. Male bats may spend the summer in this area to make use of extensive bouts of torpor. Torpor is the cooling of the body that allows for energy-savings; while females make less use of torpor in order to reproduce, males typically make regular use of torpor and therefore seek cool roosting locations (Altringham 1996). Whether bats hibernate in the Nahanni North Karst area remains unanswered and would require a late fall survey to determine. Documentation of microclimate within a variety of caves would also help determine their suitability as bat hibernacula.

Nahanni National Park Reserve (NNPR) is currently north of where conditions for *M. lucifugus* are thought marginally suitable for hibernation (Humphries et al. 2002); the climate-physiology model predicts the NNPR region will be highly suitable within 80 years. The present survey has established that the habitat in NNPR is currently suitable for a large number of bat species during the summer. Due to its abundance of rocks, trees and standing water, NNPR offers a substantial amount of ideal foraging and roosting habitat for bats. As such, the Greater Nahanni Ecosystem is likely to be important for northward expansion of bats in western Canada as global warming continues. Establishing whether bats are hibernating in the park or nearby Nahanni North Karst area, may allow for monitoring of future shifts in hibernation behaviour as climate change continues. It would also help elucidate what habitat is important for bats in the Greater Nahanni Ecosystem. Although the Nahanni North Karst does not appear to provide summer roosting habitat as suitable as that along the South Nahanni River (at least for females), this area may be important for fall mating and winter hibernation. Of the seven species identified in NNPR, four are nonmigratory (*M. evotis, M. septentrionalis, M. lucifugus, E. fuscus*), meaning that they hibernate for the winter. These four species typically hibernate in caves or rock crevices; the latter species is considered extremely cold tolerant, and has been documented flying in Alberta during the winter in temperatures as low as -8^{o}C (Lausen and Barclay 2006). That seven species were found in this park increases the likelihood that parts of the entire South Nahanni Watershed and Greater Nahanni Ecosystem are important for bats, and perhaps year-round; this should be taken into consideration in the park boundary expansion decisions.

M. lucifugus has been documented in Alaska as far north as Minto Lake, near Fairbanks (65^{o} latitude) and sight records of what is likely *M. lucifugus* has been reported as far north as Fort Yukon near the Arctic Circle (66.5 ^{o} latitude; Parker et al. 1997). *M. septentrionalis* was recently documented in the Yukon at 60^{o} latitude (Jung et al. *in press*). All captures in this survey occurred between 61^{o} and 62^{o} latitude, making the *M.*

septentrionalis, *M. evotis* and *M. volans* captures from this survey, together with the *M. septentrionalis* specimen from Fort Simpson (61^{o} 52’, Sept. 2005, D. Tate, pers. comm.; see below), the most northerly records of *Myotis* species other than *M. lucifugus*. The capture of *M. evotis* and *M. volans* in NNPR extends the range of these species approximately 300 km north (Nagorsen and Brigham 1993; Wilkinson et al. 1995; Bradbury et al. 1997; Parker et al. 1997; Vohnof et al. 1997).

That *M. volans* and *M. evotis* were found in the park is significant given the range extension for these species. Previous to this, the most northerly records of these species came from two unpublished government reports on bat surveys from NE B.C. (Bradbury et al. 1997; Vonhof et al. 1997). There is some discrepancy concerning the identification of *M. evotis* versus *M. septentrionalis*, and *M. volans* versus *M. californicus* with an earlier survey in this same area (Wilkinson et al. 1995), but results of the present survey support the former two reports in their identifications, suggesting that *M. volans* and *M. evotis* exist in NE B.C. in the Liard River and Fort Nelson River regions and extend further north into the Nahanni region. It is likely that the Liard River system acts as a transportation corridor for bats between NE B.C. and SW NWT. Based on forearm measurements presented in Wilkinson et al. (1995), it is unlikely that *M. californicus* has been captured in NE B.C., and it is therefore unlikely to be found in NWT. The capture of *M. evotis* in NNPR lends support to the suggestion by Jung et al. (*in press*) that *M. evotis* was acoustically detected recently in SE Yukon. It is highly likely that *M. volans* and *M. evotis* are present in the Yukon Territory.

Low capture numbers (1.2 bats/night in this survey) when mistnetting for bats in northern areas is typical (e.g. Fischback et al. (2005) had 0.4 captures per night for 46 nights in SE Alaska; Wilkinson et al. (1995) had 1.8 captures per night for 45 nights in

NE British Columbia). Capture of bats in this survey was difficult due to short trees, the open nature of most of the forest, abundance of standing water, and short nights. Finding distinct flyways in which to string nets across was difficult; many creeks were closed in with extreme tree clutter, and rivers were too wide with large open flood plains and shorelines. Between Rabbitkettle and Virginia Falls, many standing bodies of water exist, however, because of the large number of these bodies, bats are not limited in where they drink making them diffuse and less likely to attempt to drink in the water body over which the net is strung, especially given that light levels were such that the nets were easily detected. Often bats would approach the body of water, discover the nets and leave without attempting to drink. The canyons downriver of Virginia Falls provided increased darkness at night, less standing water bodies for bats to choose from for drinking, and the opportunity to funnel bats into nets along narrow canyon walls; however, the number of suitable netting sites accessible from the river carrying a large amount of gear was limiting.

Fewer bats were captured at higher elevation areas (e.g. Nahanni North Karst, 750 m), while more bats were detected and captured at the lower elevation sites (e.g. Lafferty Canyon, 250 m). This corroborates findings from NE B.C. where most captures were below 580 m, while no captures occurred above 716 m (Wilkinson et al. 1995).

Long-eared bats produce low intensity echolcation calls (pers. obs; Brigham et al. 2002), and are likely under-represented in the acoustic recordings. This may in part explain why long-eareds were 24% of the captures, but 10% of the acoustic recordings. Acoustic differentiation between long-eared and other *Myotis* calls is only approximate because of call characteristic overlap, also explaining the seemingly low long-eared to non-long-eared *Myotis* ratio observed in the acoustic data. Because *M. septentrionalis* is a "May be at Risk" species in Yukon, B.C. and Alberta (CESCC 2006), determining this bat's abundance in NWT is of interest to the conservation of this species. There were only two records of this species in the NWT prior to this survey: one specimen found at Kraus Hot Springs in NNPR (Carbyn and Patriquin 1976), and a dead female from Fort Simpson which was turned into the NNPR office 2 September 2005 (D. Tate, pers. comm.). Identification of this latter specimen was genetically confirmed.

Three species of bats were detected/visibly identified but not captured: *E. fuscus*, *L. cinereus* and *L. borealis*. The former species is high flying and tends to emerge earlier than others while the sun is higher on the horizon, which may explain the difficulty involved in their capture using mistnets. *E. fuscus* have been seen and/or acoustically detected in NE B.C. (Wilkinson et al. 1995; Bradbury et al. 1997; Vonhof et al. 1997) and the Yukon (Slough and Jung, *in press*), but not captured in any of these locations. *Lasiurus cinereus*, like *E. fuscus*, is large-bodied and high flying. Each species has a distinct flight pattern and body shape that can be recognized when seen. While *L. cinereus* was not visualized in this survey, its long duration echolocation calls below 20 kHz make it unique and distinguishable from all other northern Canadian bat species. *L. cinereus* is a solitary roosting species (Nagorsen and Brigham 1993). Because migratory bat species move to northern areas of Canada to raise young, *L. cinereus* and *L. borealis* detected in the park are likely reproductive females or volant (flying) juveniles.

That the migratory species *Lasionycteris noctivagans* was not found in this survey is surprising, but may be an artifact of overall low capture numbers, given that the other "low frequency" bats were not captured either. Overall, low frequency bats were much less abundant than high frequency bats, and were more prevalent in the south part of the NNPR than the north part. Although there are studies that claim to distinguish *L.*

noctivagans acoustically, due to extreme individual variation within *L. noctivagans* and *E. fuscus*, together with complete frequency overlap (both produce a variety of ~30 kHz calls), it is unlikely that these two species can be confidently differentiated acoustically. *E. fuscus* is recognizable in flight ("torpedo-shaped" body) and tends to emerge in high light levels allowing for identification visually, but this is not the case for *L. noctivagans*. Therefore, while the presence of *E. fuscus* in the NNPR was confirmed through visual identification, it is possible that *L. noctivagans* was acoustically recorded. Because of the abundance of birch and poplar trees on the Liard River and the confluence of the Liard with the South Nahanni River (areas not surveyed in this study), it is likely that mistnets set in this region would capture *L. noctivagans*. This region of tall and abundant deciduous trees is also highly suitable habitat for the other migratory bat species, *L. cinereus* and *L. borealis*; bat survey work in this Liard area is recommended (see below).

Little is known about the eastern red bat, *Lasiurus borealis*, other than that captures and acoustic detection in the western prairies and boreal region have definitely been higher in the past few years than ever before. It is possible that this species is expanding westward (Willis and Brigham 2003), however, efforts to find this species have also recently increased. In fact, the known red bat distribution seems to be changing at such a fast rate that it is difficult to say how much of a range extension has occurred from this detection. Based on the most recent Alberta records (Alberta Sustainable Resource Development, Fish and Wildlife, Biodiversity/Species Observation Database, Feb. 2006), this extends the *L. borealis* range approximately 850 km northwest. However, it is unlikely that this species has been looked for in this 850 km area, as previous surveys in NW Alberta (Vonhof and Hobson 2001) and NE B.C. (Bradbury et al. 1997; Wilkinson et al. 1995) have used heterodyne bat detectors which are not suitable for species identification given that calls are not recorded and visualized, merely heard in real-time (Brigham et al. 2002). In Alberta, this species used to be considered accidental/vagrant, but has now gained the status of "Sensitive" due to its increasing presence in the province and the occurrence of red bat carcasses found under wind turbines in SW Alberta (Robin Gutsell, Alberta Sustainable Resource Development, pers. comm.; Erin Baerwald, University of Calgary, pers. comm.). After the survey period, a river trip of the South Nahanni River through the NNPR by park staff resulted in a sighting of a red bat (3 Sept. 2006; described as an "orange bat that swooped down near the canoe and took a drink from Oxbow Lake"; Marcel Cholo and Troy Searson, pers. comm.). This sighting occurred in an area of deciduous trees (birch, poplar) mid-way between two locations where red bats were detected in the survey (~10 km from each of the *L. borealis* detection areas up- and downriver of Oxbow Lake). Because this species roosts in deciduous trees, and because this bat's colour is instrumental in species identification, this sighting lends substantial support to the presence of this species in NNPR. Of course, further acoustic detection and sightings would be beneficial to substantiate this finding given that this is a large range extension for this species.

Because of the north latitude of this survey and the tendency for male bats to reside in areas often too cold for female bats to raise young, this high latitude park was expected to have male bats. The highest altitude surveyed in this survey was the Nahanni North Karst (750 m) where night-time temperatures at the beginning of August were below freezing and only male bats were captured. However, female *M. evotis*, *M. volans* and *M. lucifugus* were captured along the South Nahanni River (~250 - 600 m range in altitude) earlier in the survey. The only female found to conclusively be raising young in the park was one *M. lucifugus* which was lactating, although two other *M. lucifugus* seemed pregnant. The volant (flying) juvenile *M. lucifugus* found in Fort Simpson (see below) 8 August suggests reproductive schedule may be highly variable in different locations of the NWT and may be unsynchronized even within an area. Similar findings with pregnant adults, lactating adults and volant juveniles all present in one area simultaneously has been reported in SE Yukon (Jen Talerico, University of Calgary, pers. comm.).

Because this is the first formal survey of bats in the NNPR that has used mistnets and acoustic equipment, it is difficult to compare this survey with other small mammal surveys in NNPR that attempted to include bats (Fenton et al. 1972, Carbyn and Patriquin 1976, Scotter and Henry 1977). For example, Scotter and Henry (1977) suggested that the Deadmen Valley area was depauperate of bats in July and August but not September, and suggested this valley was more likely important for bat hibernation rather than summer use. It is, however, difficult to establish how much effort was put into bat detection and it seems that no equipment was used (survey was by "observation" of bats; p. 93). The present survey found bat activity in July, suggesting that either this area has since become more important for bats during the summer, or that effort to survey for bats during this 1977 survey was minimal.

As climate change continues, bat distributions are predicted to shift north (Humphries et al. 2002), and protecting a large section of the Nahanni Ecosystem would ensure that bats have northern roosting and foraging habitat to move into. Certainly much of the rest of the NWT is less suitable or unusable by bats, and therefore, the protection of the unique Nahanni Ecosystem would provide suitable northern habitat for bats in the future.

This survey establishes baseline bat diversity upon which to base all future bat surveys. Monitoring for the northward expansion of bat species into the South Nahanni River Watershed would be instructive for understanding climate impact on wildlife in general, and more specifically for bats. As mammals with climate-mediated physiology and the capacity for flight, bats may be important early indicators of climate change.

RECOMMENDATIONS

Continuous long-term monitoring in the park with an AnaBat detector and CFZCaim digital recording unit would be ideal to establish activity levels from year to year. An AnaBat system running on an external battery can monitor passively for days – weeks, and infinitely if hooked up to a solar panel system, limited only by the size of the storage disk, which should be downloaded at least once per year. Such a monitoring station might be most feasible at one of the cabins, and given the low elevation, abundance of nearby rock roosts, and low level of human activity at the Deadmen Valley Warden Cabin, this cabin might be best for such a station. However, a station in the Kraus Hot Springs/Lafferty Canyon area would allow for a higher bat activity area to be monitored and may produce more meaningful results given the closer proximity to the limestone caves of the Nahanni North Karst. It may have to be downloaded more often and concealed in a locked container due to higher human traffic, but the large body of standing water west of the cabin would be an excellent place to monitor. Acoustic data collected by this remote detector system would allow for trends in bat activity to be monitored in relation to temperature/weather data over many years. Biodiversity could also be monitored this way, although mistnetting will be needed in addition to acoustics given that not all species can be acoustically differentiated.

A system of similar cost to the AnaBat is the Pettersson D240X attached to a digital mp3 player. The microphone on this system is more sensitive than the AnaBat and the recordings are time expansion rather than zero-crossing allowing for substantially better acoustic data to be collected, making species identification more reliable. However, only a few nights worth of data can be collected with this system because full spectrum data requires far greater storage capacity, and data download requires use of a laptop.

Because of the sensitivity and production of time expansion data (full spectrum acoustic data), the Pettersson detector units should be considered. Currently the Model D-1000x allows for long-term storage of full spectrum data via a flashcard, just as the CFZCaim unit saves the zero-crossing data. Therefore, the D-1000x would work well for acoustic monitoring in the park, however, these units are more than three times the cost of an AnaBat system.

The least expensive of any bat detector system is a handheld Pettersson heterodyne detector; used opportunistically by park staff when in the park at night, this detector would be beneficial to document activity levels in various areas of the park at particular times of the year, and raise awareness about bats with park visitors, but would not provide species information or meaningful long-term activity patterns. Opportunistic monitoring of activity levels in the fall would be most beneficial by determining whether activity continues late into the fall, especially in areas of substantial rock habitat likely to be used for hibernation. While I suspect bats do remain in situ for hibernation, late fall monitoring would be critical in determining this. Temperature and relative humidity dataloggers placed into various caves in the park and Nahanni North Karst would also provide valuable information about whether hibernation is currently possible in the caves of this area.

The year-round habitat usage of bats in NNPR is not known and will require further study; however, that seven bat species were found in the park increases the likelihood that parts of the entire South Nahanni River Watershed and Greater Nahanni Ecosystem are important for bats. This should be taken into consideration in the park boundary expansion process that is currently underway (Nahanni Expansion Working Group).

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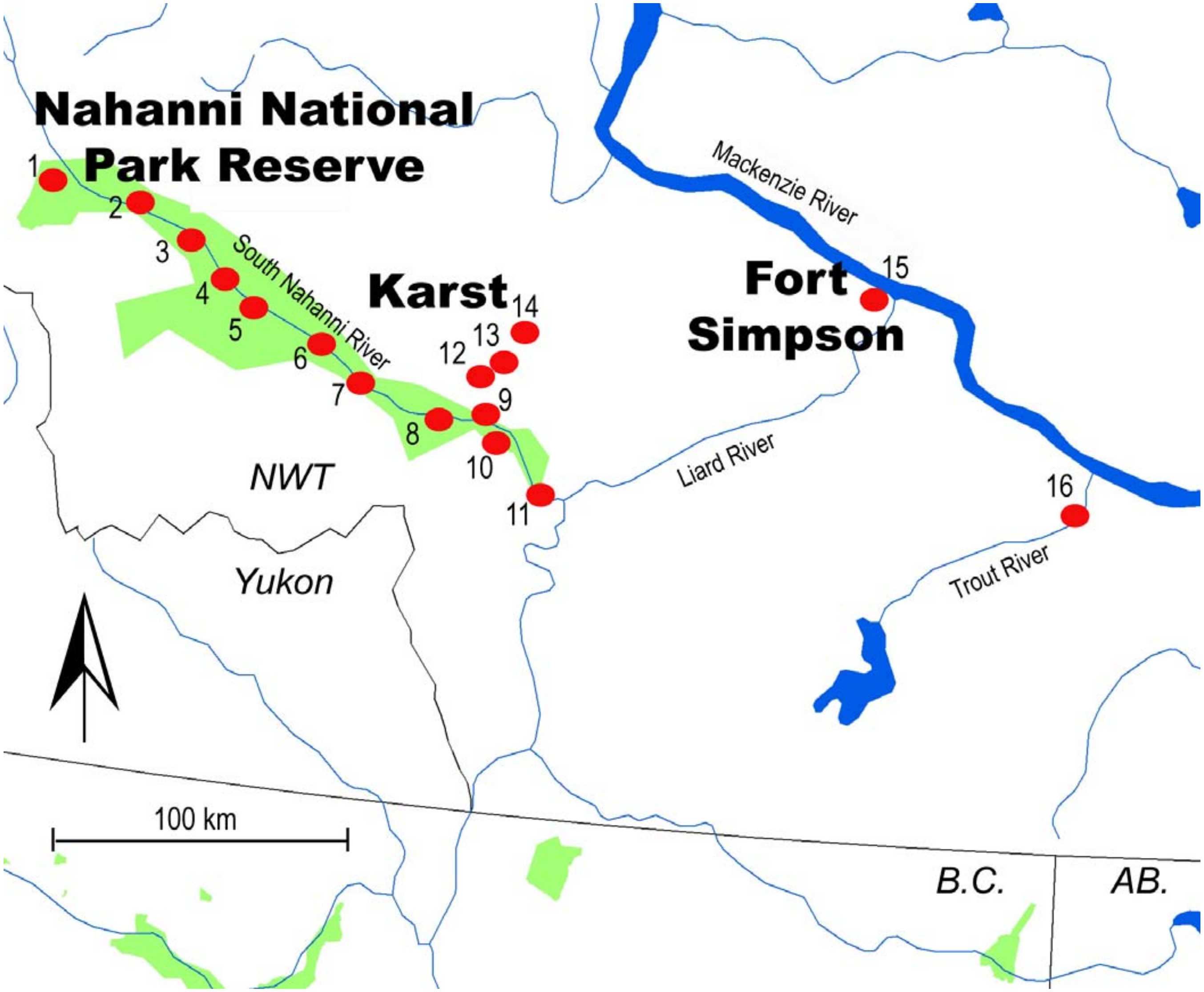

Figure 1. Map of study areas. Refer to Table 1 for specific site descriptions. Named sites: 1. Rabbitkettle Lake, 5. Virginia Falls/Sunblood, 6. Mary River, 7. The Gate, 8. Deadmen Valley Warden Cabin, 9. Lafferty Canyon, 10. Kraus Hot Springs, 11. The Splits, 12. Moraine/Death Lakes, 13. Polje One/Raven Lake, 15. Ft. Simpson, 16. Sambaa Deh Falls Territorial Park. Sites 1 – 14 are in the South Nahanni Ecosystem.

Table 1. Acoustic monitoring and mistnetting locations. Pettersson detectors are handheld and did not record. Anabat detectors recorded in digital format for species identification. Refer to Fig. 1 for map locations.

2006 Date	Sampling Location	Altitude (~m)	Coordinates (degrees)	Detector Used	Mistnetting done here?	Map Location (Fig. 1)	Site Abbrev.
16-Jul	Rabbitkettle Cabin by Lake	610	N61.959300 W127.204833	Anabat 1	N	1	RK1
16-Jul	Rabbitkettle Beaver Dam	610	N61.96690 W127.22581	Pettersson	Y	1	RK2
17-Jul	Rabbitkettle Cabin by Lake	610	N61.959300 W127.204833	Anabat 1	N	1	RK1
17-Jul	Rabbitkettle Sink Holes	610	N 61.95630 W127.21118	Pettersson	Y	1	RK3
18-Jul	Rabbitkettle Cabin by Lake	610	N61.959300 W127.204833	Anabat 1	N	1	RK1
18-Jul	Rabbitkettle Beaver Dam	610	N61.96690 W127.22581	Anabat 2	Y	1	RK2
18-Jul	Rabbitkettle Beaver Dam	610	N61.96690 W127.22581	Pettersson	Y	1	RK2
19-Jul	River R Channel downriver of RK before Hell Roaring	600	N61.968717 W127.225750	Anabat 1	N	2	DRHR1
19-Jul	Creek in River R Channel downriver of RK before Hell Roaring	600	N61.88083 W126.90835	Anabat 2	Y	2	DRHR2
19-Jul	Creek in River R Channel downriver of RK before Hell Roaring	600	N61.88083 W126.90835	Pettersson	Y	2	DRHR2
20-Jul	Flood Plain downriver of Flood Creek on River Left	590	N61.84412 W126.24401	Anabat 2	N	3	DRFC
21-Jul	River R Channel upriver of Oxbow Lake	575	N61.751917 W126.067300	Anabat 1	N	4	UPOX1
21-Jul	Creek just upriver of this location where netted	575	N61.753683 W126.065867	Anabat 2	Y	4	UPOX2
21-Jul	Creek just upriver of this location where netted	575	N61.753683 W126.065867	Pettersson	Y	4	UPOX2
22-Jul	Virginia Falls Dock Facing open area by heli pad	570	N61.60579 W125.75501	Anabat 1	N	5	VF1
22-Jul	Virginia Falls Cabin Pond	570	not GPS'd	Anabat 2	Y	5	VF2
22-Jul	Virginia Falls Cabin Pond	570	not GPS'd	Pettersson	Y	5	VF2
23-Jul	Virginia Falls Dock Facing open area by heli pad	570	N61.60579 W125.75501	Anabat 1	N	5	VF1
23-Jul	Sunblood pond	570	N61.60697 W125.75266	Anabat 2	Y	5	VF3
23-Jul	Sunblood pond	570	N61.60697 W125.75266	Pettersson	Y	5	VF3
24-Jul	Virginia Falls Dock Facing River	570	N61.60579 W125.75501	Anabat 1	N	5	VF1
24-Jul	Creek River R upriver of Virginia Falls	570	N61.60881 W125.76541	Anabat 2	Y	5	VF4
24-Jul	Creek River R upriver of Virginia Falls	570	N61.60881 W125.76541	Pettersson	Y	5	VF4

2006 Date	Sampling Location	Altitude (~m)	Coordinates (degrees)	Detector Used	Mistnetting done here?	Map Location (Fig. 1)	Site Abbrev.
26-Jul	Mary River mouth	440	N61.45585 W125.13263	Anabat 1	N	6	MR1
26-Jul	~200 m up Mary River	440	approx. N61.45384 W125.13297	Anabat 2	Y	6	MR2
27-Jul	The Gate: Base of rock rubble N of campsite	360	N61.412767 W124.928183	Anabat 1	N	7	GT1
27-Jul	The Gate	360	N61.41091 W124.92824	Anabat 2	N	7	GT2
27-Jul	The Gate	360	N61.41091 W124.92824	Pettersson	N	7	GT2
28-Jul	Deadmen Valley Warden Station	280	N61.24307 W124.44433	Anabat 1	Y	8	DMV1
28-Jul	Deadmen Valley Warden Station	280	N61.24307 W124.44433	Anabat 2	Y	8	DMV1
29-Jul	Lafferty Canyon at narrow opening	250	approx. N61.28488 W124.08211	Anabat 1	Y	9	LAF1
29-Jul	Lafferty Canyon Flood Plain at River	250	N61.27643 W124.08266	Anabat 2	N	9	LAF2
30-Jul	Kraus Hot Springs Creek (beaver dams) just upriver of camp	245	N61.254267 W124.058433	Anabat 1	Y	10	KRS1
30-Jul	Kraus Hot Springs Large Pool behind cabin	245	N61.256967 W124.064733	Anabat 2	N	10	KRS2
31-Jul	Splits just outside of real park boundary	195	N61.133100 W123.633767	Anabat 2	N	11	SPL1
3-Aug	First Polje	750	N61.56110 W124.06726	Anabat 1	N	12	KRST1
3-Aug	Raven Lake near First Polje 1	750	N61.55746 W124.06863	Anabat 2	Y	12	KRST2A
4-Aug	First Polje	750	N61.56110 W124.06726	Anabat 1	N	12	KRST1
4-Aug	Raven Lake near First Polje 2	750	N61.55576 W124.06917	Anabat 2	Y	12	KRST2B
5-Aug	Ponds on Edge of Ram Plateau	760	N61.63378 W124.02692	Anabat 2	Y	14	KRST3
5-Aug	Ponds on Edge of Ram Plateau	760	N61.63378 W124.02692	Pettersson	Y	14	KRST3
5-Aug	Between Moraine and Death Lakes	760	N61.49392 W124.14579	Anabat 1	N	13	KRST4

Table 2. Common and taxonomic names and descriptions of bat species (van Zyll de Jong 1984, Adams 2003).

Latin Name (Genus species)	Common Name	Acoustic characteristics	Physical description	Ecology
Myotis lucifugus	Little brown	High frequency (35 - 45 kHz)	Brown fur and membranes; short ears; long hairs on toes	Roost in tree cavities/bark, rock crevices, buildings; females tend to form colonies; hibernates
M. volans	Long-legged	High frequency (35 - 45 kHz)	Similar to *M. lucifugus* but typically a bit larger with more hair under armpits; defining trait is small protruding piece of membrane (keel) near ankle	Roost in tree cavities/bark, rock crevices, buildings; have been found to share roosts with *M. lucifugus* ; hibernates
M. evotis	Western long-eared	High frequency (30-38 kHz); calls have steep slope	Long-eared bat; blonde (light brown) fur, dark membranes; longer ear than *M. septentrionalis*; dark face mask; ear tragus wide and blunt	Roost in tree cavities/bark, rock crevices, and occasionally in buildings; tend to roost in small groups or solitarily; hibernates
M. septentrionalis	Northern long-eared	High frequency (>38 kHz); calls have steep slope	Long-eared bat; shorter ear than *M. evotis*; darker fur (brown) than *M. evotis*; no mask; ear tragus is pointy sharp	Roost in tree cavities/bark; other roosts unknown (species not well studied); tend to roost in small groups or solitarily; hibernates
Lasiurus borealis	Eastern red	High frequency (30 – 42 kHz); calls have very shallow slope and often upturned at end	Easily distinguished, even from a distance because of diagnostic fur colour which varies from orange to orange-brown or brick red; hairy tail membrane	Migratory; roosts in foliage of trees; ecology not well studied
Eptesicus fuscus	Big brown	Low frequency (20-30 kHz); variable calls	Brown fur; keel at ankle; larger than *M. lucifugus*; characteristic dog-like face	Roost in tree cavities/bark, rock crevices, buildings; females tend to form small colonies; hibernates
Lasionycteris noctivagans	Silver-haired	Low frequency (20-30 kHz); variable calls, difficult to differentiate from *E. fuscus*	Black or very dark brown fur; generally with silver tipped hairs on back; hairy tail membrane.	Migratory; roosts in tree cavities or under bark; occasionally on outside of buildings (e.g. behind barn doors); solitary or small colonies
Lasiurus cinereus	Hoary	Low frequency (<25 kHz); defining calls are < 20 kHz	Black/grey/dark brown fur with substantial white tipped hairs giving “frosted” appearance; yellow fur around face; hairy tail membrane.	Migratory; roosts exclusively in foliage of trees; solitary

Table 3. Capture and sight data. Location codes are found in Table 1. Reproductive status (Repr. State) is pregnant (P), lactating (L), not reproductive (NR), not scrotal (NS; meaning testes are not enlarged), early scrotal (ES; testes are starting to enlarge) or scrotal (S; testes are enlarged and producing sperm). TC (toothclass; index of relative age) is the relative toothwear of the upper canines on a scale of 1 – 7 where 1 is reserved for sharp teeth of young of the year (Holroyd 1993). Mean FA (forearm) and ear lengths are in mm.

2006 Date	Site	Field Identification	Genetic Species I.D.	Capture Method	Sex	Repr. State	Mean FA (mm)	Mass (g)	Ectoparasites	TC	Ear (mm)
16-Jul	RK2	Unidentified	n/a - escaped	mistnet							
19-Jul	DRHR2	*M. lucifugus*	*M. l. lucifugus*	mistnet	F	P	37.70	10.1	orange ear mites both pinnae	3	
20-Jul	DRFC	*E. fuscus*	n/a	visual							
21-Jul	UPOX2	*M. lucifugus*	*M. l. lucifugus*	mistnet	F	L	37.45	8.2	white mites on wings	3	
21-Jul	UPOX2	*M. lucifugus*	*M. l. lucifugus*	mistnet	F	NR	36.25	8	none	2	
24-Jul	VF4	*M. lucifugus*	*M. l. lucifugus*	mistnet	M	NS	36.67	7.3	none	L3; Rgone	
28-Jul	DMV1	*M. evotis*	*M. evotis***	mistnet	F	NR	36.36	5.7	none	5	17.7
29-Jul	LAF1	*M. lucifugus*	*M. l. lucifugus*	mistnet	M	ES	37.12	8.3	white mites on wings	2	
29-Jul	LAF1	*M. volans*	*M. volans*	mistnet	M	NS	37.12	7.3	white mites on wings	L5;R3	
29-Jul	LAF1	*M. septentrionalis*	*M. septentrionalis*	mistnet	M	NS	35.95	6.9	white mites on wings	2	15.8
29-Jul	LAF1	*M. lucifugus*	*M. l. lucifugus*	mistnet	M	NS	36.62	7.9*	none	2	
29-Jul	LAF1	*M. septentrionalis*	*M. septentrionalis*	mistnet	M	NS	35.55	6.85*	red and white mites on wings	3	14.7
30-Jul	KRS1	*M. septentrionalis*	*M. septentrionalis*	mistnet	M	NS	34.91	6.3	white mites on wings	3	15.5
30-Jul	KRS1	*M. volans*	*M. volans*	mistnet	F	NR	36.45	7.8	red and white mites on wings	L3;L5	
30-Jul	KRS1	*M. volans*	*M. volans*	mistnet	F	NR	37.62	8	orange mites on wing and pinnae	L2;L4	
30-Jul	KRS1	*M. lucifugus*	*M. l. lucifugus*	mistnet	F	P	40.58	9.7	red wing mites	2	
3-Aug	KRST2A	*E. fuscus*	*n/a*	visual							
4-Aug	KRST2B	*M. lucifugus*	*M. l. lucifugus*	mistnet	M	NS	38.05	8.4	none	6	
4-Aug	KRST2B	*M. lucifugus*	*M. l. lucifugus*	mistnet	M	ES	37.18	8.1	none	3	
4-Aug	KRST2B	*M. lucifugus*	*M. l. lucifugus*	mistnet	M	S	37.82	8.1	none	3	

*Bat not held for one hour prior to mass measurement. **The 16S locus cannot resolve *M. evotis* from *M. thysanodes*, *M. keeni*, *M. l. carissima*, however, the range of these other species would not include NWT, and therefore, field I.D. must be used together with genetics for positive I.D.

Table 4. Netting effort. Refer to Table 1 for site abbreviations.

2006 Date	Netting Site	LENGTH OF NETS (m) (2.6 m high): 2.6	6	9	12	18	Time nets open (mins)	Total Area net (m^2)	Netting Effort (m^2*min)	Bats	Approx. Altitude (m)	# of "walls" of net	# of single high nets	Bats in "walls"	Location of majority of nets + other notes
16-Jul	RK2	0	1	0	0	1	135	62.4	8424	1	610	0	2	n/a	Over beaver pond that was >20 m wide)
17-Jul	RK3	0	3	3	2	0	145	179.4	26013	0	610	1	6	0	Along edge and between sink hole ponds; no bats heard
18-Jul	RK2	0	1	0	2	2	135	171.6	23166	0	610	0	5	n/a	over pond that was >20 m wide)
19-Jul	DRHR2	1	0	2	0	0	150	53.56	8034	1	600	0	3	n/a	Along narrow creek.
21-Jul	UPOX2	0	5	3	0	0	165	148.2	24453	2	590	1	6	0	Along narrow creek.
22-Jul	VF2	0	1	5	0	0	150	132.6	19890	0	575	2	2	0	Jutting into and adjacent to large pond.
23-Jul	VF3	0	1	2	3	1	190	202.8	38532	0	575	0	7	n/a	Over and across pond (<20m in most places).
24-Jul	VF4	0	6	1	2	0	205	179.4	36777	1	575	1	7	0	Along narrow creek.
26-Jul	MR2	1	3	2	0	0	180	100.4	18064.8	0	440	0	6	n/a	Along creek (surrounded by vegetation but on fairly open flood plain.)
28-Jul	DMV1	0	0	2	5	2	205	296.4	60762	1	280	3	3	1	Nets surrounding cabin.

29-Jul	LAF1	0	3	3	1	0	255	148.2	37791	5	250	2	3	5	Nets across narrow canyon (<20m wide).
30-Jul	KRS1	0	4	1	0	0	245	85.8	21021	4	245	1	3	3	Across creek and beaver dams.
3-Aug	KRST2A	0	2	0	1	2	130	156	20280	0	750	1	3	0	Valley bottom flyways; frost later in night
4-Aug	KRST2B	0	2	2	2	0	180	140.4	25272	3	750	2	2	3	Rocky flyway between potential rock roosts and Raven Lake; frost later in night
5-Aug	KRST3	0	1	0	3	1	110	156	17160	0	760	0	5	0	Over pond (>20m wide) and across narrow creek; no bats heard
TOTAL:		2	33	26	21	9	2580	2213	385640	18		14	63	12	

Table 5. Comparison of forearm length and mass of captures with B.C. and Alberta bats. Mean values are followed by sample size in parentheses and range below. Adult males and adult females were used in calculations, but pregnant females were not included in mass.

	Present survey		Northern B.C.		Southern B.C.		Southern AB*	
			Bradbury et al. (1997)		Nagorsen & Brigham (1993)		unpublished data, C.L.L.	
Species	Forearm (mm)	Mass (g)	Forearm (mm)	Mass (g)	Forearm (mm)	Mass (g)	Forearm (mm)	Mass (g)
M. lucifugus	37.5 (10)	8.0 (8)	38.0 (186)	8.1 (145)	36.4 (298)	6.2 (98)	38.0 (84)	7.5 (59)
	(36.3 - 40.6)		(30.5 - 40.9)		(33 – 40.3)		(32.0 - 40.0)	
M. evotis	36.6 (1)	5.7 (1)	37.0 (7)	7.7 (7)	38.4 (47)	5.5 (25)	36.9 (117)	6.1 (93)
			(36.2 - 39.2)		(36.0 – 42.0)		(34.5 - 39.8)	
M. septentrionalis	35.5 (3)	6.7 (3)	36.6 (18)	7.3 (14)	36.1 (57)	6.5 (33)	n/a	n/a
	(34.9 - 36.0)		(33.6 - 38.4)		(34.0 – 38.0)			
M. volans	37.1 (3)	7.7 (3)	37.7 (13)	7.7 (11)	38.3 (46)	7.2 (18)	38.5 (28)	7.3 (28)
	(36.4 - 37.6)		(36.6 - 39.2)		(34.0 – 43.0)		(36.5 - 40.2)	

*includes some *M. volans* captures from North Central Montana

Table 6. Acoustic recording during survey. Passes were assigned to High (>30kHz) and Low (<30kHz) frequency acoustic categories. Bats producing high frequency echolocation include: *Myotis lucifugus*, *M. volans*, *Lasiurus borealis*, and the long-eared species *M. septentrionalis*, and *M. evotis*. Low frequency echolocation is produced by *Eptesicus fuscus*, *Lasionycteris noctivagans*, and *Lasiurus cinereus.* Refer to Table 1 for site abbreviations.

			MONITORING					
2006 Date	Site	Anabat Unit	% of night	mins.	Temperature Reading	High Frequency Passes	Low Frequency Passes	Total Bat Passes
16-Jul	RK1	1	100	140	13^{o}C at 2:30	12	0	12
17-Jul	RK1	1	100	140	15^{o}C at 1:30	3	0	3
18-Jul	RK1	1	100	140	10^{o}C at 2:20	20	0	20
18-Jul	RK2	2	100	140	10^{o}C at 2:20	182	0	182
19-Jul	DRHR1	1	100	150	12^{o}C at 3:45	1	0	1
19-Jul	DRHR2	2	87	131	12^{o}C at 3:45	0	0	0
20-Jul	DRFC	2	84	126	not taken	1	0	1
21-Jul	UP0X1	1	100	160	14^{o}C at 2:10	0	0	0
21-Jul	UPOX2	2	100	160	14^{o}C at 2:10	2	0	2
22-Jul	VF1	1	100	180	10.5^{o}C at 2:30	18	0	18
22-Jul	VF2	2	100	180	10.5^{o}C at 2:30	18	0	18
23-Jul	VF1	1	100	200	13^{o}C at 3:00	12	0	12
23-Jul	VF3	2	100	200	13^{o}C at 3:00	54	0	54
24-Jul	VF1	1	100	220	15^{o}C at 0:20	28	0	28
24-Jul	VF4	2	97	213	15^{o}C at 0:20	32	0	32
26-Jul	MR1	1	100	230	15^{o}C at 1:00; 8^{o}C at 3:35	1	0	1
26-Jul	MR2	2	100	230	15^{o}C at 1:00; 8^{o}C at 3:35	1	8	9
27-Jul	GT1	1	100	235	15^{o}C at 0:15	2	0	2
27-Jul	GT2	2	100	235	15^{o}C at 0:15	5	0	5
28-Jul	DMV1	1	70	165	10^{o}C at 1:00	15	0	15
28-Jul	DMV1	2	100	235	10^{o}C at 1:00	3	1	4
29-Jul	LAF1	1	98	250	12^{o}C at 2:00	24	1	25
29-Jul	LAF2	2	100	255	12^{o}C at 2:00	80	0	80
30-Jul	KRS1	1	100	255	10^{o}C at 1:50	35	2	37
30-Jul	KRS2	2	72	183	10^{o}C at 1:50	46	11	57

			MONITORING					
2006 Date	Site	Anabat Unit	% of night	mins.	Temperature Reading	High Frequency Passes	Low Frequency Passes	Total Bat Passes
31-Jul	SPL1	2	100	255	not taken	13	2	15
3-Aug	KRST1	1	100	310	8°C at 0:00; 3°C 0:35; -2°C at 2:00	0	0	0
3-Aug	KRST2A	2	100	310	8°C at 0:00; 3°C 0:35; -2°C at 2:00	0	0	0
4-Aug	KRST1	1	100	310	8°C at 0:40; 3.5°C at 2:15; frost overnight	0	0	0
4-Aug	KRST2B	2	100	310	8°C at 0:40; 3.5°C at 2:15; frost overnight	12	18	30
5-Aug	KRST4	1	100	310	not present at site	3	0	3
5-Aug	KRST3	2	100	310	5°C at 1:30; frost overnight	4	0	4
			TOTAL:	**6868**		**627**	**43**	**670**

Table 7. Summary of bat species at each sampling area in NNPR

General Sampling Area in NNPR	Sites Sampled	Bat species present
Rabbitkettle (RK)	RK1, RK2	*M. lucifugus/volans*, *M. septentrionalis* (possibly *L. cinereus* and *M. evotis*)
Creek draining into Channel downriver of RK before Hell Roaring	DRHR1, DRHR2	*M. lucifugus* (possibly *M. volans*)
Flood Plain downriver of Flood Creek on River Left	DRFC	*M. lucifugus/volans*, *E. fuscus*
River R Channel and Creek upriver of Oxbow Lake	UPOX1, UPOX2	*M. lucifugus*, *L. borealis* (possibly *M. volans*)
Virginia Falls/Sunblood	VF1, VF2, VF3, VF4	*M. lucifugus*, *M. evotis, M. septentrionalis, L. borealis* (possibly *M. volans*)
Mary River	MR1, MR2	*E. fuscus/L. noctivagans, M. evotis/septentrionalis, L. cinereus*
The Gate	GT1, GT2	*M. lucifugus/volans, M. septentrionalis, M. evotis*
Deadmen Valley Warden Station	DMV1	*M. lucifugus/volans, E. fuscus/L. noctivagans, M. evotis*
Lafferty Canyon	LAF1, LAF2	*M. lucifugus, M. septentrionalis, M. volans, M. evotis, E. fuscus/L. noctivagans*
Kraus Hot Springs Large Pool behind cabin	KRS1, KRS2	*M. septentrionalis, M. lucifugus, M. volans, M. evotis, E. fuscus/L. noctivagans*

Table 8. Capture and acoustic data collected outside of the South Nahanni Ecosystem. Passes were assigned to High (>30kHz) and Low (<30kHz) frequency acoustic categories. Bats producing high frequency echolocation include: *Myotis lucifugus*, *M. volans*, *Lasiurus borealis*, and the long-eared species *M. septentrionalis*, and *M. evotis*. Low frequency echolocation is produced by *Eptesicus fuscus*, *Lasionycteris noctivagans*, and *Lasiurus cinereus*. No passes resembling *L. borealis* calls were detected, suggesting all high frequency passes were Myotis species; steep sloped calls were recorded suggesting long-eared myotis were present. The only low frequency pass recorded was <20kHz, allowing this bat to be positively identified as *L. cinereus*.

A. Acoustic Data

2006 Date	Site	Location on Fig. 1 Map	MONITORING % of night	MONITORING mins.	Weather	High Frequency Passes	Low Frequency Passes	Total Bat Passes
1-Aug	Ft. Simpson Campground	15	100	330	warm, overcast, calm	1	0	1
5-Aug	Ft. Simpson Snye	15	100	330	periodic rain storms	3	0	3
6-Aug	Ft. Simpson Snye	15	100	330	heavy rain	0	0	0
7-Aug	Ft. Simpson Snye	15	100	330	periodic rain storms	4	0	4
8-Aug	Ft. Simpson Snye	15	100	330	periodic rain storms	29	1	30
9-Aug	Ft. Simpson Snye	15	100	330	periodic rain storms	2	0	2
10-Aug	Trout River	16	75	225	calm, full moon	5	0	5
					TOTAL:	44	1	45

B. Capture Data

Date	Location	Species	Capture Method	Sex	Reproductive Status	Epiphyseal Gap of Metacarpal Joint	Forearm Length (mm)
8-Aug-06	Ft. Simpson: Jen Simon's house, Wild Rose Acres	*M. lucifugus*	killed by cat	Female	volant juvenile	Top Gap = 0.5 mm Bottom Gap = 0.5 mm	39.30

APPENDIX A

Incidental bird captures or sightings during survey. Refer to Table 1 for site abbreviations and coordinates.

Date	Site	Method of Sighting	Identification	Notes
21-Jul-06	DRFC	heard call	Northern Saw-whet owl	Very clear distinct call heard (however, this area is out of the known range for this bird)
23-Jul-06	VF3	Capture in mistnet	Nighthawk	
24-Jul-06	VF4	Capture in mistnet	Hermit Thrush	
24-Jul-06	VF4	Capture in mistnet	Dark-eyed Junco	Slate variety
3-Aug-06	KRST2A	Capture in mistnet	Wood Peewee or Flycatcher?	Presence of eye-ring not recorded; 2 light wing bars on top, with slight orange wing bar underneath
3-Aug-06	KRST2A	Capture in mistnet	Unidentified sparrow	
4-Aug-06	KRST2A	Capture in mistnet	Wood Peewee or Flycatcher?	Presence of eye-ring not recorded; 2 light wing bars on top, with slight orange wing bar underneath
5-Aug-06	KRST3	2 close-up sightings while it was hunting a sandpiper	Peregrine Falcon	Pair sighted; very vocal; nest not seen; kill of sandpiper witnessed
5-Aug-06	KRST3	Capture in mistnet	Solitary Sandpiper	Net opened at dark but birds flying much later than anticipated
5-Aug-06	KRST3	Capture in mistnet	Pipit	Yellow legs and heavily striped suggests Sprague's but out of range; flew like juvenile, so possibly young American Pipit
5-Aug-06	KRST3	Capture in mistnet	Yellow-rumped warbler	Immature