BATS OF SOUTHERN WYOMING: DISTRIBUTION & MIGRATION

YEAR 3 REPORT

2013

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Suggested Citation: Abernethy, I.M., M.D. Andersen, and D.A. Keinath. 2014. Bats of southern Wyoming: distribution and migration year 3 report. Prepared for the USDI Bureau of Land Management by the Wyoming Natural Diversity Database, University of Wyoming, Laramie, Wyoming.

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EXECUTIVE SUMMARY

Distributions and habitat associations of bats in Wyoming are poorly understood. Wind energy development is an existing and growing aspect of Wyoming's energy economy and land use. These activities also represent a threat to resident and migratory bat species. As part of the third year of a multi-year research project, we conducted bat surveys throughout southern Wyoming to better understand species composition, distribution, habitat associations, and migration in south central Wyoming. Evidence from previous studies suggests that placement of wind turbines away from bat habitat and movement corridors may limit negative impacts to bat populations. Our study area in 2013 encompassed a large portion of southern Wyoming and corresponded roughly with the administrative boundaries of the Rawlins Field Office and Rock Springs Field Office of the BLM. Because this area encompassed approximately 48,000 km^2, we focused survey effort first on areas of management interest identified by the BLM, and secondly on areas with few or no occurrence data (Figure 1). The primary goal of this project is to better understand distribution and migration of bats in relation to potential wind energy development facilities. In turn, land managers can then make better informed management decisions when evaluating potential impacts to local bat populations and migrating bats when citing wind energy development. Specific objectives for this multi-year project included:

1. Inventory bats occurring in and near areas with potential for establishment of wind-energy facilities. (Primary Objective)
2. Validate and improve distribution maps of bat species in southern Wyoming. (Primary Objective)
3. Identify potential zones of conflict between wind-energy facilities and areas of bat use. (Primary Objective)
4. Identify areas that are likely to be of particularly high importance for bats. (Secondary Objective)
5. Document evidence of White-nose Syndrome in Wyoming. (Secondary Objective)

In 2013, we conducted 44 mist net surveys and 188 acoustic surveys. Mist net activities resulted in 65 occurrences from captures and acoustic detections representing 10 species, while acoustic surveys identified 266 species occurrences representing the same 10 species (Tables 1 and 2). Mist net captures comprised 88 females and 121 males (Table 3). Sex ratios of Little Brown Myotis and Long-legged Myotis were slightly skewed towards females. For most species, we observed females in reproductive condition including: Hoary Bat, Little Brown Myotis, Western Long-eared Myotis, Long-legged Myotis, Townsend's Big-eared Bat, Western Small-footed Myotis, and California Myotis. We captured juvenile individuals of Little Brown Myotis and Long-legged Myotis (Table 3). Reproductively active females and juvenile bats were most prevalent in areas at lower elevations with permanent water sources and abundant suitable roosts. In particular, the foothills of the Wind River and Wyoming Ranges, Seedskadee National Wildlife Refuge, and the Little Mountain and Pine Mountain areas may be important maternity areas for these species. A more formal evaluation identifying suitable roosting areas would be useful for management of bats in Wyoming. Possible approaches are to identify specific locations of maternity roosts by radio tagging reproductively active female bats and tracking them to day roosts or by modeling suitable roosting habitat across the study area.

Analyses of species presence relative to habitat types at survey locations suggest that habitat associations of bats in the study area roughly correspond with our expectations (Table 4; Figure 2). For example, Big Brown Bat was associated with forested habitats where the species is known to roost and riparian habitats where the species is known to forage. However, we observed some discrepancies with our current understanding of habitat associations, which points to our limited understanding of bats in southern Wyoming. For example, Long-legged Myotis is commonly associated with forested habitat, but our results suggest that the species was not associated with forested habitats in our study area. Rather they were frequently documented in shrubland habitats within one nights travel distance to forested habitats. Our analyses revealed significant habitat associations for six species: Pallid Bat, Townsend's Big-eared

Bat, Big Brown Bat, California Myotis, Fringed Myotis, and Long-legged Myotis (Table 4). Tests for other species were not statistically significant, although weak positive or negative relationships between species presence and single habitat types were observed (Table 4). Specifically, California Myotis and Silver-haired Bat were negatively associated with shrub steppe habitats. Little Brown Myotis and Silver-haired Bat were detected in riparian habitats more than expected based on availability across survey sites (Table 4). Proportions of habitats observed at mist net and acoustic survey sites can be found in Figure 2.

We field validated summer distribution models created by Abernethy et al. (2012), which can be obtained by contacting the authors of this report. Validation of summer distribution models indicates varied performance. Models for Big Brown Bat, Long-legged Myotis, Pallid Bat, and Little Brown Myotis predicated presence very well. Models for Long-eared Myotis and Western Small-footed Myotis did not predict presence adequately (Figures 3 – 10). Importantly, model errors were usually in moderate and low probability classes, and most models accurately predicted high-probability areas. This indicates that areas identified by models as having high probability of bat occurrence can be effectively used by mangers to highlight important bat areas. Many of the model errors were false negatives (i.e., bats were found in areas where the models predicted them to be absent, which is likely due to key shortcomings of common methods used to survey for bats. Specifically, all standard bat survey methods are plagued by imperfect detection (i.e., a species is not always detected in a single night of sampling even though it is present at a site). To overcome this, in 2014, we will structure our sampling effort so that we can estimate detection probabilities. As a result, we will be able to estimate the probability of a bat species occupying a site even if it was not detected and this can be used to improve habitat and distribution analyses. Occurrence data from the WYNDD database and additional information from northeastern Wyoming collected in 2014 will be used to generate new distribution models encompassing all of Wyoming. This will allow us to use a larger dataset collected over a longer time span. We will also extrapolate migration stopover habitat models to encompass all of Wyoming. Updated models will appear as an addendum to this report published by the end of 2014.

Migratory stopover habitat models created by Griscom et al. (2012) suggest that that portions of southern and eastern Wyoming slated for wind energy development are likely to overlap with areas used by migrating bats. In particular, White Mountain north of Rock Springs and the foothills of the Sierra Madre Range south of Rawlins have been proposed for wind energy development and correspond with areas predicted to be used by migrating bats. We field validated these migration models with data collected in 2013, but we recorded few occurrences of bats during the migration season, which limited our ability to assess migratory stopover habitat models (Figures 11 and 12). The low migratory detection rate was likely caused by temporal variation in migration, which is dictated by factors such as weather events and prey abundance that cannot be readily predicted. These factors may result in discrete movement events where relatively large numbers of bats move through an area in a short period of time (Arnett et al. 2008).

White-nose Syndrome (WNS) is a disease that has caused significant declines in bat populations in eastern North America. The disease has spread great distances since first observed in 2006 and may eventually affect the entire content, including Wyoming. Examination of the membranes of both wings and uropatagium of bats captured in 2013 did not reveal any evidence of WNS.

Other products presented in this report include a map of focal areas and survey locations (Figure 1), raw occurrence and capture data (Appendices 1 and 2), and species keys (Appendices 3 and 4). This report summarizes efforts for the third year of an ongoing study. Survey efforts in 2014 will follow similar survey methods, but will take place primarily in northeastern Wyoming and focus on the Northern Long-eared Myotis (*Myotis septentrionalis*). Surveys will attempt to identify important habitat features for this species, but will document occurrences of all bats. This information will be used to improve our understanding of Northern Myotis in Wyoming as well as the habitat, distribution and migration models presented herein.

INTRODUCTION

Bats are an important component of ecosystems worldwide. They are integral pollinators and seed-dispersers for many plant species. Bats also consume large quantities of insects, many of which cause significant agricultural losses and threaten human health (Kunz and Parsons 2009). It is estimated that in North America alone, bats prevent $3.7 billion in damage to agricultural resources each year (Boyles et al. 2011). Unfortunately, many bat species have undergone large population declines and are faced with increasing risks of extinction. For example, of the 47 bat species known to occur in the United States, six are currently listed as “Endangered” under the Endangered Species Act (ESA) and at least three others are under active petitions for ESA protections (Harvey et al. 2011, United States Fish and Wildlife Service 2011). Observed population declines across the globe have many causes including habitat loss and alteration, disease, and renewable energy development.

Wind energy is a rapidly expanding form of energy production. As with other forms of renewable energy, generating electricity in this fashion is attractive primarily because it does not produce carbon emissions that contribute to climate change. However, increased wind energy development has been cited as a current and growing threat to bat populations worldwide. Bat fatalities at wind facilities were first observed in the early 1990s. Since this time, research has recorded bat deaths at most wind farms with high fatality rates at some wind facilities (Arnett et al. 2008).

Increasingly, wind resources have been sought out in Wyoming. As of 2013, 1,410 Megawatts of electricity could be generated from existing infrastructure. Existing proposals would allow for approximately five times this production (5,742 MW) (American Wind Energy Association 2013) . Furthermore, as of 2012, wind projects in Wyoming covered 116,300 acres while proposed wind projects would occupy an estimated additional 510,505 acres (Jakle 2012). Within Wyoming, the south-central portion of the state has particularly good wind-energy potential and several large wind energy facilities currently exist, with more slated for development in the near future.

Observations of bat mortalities at wind energy sites have led to increased funding for research to identify mitigation measures that reduce the impacts of wind energy to bats. One promising line of research indicates that minor modifications to turbine operations, such as shutting down rotors on low wind speed nights during bat migration may reduce the number of bats killed at wind energy facilities (Arnett et al. 2008). An alternative line of research has focused on the location of wind turbines in relation to bat habitat. Although results vary across studies, some have shown that fatalities can be reduced by placing turbines in locations where fewer bats are likely to come into contact with them (Baerwald and Barclay 2009). This is the focus of our research. Our aim is to better understand bat distribution and migration in southern Wyoming. This will allow us to model these aspects of bat ecology in relation to areas with high wind energy potential. These tools will be available to managers and planners seeking ways to mitigate the impact of wind energy on bats. Eventually, we would like to provide these data for all of Wyoming. Planning future wind energy development based on the premise that specific locations may result in reduced mortalities requires an extensive knowledge of local bat distributions. Unfortunately, little is known about bat distribution and habitat use in southern Wyoming. This can largely be attributed to a lack of systematic survey effort. Additionally, it was thought that the basins of Wyoming support few species and low densities of bats. Recent distribution maps produced by the Wyoming Natural Diversity Database (WYNDD) have provided a much-needed tool for bat management (Keinath et al. 2010). These tools also highlight the paucity of bat occurrences available for generating these maps and the resulting uncertainty associated with them. In light of increasing wind energy development in the region, this gap in our understanding of where bats occur and how they use the landscape has become particularly problematic, especially for land managers, including the Bureau of Land Management (BLM), the principle manager of public land in southern Wyoming.

Bats display varied life history traits. Evidence suggests that specific life history traits make certain bat species more vulnerable to wind energy development. Generally, migratory species make up a large proportion of bat fatalities at wind facilities across the United States (Arnett et al. 2008). However, resident bat species are affected as well (Jain et al. 2011). In addition to direct effects (i.e. mortality), there are also indirect effects associated with wind turbines. Specifically, wind energy development has the potential to fragment habitats, limiting the ability of bats to move across the landscape. These indirect effects are poorly understood at this time. Because direct and indirect effects likely impact both resident and migrant bat species, we modeled the distribution of resident bats during the summer season and have tested models of stopover habitat of migratory bats created by Griscom et al. (2012).

Predictive modeling of species distributions has become a common and important tool for biologists and land managers (Phillips et al. 2006, Elith et al. 2011). Species distribution models are created by evaluating the relationships between species occurrences and remotely sensed environmental and spatial characteristics of the occurrence locations (Elith et al. 2011). MaxEnt (Phillips et al. 2006) is a commonly used program for modeling species distributions and is well suited for modeling distributions of bats because most common bat survey techniques generally produce presence-only occurrence data.

Another emerging issue for bats in North American is White-nose Syndrome (WNS). The disease is caused by the fungal pathogen *Geomyces destructans* and affects hibernating bats (Lorch et al. 2011). The disease was first noted in New York in 2006. Since that time, an estimated 5.7 million bats have died from WNS (Bat Conservation International 2013). In affected areas, mortality rates of up to 100% have been documented (Frick et al. 2010). The disease continues to spread across the eastern and southeastern US and has been detected as far west as Oklahoma. To date, bats in western North American have not been affected. It is thought that WNS may eventually occur across North America but it is unknown if the disease will affect bats in warmer or drier climates that occur in the western United States to the degree it has in eastern North America. Our work also serves to provide a baseline for bat health as well as to monitor for signs of WNS in Wyoming. Early detection of the disease may help to reduce the scale of effects and transmission in the state (Abel and Grenier 2011).

In order to provide land managers a better understanding of bat distributions and habitat associations in southern Wyoming, we conducted an extensive inventory of bats and their habitats during the summer of 2013. We were able to build upon work conducted in 2011 and 2012 by continuing bat surveys in areas of management interest and in areas with limited bat occurrence data. These data also allowed us to validate distribution and migration models, and refine models to aid in land management decisions regarding bats in Wyoming.

Study Objectives

Funding for this project was provided by the Wyoming Office of the BLM. All reports, maps, and data will be freely available to the public. This work will provide information allowing the BLM to fulfill multiple-use mandates on lands it manages as well provide data aiding in land management and resource development decisions the agency is responsible for. This report details the results of the second year of a multi-year research effort. Objectives of this multi-year research effort are:

1. **Inventory bats occurring in and near areas with potential for establishment of wind-energy facilities.**
2. **Validate and improve distribution maps of bat species in southern Wyoming.**
3. **Identify potential zones of conflict between wind-energy facilities and areas of bat use.**
4. **Identify areas that are likely to be of particularly high importance for bats, such as those proximate to maternity colonies or with high species diversity.**
5. **Document evidence of White-nose Syndrome in Wyoming.**

METHODS

Field Surveys

Our study area in 2013 encompassed a large portion of southern Wyoming and corresponded roughly with the administrative boundaries of the Rawlins Field Office and Rock Springs Field Office of the BLM (Figure 1). Because this area encompassed approximately 48,000 km^2, we focused survey effort first on areas of management interest identified by the BLM, and secondly on areas with few or no occurrence data. Areas of interest highlighted by the BLM included portions of the Green River Basin between the towns of Green River, Wyoming and Big Piney, Wyoming (1), The Big Sandy River drainage between Farson, Wyoming and the Wind River Mountains (2), and the Bitter Creek drainage in central Sweetwater County (3; Figure 1). Portions of the study area that lacked occurrence data included the Little Mountain and Pine Mountain area in extreme southern Sweetwater County (4) and west of Flaming Gorge Reservoir (5; Figure 1). We focused on lower elevation basin and foothills sites for two reasons. First, these areas are typically managed by the BLM and second, higher elevation forested sites within the study area were surveyed by the Wyoming Game and Fish Department in 2011 (Wyoming Game and Fish Department 2012) .

We trained and deployed two crews of two people each from July 1 to September 25, 2013. Crews conducted two types of surveys: active mist-netting and passive acoustic monitoring. Capturing live bats with mist nets allowed us to verify species presence, inspect individuals for disease, assess physical condition, and collect demographic information. Passive surveys allowed us to efficiently collect species presence information from multiple sites each night.

Mist Net Surveys

Potential mist net sites were identified using aerial imagery from the 2012 National Agriculture Imagery Program (United States Department of Agriculture Farm Service Agency Aerial Photography Field Office 2012)). Potential sites included small reservoirs, natural ponds, streams, rivers, and springs that could be identified from NAIP imagery. While in the field, surveyors evaluated potential sites and conducted a mist net survey at appropriate sites.

At suitable mist net sites, combinations of 6, 9, 12, and 18 m mist nets[1] were suspended over water between aluminum poles in single-high arrangements to catch bats while feeding or drinking. Mist nets were opened at civil sunset unless nontarget taxa (e.g. birds) were active at the site. In this case, nets were opened as soon as bird activity ceased. Nets were checked for captures at least every 15 minutes and captures were removed from nets immediately to minimize injury, drowning, strangulation, or stress associated with being in the net. Experienced and well trained surveyors removed bats from nets with great care to protect wing bones and patagia. If large numbers of bats were captured, nets were closed to ensure that all captures were removed from nets, processed and released within 30 minutes of capture. Nets were not set in high winds or temperatures below 40ºF to minimize bat stress and injury. If these conditions occurred during a survey, the survey was discontinued. Once removed from the net captures were placed in a cloth bag for transport and processing to minimize stress. Captured bats were measured (forearm length, ear length), weighed, sexed, aged, identified to species, photographed, and released on site.

Additionally, the membranes of both wings and the uropatagium of each captured bat were inspected following the methods presented by Reichard and Kunz (2009). After each survey, we decontaminated all survey equipment and supplies following the National White-Nose Syndrome Decontamination Protocol Version 06.25.2012 (2012). We also followed all guidelines laid out in the Wyoming White-Nose Strategic Plan (Abel and Grenier 2011).

At each mist net survey site, acoustic monitoring equipment was also deployed to detect any additional bat species present but not captured in nets. Acoustic monitoring equipment at mist net sites included an

[1] Avinet bat-specific mist nets, 38mm mesh, black polyester, Dryden, NY, www.Avinet.com

Anabat II detector connected to an Anabat Storage ZCAIM[2] and an Echo Meter 3[3] detector. Anabat recordings were analyzed in Analook W[4] viewing software while Echo Meter 3 recordings were analyzed using SonoBat 3 Wyoming Species Package[5] (details in Acoustic Surveys section below).

Acoustic Surveys

Acoustic surveys were conducted using Wildlife Acoustics Song Meter SM2BAT and SM2BAT+[6] full-spectrum recording equipment. Units were programed to begin recording one half hour before civil sunset and to stop recording one half hour after civil sunrise. On each recorder, one SMX-US[7] ultrasonic microphone was attached to a 3 m cable and placed between 1 m and 2 m above the ground. All calls were analyzed using the Sonobatch automated call analysis algorithm in the SonoBat 3 Wyoming Species Package. We used an acceptable call quality threshold of 0.70 and a discriminate probability threshold of 0.80.

Acoustic surveys were designed to explicitly test summer distribution models developed by Abernethy et al. (2012) and fall stop-over habitat migration models developed by Griscom et al. (2012). To test the summer distribution models, sites were selected in a stratified random fashion in a Geographic Information System using the predicted species richness map produced by Abernethy et al. (2012). . Within each 10-digit Hydrologic Unit (HUC) in the study area, 5 sites that were within a raster cell with a predicted species richness value of 0, 1-3, 4-6, 7-8, and 9 were randomly placed (total of 25 random sites per HUC). In the field, surveyors placed one detector at the randomly selected point and one detector an easily accessible location at least 1 km away at a location with a different predicted species richness level for one night. This procedure was repeated each night so that each species richness category had been sampled an approximately even number of times within each HUC and throughout the field season. To test the fall stop-over habitat models, a buffer with a 2.5 mile radius was placed around each location where a summer distribution acoustic survey had been conducted. Within this buffer, four points were randomly placed at least 1 km apart in raster cells that had a predicted probability of migratory species presence of 0, 0.01-0.25, 0.26-0.50 or 0.50-1. A detector was placed at each of these four points for one night. We chose this clustered sampling strategy in an attempt to account for spatial, temporal, and habitat effects.

Habitat Associations of Bat Species

Chi-square analysis is an appropriate tool for handling categorical data such as habitat type and was used to evaluate possible habitat relationships from 2013 field surveys. This analysis was intended to look for positive or negative relationships between species and habitat types. The test was conducted by comparing the prevalence of habitat types (Wyoming Game and Fish Department 2010) at all sites sampled to the prevalence of that type where the target species was found. All habitat types were compared for all species. The Chi-square value for each comparison was used to determine if there was a positive or negative relationship between the species and the habitat type at the 95% confidence level.

Summer Distribution and Migratory Stopover and Foraging Habitat Models

Models, methods used to generate models, and discussion of models will appear as an addendum to this report submitted late summer or fall of 2014.

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[2] Anabat SD1 Bat Detector and Anabat Storage ZCAIM, Columbia, MO, www.titley-scientific.com

[3] Echo Meter 3 Active ultrasonic monitoring unit, Concord, MA, www.wildlifeacoustics.com

[4] Analook W viewing software for Anabat files, www.users.lmi.net/corben/Beta (Corbin 2011)

[5] SonoBat 3, Wyoming species package, Arcata, CA, www.sonobat.com (Szewczak 2011)

[6] Song Meter SM2Bat+ ultrasonic monitoring unit, Concord, MA, www.wildlifeacoustics.com

[7] SMX-US ultrasonic microphone, Concord, MA, www.wildlifeacoustics.com

Distribution and Migration Model Validation

Model Validation Analyses

We used the field data collected in the 2013 field season to test predictions made by the summer distribution and models generated in 2013. To evaluate the migratory stopover habitat models, we combined 2013 field data with data from previous field seasons. Summer and migration seasons were not defined explicitly by Griscom et al. (2012). To better reflect temporal differences in distribution and habitat use, we have limited data included in the analyses of summer distribution to occurrences documented between June 1 and August 31 for non-migratory species and between June 1 and August 15 for migratory species (Hoary Bat and Silver-haired Bat). We were limited by small sample size for some species and only present an evaluation for species with 10 or more presence locations. For analysis of the migration models, occurrences documented between August 15 and September 30 were included. . For both summer and fall models, we plotted the proportion of sites that had detections against the model predictions associated with the site, to provide an indication of model fit. For summer models, we also produced Receiver Operator Characteristic (ROC) plots to indicate the difference in model performance measures between the training data used to generate models and 2013 field data (also referred to as test data throughout), to indicate the level of overfitting in the models and to provide an Area Under Curve (AUC) value as an overall indication of model quality (Fielding and Bell 1997).

RESULTS

Mist Net and Acoustic Surveys

Mist Net Surveys

In 2013, we conducted 44 nights of mist netting. We captured 209 bats representing 10 species (Tables 2 and 3). The most commonly captured species was the Long-legged Myotis, comprising 28.2% of all captures. Other commonly captured species included the Western Long-eared Myotis, Western Small-footed Myotis, and the Little Brown Myotis, making up 12.9%, 12.9%, and 11.9% respectively of all captures. Overall, sex ratios were skewed towards males (122 males: 87 females). We captured more female Little Brown Myotis and Long-legged Myotis than males (Table 3). We captured juvenile individuals of two species (Table 3), with no juveniles being captured before August 7, 2013. Examination of membranes of both wings and the uropatagium did not reveal any evidence of WNS. In addition to captures, a total of 34 nights of acoustic data were collected at mist net sites (Table 1). This accounted for a total of 59 bat occurrences. Of these, 40 occurrences (11 from Anabat recordings and 29 from EM3recordings) would not have been detected via mist net captures alone.

Acoustic Surveys

A total of 188 acoustic surveys were conducted in 2013. From these, 266 species occurrences representing 10 species were documented (Tables 1 and 2). The most frequently detected species was the Western Small-footed Myotis, followed by the Western Long-eared Myotis and Little Brown Myotis (Table 2). Only one species, Pallid Bat, was documented from acoustic recordings alone in 2013.

Habitat Analyses

Chi-square analyses of species presence relative to habitat types revealed significant results for six species: Pallid Bat, Townsend's Big-eared Bat, Big Brown Bat, California Myotis, Fringed Myotis, and Long-legged Myotis (Table 4). A marginally significant result was seen for Silver-haired Bat. While tests for other species were not statistically significant, weak positive or negative relationships between species presence and single habitat types were observed (Table 4). Specifically, California Myotis and Silver-haired Bat were negatively associated with shrub steppe habitats. Little Brown Myotis and Silver-haired

Bat were detected in riparian habitats more than expected (Table 4). Proportions of habitats observed at mist net and acoustic survey sites can be found in Figure 2.

Validation of Summer Distribution and Migration Stop-over Habitat Models

We had sufficient observations to evaluate summer distribution models for eight species (Table 5). ROC plots provide a threshold-independent evaluation of model quality, and illustrate the difference between performance on training data (model fit) and performance on independent test data (model accuracy; Figures 3 - 10). AUC values suggest that the best-performing models were those for Big Brown Bat, Long-legged Myotis, Pallid Bat, and Little Brown Myotis (Table 5). The summer model for Long-eared Myotis was the worst-performing, with an AUC that was not significantly different from a random prediction. The largest differences in values between training and test AUC were for Long-eared Myotis and Western Small-footed Myotis. Large differences between training and test AUC suggest that a model was overfit to training data, while smaller differences between training and test AUC suggest that a model is able to predict presence/absence well in a new location. Although these summary statistics suggest relatively poor predictive power for most models, it is likely that they substantially underestimate model quality, for a number of reasons (see Discussion section).
Bubble plots provide another threshold-independent indication of model quality by plotting the proportion of sites with detections as a function of the predicted probability assigned to the site by the model (Figures 3 – 10). A perfect model would be one in which there is a linear, one-to-one relationship between predicted probability and proportion of sites occupied. However, a model that exhibits a monotonic relationship between these values (i.e., the proportion of sites occupied increases as predicted probability increases, though not necessarily in a linear fashion) is still useful in mapping relative probabilities of occurrence and indicating the areas that are most and least likely to be occupied by a species. Plots for Big Brown Bat (Figure 4) and Little Brown Myotis (Figure 9) show the strongest monotonic relationship between predicted probability and proportion of sites occupied. This suggests that the model works reasonably well across a range of predicted probabilities. Bubble plots for other species display patterns that are less clear, suggesting that models may perform poorly within certain ranges of predicted probability. As with the ROC plots and the associated AUC values, these plots should be interpreted with some caution, as they may also substantially underestimate the performance of the models (see Discussion section).

The threshold-independent evaluation metrics presented above are generally more useful in evaluating presence-only distribution models than are statistics based on binary, presence/absence expressions of the model. However, we also present sensitivity, specificity, and confusion matrices for the binary (presence/absence) version of each model as another indication of overall model quality (Table 6). Model sensitivity and specificity measure the percent of validation presences and absences, respectively that are correctly classified. Sensitivity and specificity for the models were quite variable among species (Table 6). Sensitivity was relatively high for Pallid Bat and Big Brown Bat models, suggesting that the binary versions of the models are less likely to miss occupied areas, relative to models for Silver-haired Bat, Long-eared Myotis, Little Brown Myotis, Hoary Bat, and Long-legged Myotis. The binary version of the model for Western Small-footed Myotis appears to omit a relatively high proportion of the species' distribution, and should therefore be used with caution. Conversely, the binary models for Long-legged Myotis and Little Brown Myotis had the highest specificity, meaning that they are the less likely to over-predict occurrence than models for Long-eared Myotis and Silver-haired Bat, which have much lower specificity.

We had relatively few observations of migratory bats during the migration season. As a result inferences about migratory model quality are limited. The bubble plots showing the relationship between predicted probability and proportion of sites occupied suggests poor accuracy and goodness-of-fit for the models of Hoary Bat and Silver-haired Bat (Figures 11 and 12). Although these deductive models provided a working hypothesis for migratory distribution of the two species, the data we have collected during surveys in recent years suggest that the models do not provide an accurate representation of migration for the species.

DISCUSSION

Mist net surveys in 2013 were quite successful, accounting for approximately 32% of occurrences. As opposed to many bat surveys conducted in the region and in Wyoming that have shown Little Brown Myotis to be the most frequently observed species (Griscom and Keinath 2011, Griscom et al. 2012), our most frequently captured species was the Long-legged Myotis. This is fairly surprising given that much of our survey effort took place in relatively dry, treeless habitats where Long-legged Myotis would not be expected to occur. Observations of Long-legged Myotis typically occurred in areas in the vicinity of forested habitats such as in the Little Mountain and Pine Mountain areas. This unexpected result and relatively high number of captures of other bat species associated with dry shrubland habitats (e.g. Western Small-footed Myotis and Pallid Bat among others) highlights the importance of continued species inventories in areas and habitats that have received little survey effort.

Another interesting and important finding from mist net surveys was the presence of reproductively active females and juvenile individuals (Table 3), indicating that we sampled in areas where offspring are raised. We captured far fewer juvenile individuals in 2013 than in 2012. We captured numerous pregnant, lactating, or post-lactating females. The discrepancy between the observations of reproductively active female bats but few juvenile bats may result from several different circumstances. We may have sampled in areas unsuitable for raising offspring later in the summer. Alternatively, little precipitation fell within the study area in 2013. This may have resulted in few juvenile bats surviving until they were volant. It is extremely important to understand where female bats raise their young. While pregnant and while raising offspring, female bats select very specific roosting habitats (Adams 2003, Harvey et al. 2011) and females of many bat species congregate in maternity colonies that represent a very important component of the local bat community (Adams 2003). Furthermore, bats have extraordinarily low fecundity, with most species raising only one pup per year (Harvey et al. 2011). In the context of wind energy development, it is important to identify areas where female bats raise young. A logical next step would be to identify the specific locations of maternity roosts that are being used in these areas. This could be accomplished by radio tagging reproductively active female bats and tracking them to day roosts or by trying to model suitable roosting habitat across the study area.

Acoustic surveys continue to be a very efficient survey method, accounting for 68% of occurrences in 2013. We observed a lower number of detections per night than Griscom et al. (2012) in 2011, but a similar number of detections observed in 2012 (Abernethy et al. 2012). This is likely because Griscom et al. (2012) frequently placed acoustic recorders in areas that were predicted to have high bat activity (e.g. riparian corridors) while in 2012 and 2013, we placed acoustic recorders in stratified random manner in order to validate distribution models, which necessarily included areas with low likelihoods of being used by bats. This also helped us to gain a better understanding of habitats that bats may be using away from features that typically concentrate bat activity, such as water sources. Interestingly, even detectors placed several kilometers from water sources and riparian areas recorded some bat activity, suggesting that bats utilize portions of the landscape that are not typically associated with supporting bats. While acoustic surveys are effective at answering some questions, acoustic monitoring in conjunction with mist net surveys continues to provide the best picture of species occurrence, local demographics, and allowing us to monitor disease status of bats in hand.

Habitat analyses relating species presence relative to habitat types revealed significant results for five species (Table 4). While some of these results line up with our expectations, many positive or negative relationships did not accord with known habitat affinities of these species. For example, Long-legged Myotis is typically associated with forested habitats, but our results indicate it was observed in grassland habitats more than expected. It should be noted that results for species with few captures (e.g. Townsend’s Big-eared Bat) or occurring in habitat types that were not prevalent in our study area (e.g. grasslands) may lead to erroneous conclusions and should be viewed with caution. On the other hand, the

unexpected results for species with sufficient sample size point to our lack of understanding of habitat associations of bats in our study area.
Observed distribution of bat species roughly correspond with our current understanding of species distributions in the state (Clark and Stromberg 1987, Adams 2003, Keinath et al. 2010, Abernethy et al. 2012, Griscom et al. 2012). While California Myotis was known to occur in extreme south central Wyoming in the vicinity of Flaming Gorge Reservoir, we were able to confirm species presence with mist net captures and acoustic recordings. Mist net captures of California Myotis included one lactating female, which providing confirmation of breeding in Wyoming. Our understanding of bat distributions in southern Wyoming have been greatly enhanced through surveys associated with this project. Continued monitoring of bat populations is important in the face of current and potential threats such as WNS.
Results from our model validation indicate that summer distribution models varied in quality among species. Models for Big Brown Bat, Long-legged Myotis, Pallid Bat, and Little Brown Myotis are the most reliable, and represent useful tools for management of these species. Models for Long-eared Myotis and Western Small-footed Myotis provided inaccurate predictions of species occurrence and caution should be used when using these models. Performance of models for Hoary Bat and Silver-haired bat was generally low, especially in areas of low predicted probability of occurrence and the utility of models for Hoary Bat and Silver-Haired Bat in making management decisions is uncertain. Validation statistics, however, likely underestimate the quality and goodness-of-fit for these models, due to imperfect detection (i.e. the species was present but not detected) and other sampling considerations. Sites where a species was not detected were considered “absences” in our evaluation statistics and graphs, though the level of sampling effort may not have been sufficient to ensure detection if the species was present. Further, a relatively low proportion of the recorded calls from acoustic detectors can be confidently assigned to a species, meaning that some of the absence points used in model evaluation may have been false negatives (i.e., the species was present, but not positively identified via acoustic recordings). As the false negative rate is a component of the AUC calculation, test AUC values will be reduced by either of these non-detect scenarios. Although it is difficult to estimate the proportion of sites incorrectly classified as absences and the bubble plots are somewhat noisy due to small sample sizes, these plots suggest that there is a positive relationship between predicted probability and actual probability of occurrence for most species.
We had relatively few observations of migratory bats during the migration season. Because of this, validation results of migration stop-over habitat models should be viewed with caution. Evidence suggests temporal variation in migration is dictated by factors such as weather events, prey abundance and other factors. These factors may result in discrete movement events where relatively large numbers of bats move through an area in a short period of time (Arnett et al. 2008). This may be one potential explanation for the low number of detections of migratory bat species during migration. Additionally, numerous detections of migratory bat species were in very close proximity to areas predicted to be used as stopover and foraging habitat by migrating bats. This suggests that predictions made by our migration stop-over habitat models may be too constrained to the habitat features represented by the models. For example, current models have a threshold value where cells with a predicted probability of use less than this threshold are deemed unsuitable for use (i.e. probability of use = 0). This constraint is likely an invalid assumption of actual bat behavior.

For any distribution model that makes a binary prediction of occurrence by applying a threshold to modeled probability values, the choice of a threshold value can have a large influence on sensitivity, specificity, and the spatial extent of the predicted distribution. In distribution modeling, sampling bias, the potential for false negatives in the “pseudo-absence” training data, and considerations related to the chosen modeling algorithm mean that a default threshold choice of 0.5 is often not appropriate. We chose a threshold value for each model to maximize the sum of sensitivity and specificity in the training data, therefore balancing omission and commission error on training data. The test sensitivity and specificity values for the 2013 validation data presented for each model in Table 6 reflect the original threshold value. While the error rates for some models are high, we believe much of this apparent error is related to incomplete detection of bat species during field surveys. Incomplete detection leads to overestimating commission error rates, in other words, as sites that are actually part of a species distribution are counted as absences. This inflation of commission error influences the selection of a threshold value which in turn, leads to lower sensitivity. This issue is particularly problematic for bats. Many bat studies found in the literature that indicate that their results and conclusions are negatively impacted by imperfect detection (Duchamp et al. 2006, Yates and Muzika 2006). Imperfect detection of both mistnet surveys and acoustic surveys arises from several causes. Bats may obtain water from portions of water bodies where nets are not. Also, bats with agile flight may detect the nets via echolocation and maneuver around them. Acoustic detectors have limited range, especially in bats that echolocate at high frequencies because calls attenuate as they travel through the atmosphere. Additionally, a high proportion of bat passes may not be identifiable to species. This may be a result of detector placement, overlap in call characteristics among species among other causes. For example, detectors placed in cluttered environments will lead to more overlap in call among species resulting in few identifiable calls. Some species have very similar calls, such as Big Brown Bat and Silver-haired Bat which are only identifiable under certain circumstances. To reduce issues related to imperfect detection, we will place detectors in such a way that we can estimate detection probabilities using an occupancy modeling framework. Specifically, we place detectors in pairs and leave detectors out for multiple nights (Duchamp et al. 2006, Yates and Muzika 2006). This will allow us to infer the proportion of our study area in 2014 that is occupied by bat species detected.

Although it is not possible to estimate the prevalence and impact of false non-detections from the available data, the models generated in 2013 generally reflect our current understanding of the species' habitat associations, giving us greater confidence that many of these models can be useful tools for management. It is important to note that, as previously discussed, we observed bats in habitats they are not typically associated with. For example, forest associated bats such as Long-legged Myotis and Hoary Bat were observed using shrubland habitats. Most importantly for land use planning, wind farms constructed in the higher probability areas of most models are more likely to encounter bats than in areas of lower probability. Since factors other than occurrence are important determinants of impact, this does not necessarily mean that increased moralities will occur in those areas. More work is needed to create a clear picture of bat species ecology and distribution in Wyoming. Iterative rounds of modeling and field sampling for model evaluation that have been completed to-date provide invaluable information and guidance for future field surveys and for the forthcoming statewide modeling effort for these species.

ACKNOWLEDGEMENTS

Dennis Saville, Wildlife Program Lead for the Wyoming State Office of the BLM has been instrumental in establishing this project and continues to provide logistical support and administrative guidance. Hannah Griscom, WYNDD Contract Zoologist has provided invaluable input throughout all phases of this project. Lorraine Keith, Biologist with the Rock Springs Field Office of the BLM has provided us with equipment and logistical support. Leah Yandow and Martin Grenier, Nongame Mammal Biologists with the Wyoming Game and Fish Department have provided us with occurrence data used in models, technical advice, assistance with project planning and coordination, and training. Steve Brandebura, Kathryn Walpole, Mary Johnson, and Megan McDowell worked many long days and nights in the field.

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TABLES

Table 1. Number occurrences documented in 2013 and the efficiency of detection by survey method.

Survey method	Species occurrences*	Nights surveyed	Efficiency+
Mist net	65	44	1.48
Anabat	13	16	0.81
EM3	46	18	2.56
Songmeter	266	188	1.41

*An occurrence is the detection of a species at a site (regardless of the number of captures or recordings)
+Efficiency is the average number of species occurrences per survey night.

Table 2. Bat species detected in 2013 in southern Wyoming, their relative abundance and seasonal residency.

Common name	Scientific name	Relative abundance	Mist net occurrences*	Acoustic occurrences*	Season of residency
Big Brown Bat	*Eptesicus fuscus*	Uncommon	6	10	Year round
California Myotis	*Myotis califonicus*	Very uncommon	1	2	Year round
Fringed Myotis	*Myotis thysanodes*	Uncommon	1	1	Year round
Hoary Bat	*Lasiurus cinereus*	Common	9	48	Spring, summer, fall
Little Brown Myotis	*Myotis lucifugus*	Common	9	62	Year round
Long-legged Myotis	*Myotis volans*	Common	11	9	Year round
Pallid Bat	*Antrozous pallidus*	Uncommon	0	8	Year round
Silver-haired Bat	*Lasionycteris noctivagans*	Uncommon	5	34	Spring, summer, fall
Townsend's Big-eared Bat	*Corynorhinus townsendii*	Uncommon	2	0	Year round
Western Long-eared Myotis	*Myotis evotis*	Common	12	64	Year round
Western Small-footed Myotis	*Myotis ciliolabrum*	Common	10	87	Year round

*An occurrence is the detection of a species at a site, regardless of the number of captures or recordings.

Table 3. Number of bats captured during 2013 mist net surveys by sex and age.

Species	Males (repro[1])	Females (repro[2])	Adults	Juveniles
Big Brown Bat	9 (1)	0 (0)	10	0
Fringed Myotis	1 (0)	0 (0)	1	0
Hoary Bat	9 (1)	1 (2)	13	0
Little Brown Myotis	11 (0)	14 (3)	25	3
Western Long-eared Myotis	31(3)	8 (11)	27	0
Long-legged Myotis	25 (1)	15 (19)	59	1
Silver-haired Bat	7 (2)	0 (0)	9	0
Townsend's Big-eared Bat	0 (0)	0 (2)	2	0
Western Small-footed Myotis	14 (1)	4 (8)	27	0
California Myotis	2 (3)	0 (1)	6	0

[1]Number of males with descended testis.
[2]Number of females pregnant, lactating, or post-lactating.

Table 4. Chi-square analysis of habitat types used by bats compared to those available in the immediate vicinity of mist net and acoustic survey locations. "+" and "++" indicates that the species in question occurred in the habitat more and much more than expected based on availability. "-" indicates the species occurred less than expected based on availability. Blank cells indicate no difference. Habitat types are defined in the 2010 State Wildlife Action Plan.

Species	Shrub steppe	Grass-land	Wetland / Open water	Rock outcrop	Cliff/ Canyon	Cave	Conifer Forest	Deciduous Forest	Foothills	Riparian Shrub	Bad-lands	Disturbed
Big Brown Bat**	-						+	+		+	-	-
Fringed Myotis**	-	-	+	-	-	-	-	-	-	+	-	+
Hoary Bat												
Little Brown Myotis										+		
Western Long-eared Myotis												
Long-legged Myotis**	-			+						+	-	
Pallid Bat**					++					++		-
California Myotis**	-	-	+	-	+		+	-		+	-	+
Silver-haired Bat									+			
Townsend's Big-eared Bat**	-	+	-	-	-	-	-	-	-	++	-	+
Western Small-footed Myotis				+								

*Significantly different than expected at $p < 0.05$; ** Significantly different than expected at $p < 0.001$

Table 5. Number of detections, training AUC, test AUC, 95% confidence intervals of test AUC, and training/test AUC differences for summer distribution models for eight species based on 2013 survey data. Higher AUC values indicate better models, with values of 0.5 suggesting a model is no better than random in its discriminatory power. Models for which the lower 95% confidence interval is above 0.5 are significantly better than a random model at correctly predicting presence/absence at new locations. Higher test AUC values indicate a better ability to predict presence or absence for the species in unsurveyed areas. Larger differences between training and test AUC indicate model overfitting, which is best remedied by collecting additional presence / absence data.

Species	Detections	Training AUC	Test AUC	Lower 95% Test AUC Confidence Interval	Upper 95% Test AUC Confidence Interval	Difference between Training and Test AUC
Little Brown Myotis	82	0.907	0.667	0.584	0.751	0.240
Western Long-eared Myotis	79	0.933	0.422	0.332	0.512	0.511
Long-legged Myotis	33	0.924	0.679	0.576	0.782	0.245
Western Small-footed Myotis	108	0.899	0.492	0.393	0.591	0.407
Silver-haired Bat	35	0.894	0.539	0.418	0.659	0.355
Big Brown Bat	19	0.921	0.721	0.581	0.862	0.200
Hoary Bat	54	0.892	0.569	0.472	0.666	0.323
Pallid Bat	14	0.839	0.676	0.531	0.821	0.163

Table 6. Summary statistics for summer distribution models, by species. Sensitivity (true positive rate) is the percentage of sites with detections that were correctly predicted as occupied by the species, while specificity (true negative rate) is the percentage of sites without detections that were correctly predicted as unoccupied by the species. Note that the estimates for sensitivity and specificity of models for which there are relatively few presence points likely are subject to high variance, and caution should be used in their evaluation. Full confusion matrices are presented in the last three columns. As with the other estimates of model quality, these statistics likely underestimate model accuracy, as any non-detections lead to reduced specificity.

Species	Sensitivity	Specificity	Model Prediction	Observed	
				Present	Absent
Little Brown Myotis	57.3%	69.6%	Present	47	24
			Absent	35	55
Western Long-eared Myotis	58.2%	30.5%	Present	46	57
			Absent	33	25
Long-legged Myotis	51.5%	70.3%	Present	17	38
			Absent	16	90
Western Small-footed Myotis	26.9%	66.0%	Present	29	18
			Absent	79	35
Silver-haired Bat	60.0%	33.3%	Present	21	84
			Absent	14	42
Big Brown Bat	79.0%	49.3%	Present	15	72
			Absent	4	70
Hoary Bat	55.6%	56.1%	Present	30	47
			Absent	24	60
Pallid Bat	85.7%	37.4%	Present	12	92
			Absent	2	55

FIGURES

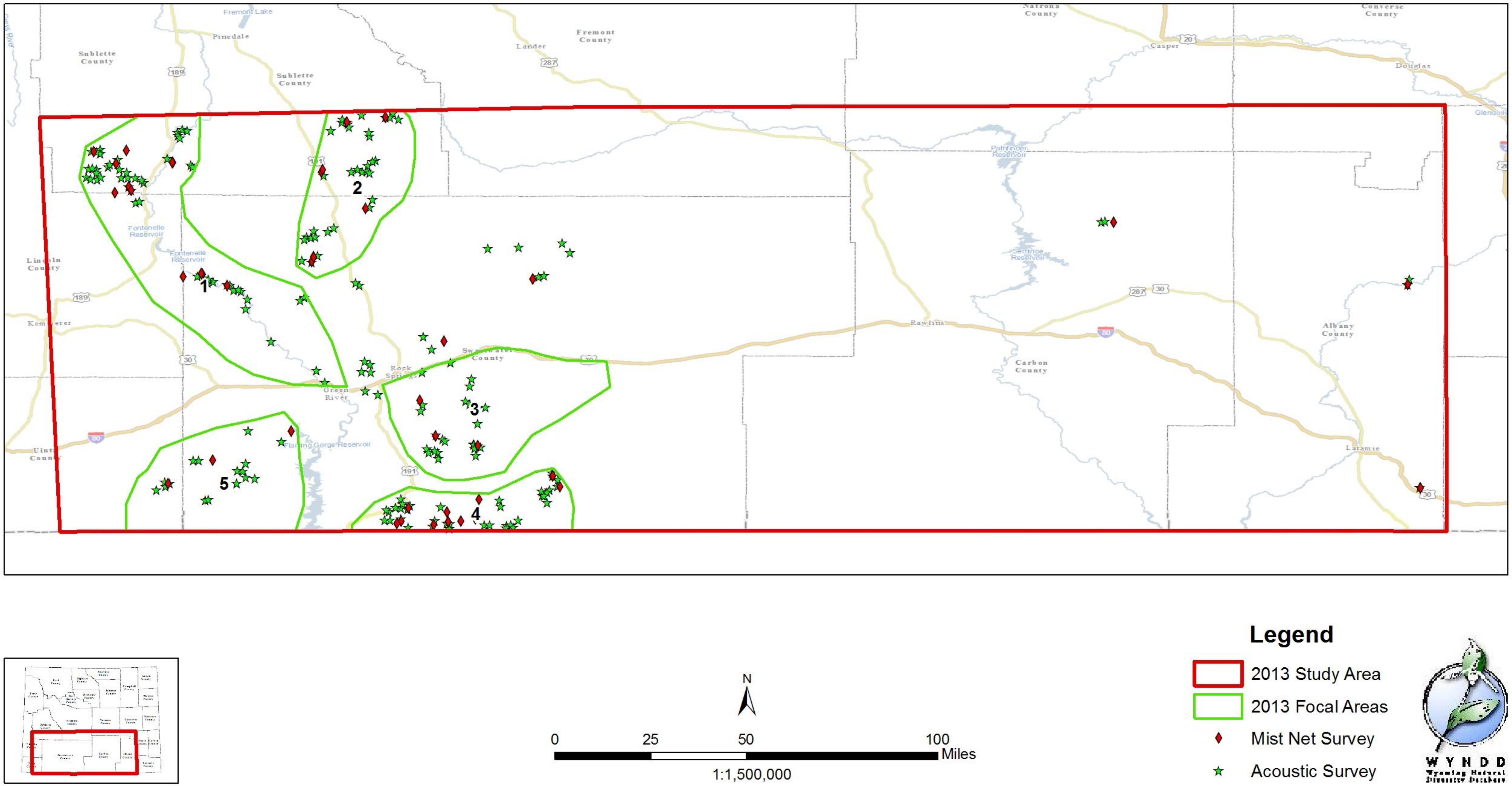


Figure 1. Study area including areas of interest, Green River Basin (1), Big Sandy drainage (2), Bitter Creek drainage (3), Little Mountain and Pine Mountain (4), and western Red Desert (5), and mist net and acoustic survey sites sampled in 2013.

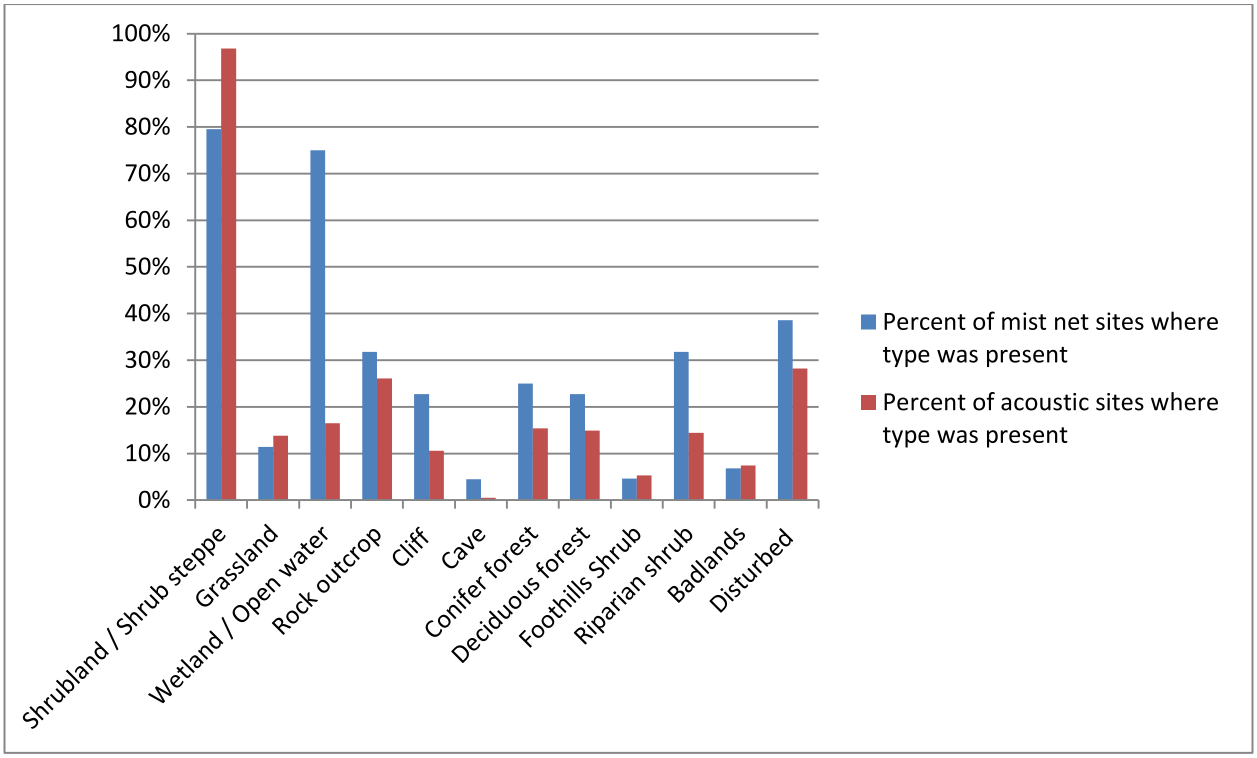


Figure 2. Habitat types observed at mist net and acoustic survey sites.

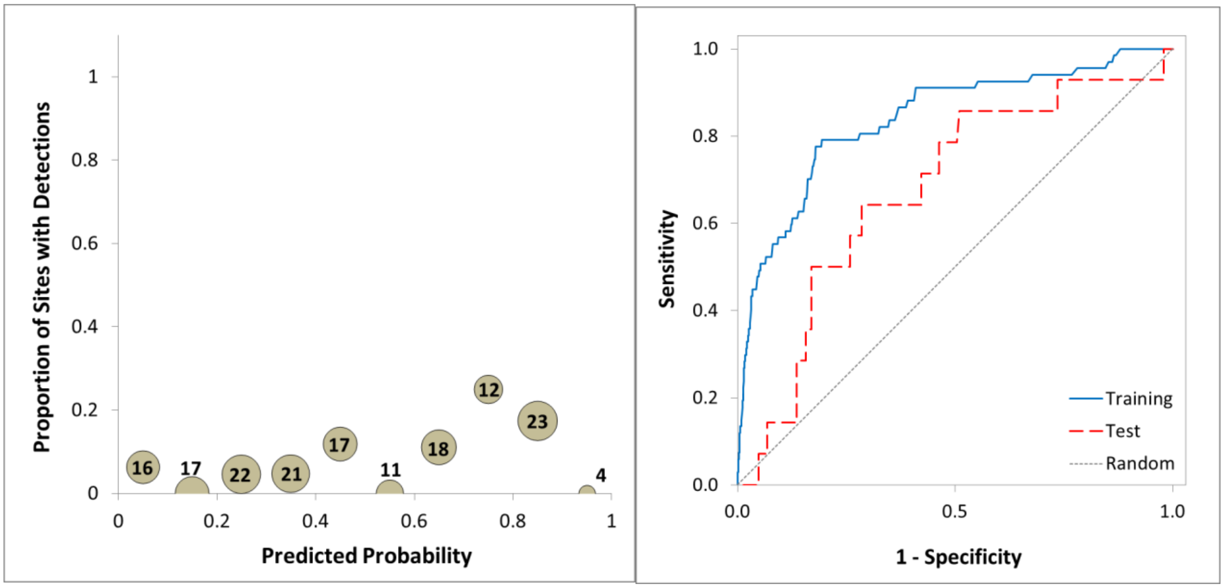


Figure 3. Bubble plot and ROC plot evaluating the summer distribution model for Pallid Bat. The position of the bubbles shows the relationship between the predicted probability of occurrence from the distribution model and the proportion of surveyed sites within probability bins that were actually occupied. Bubble sizes are based on the number of sites falling within each bin of predicted probability and are labeled as such. Bubble plots for models with greater overall accuracy should have an increasing number of proportion of sites with detections with increasing predicted probability of occurrence. ROC plots show the tradeoff between sensitivity and specificity (the proportion of true presences and true absences that are correctly predicted, respectively), as a function of differing thresholds, for both the training data and the 2013 test data. The more area contained under the curve, the greater the overall accuracy of the model. The diagonal line shows the ROC curve for a null model (i.e. a model for which random probabilities are assigned.

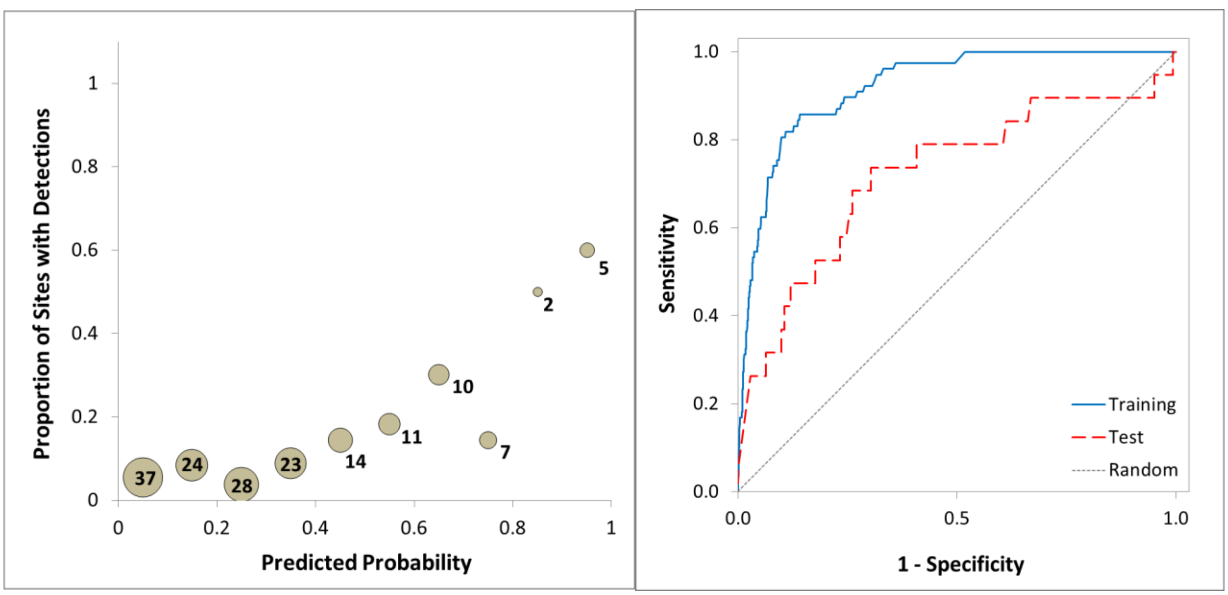


Figure 4. Bubble plot and ROC plot evaluating the summer distribution model for Big Brown Bat. See Figure 3 for full explanation.

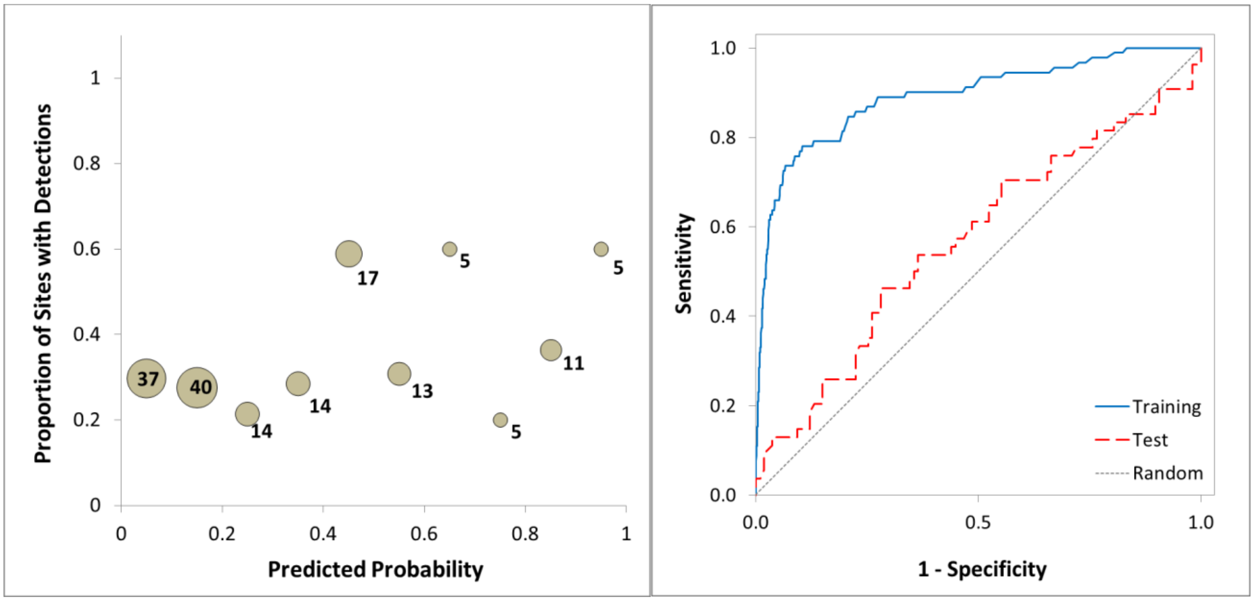


Figure 5. Bubble plot and ROC plot evaluating the summer distribution model for Hoary Bat. See Figure 3 for full explanation.

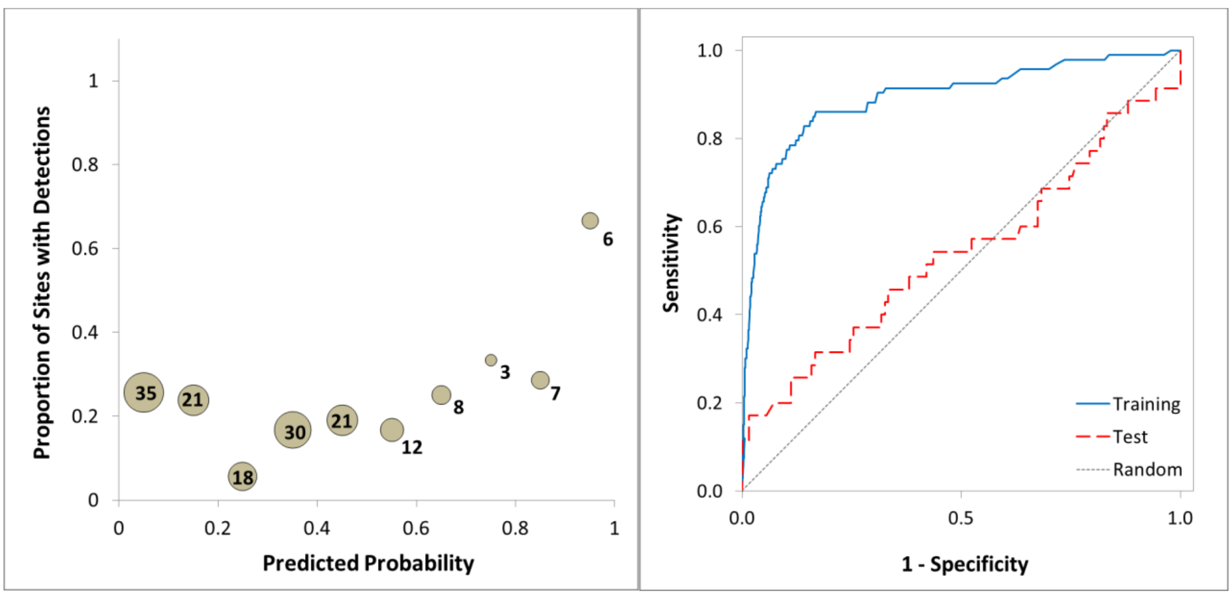


Figure 6. Bubble plot and ROC plot evaluating the summer distribution model for Silver-haired Bat. See Figure 3 for full explanation.

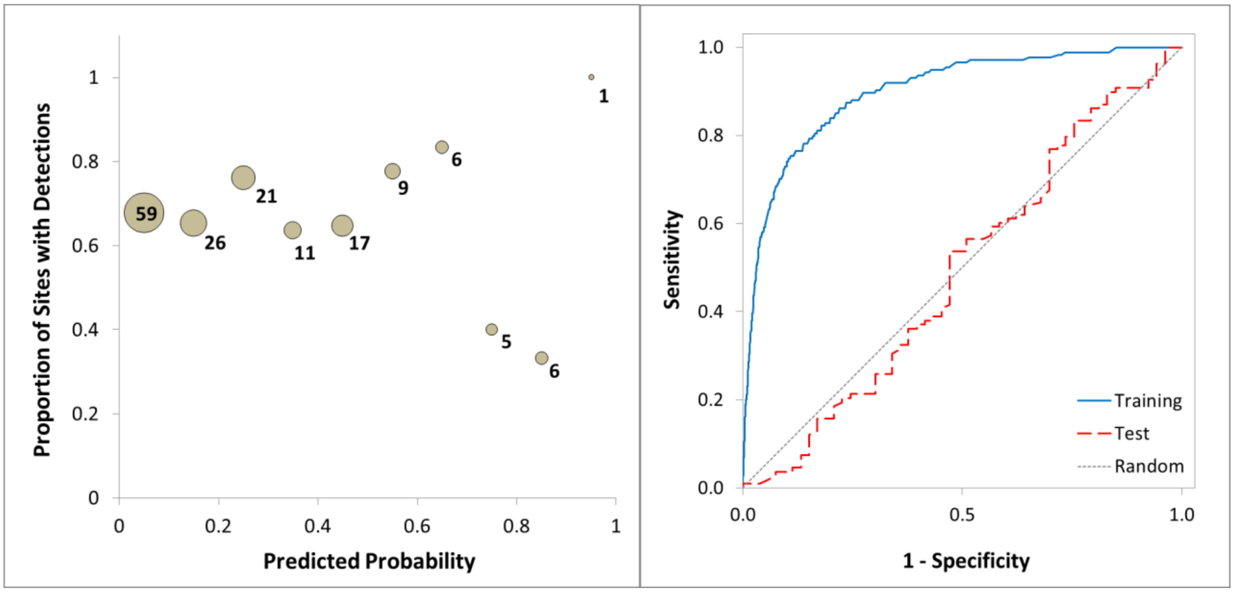


Figure 7. Bubble plot and ROC plot evaluating the summer distribution model for Western Small-footed Myotis. See Figure 3 for full explanation.

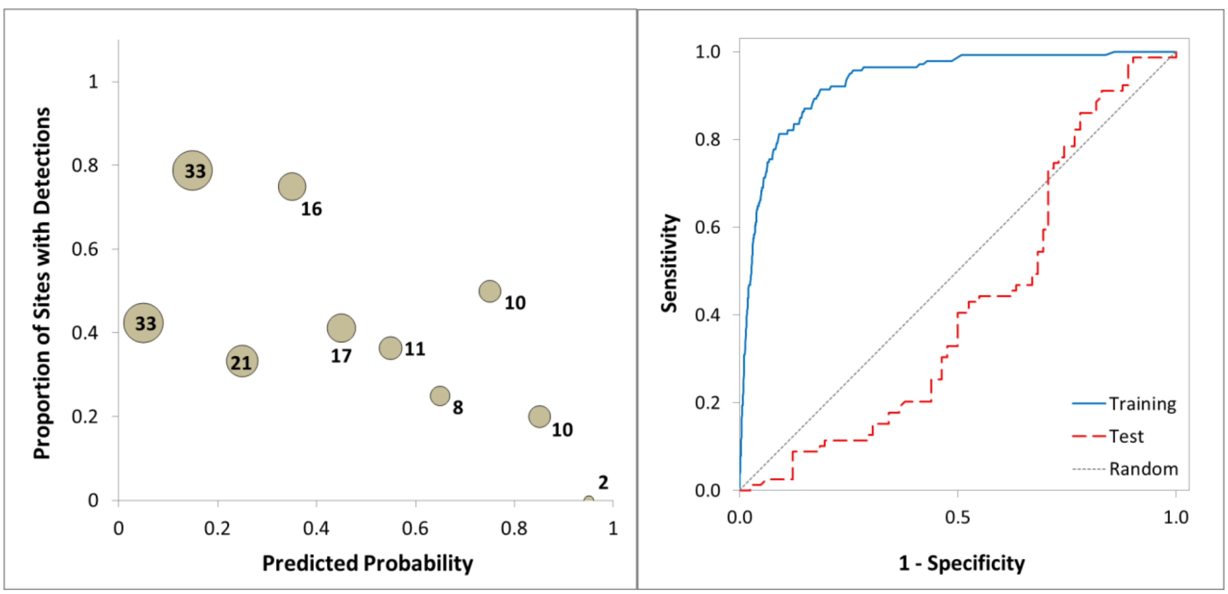


Figure 8. Bubble plot and ROC plot evaluating the summer distribution model for Long-eared Myotis. See Figure 3 for full explanation.

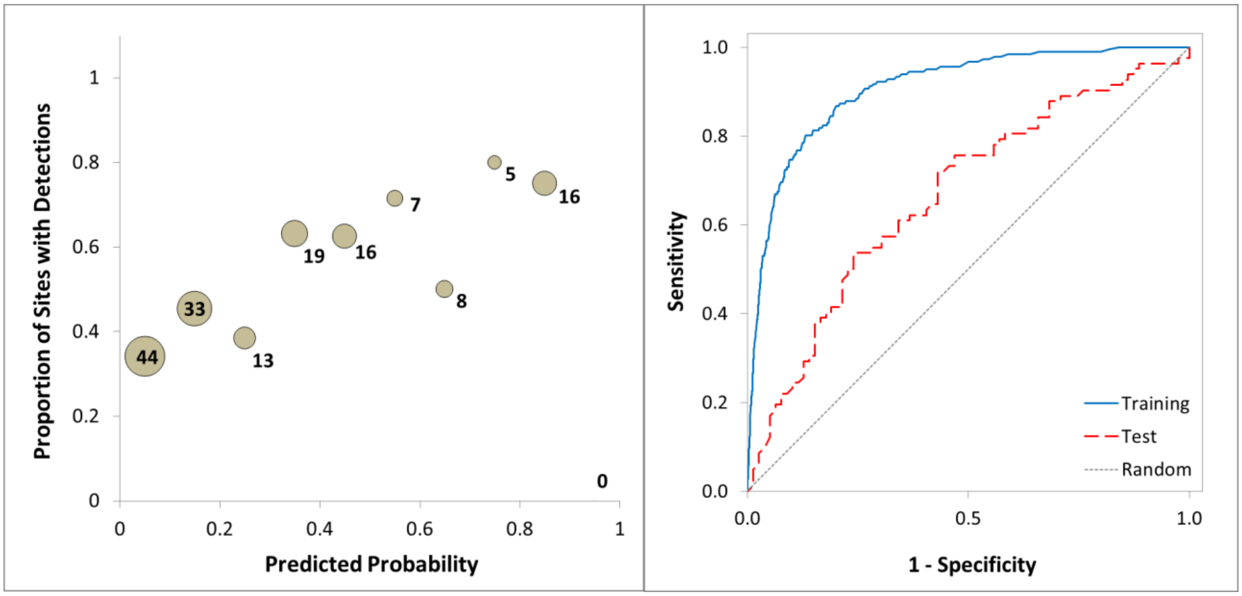


Figure 9. Bubble plot and ROC plot evaluating the summer distribution model for Little Brown Myotis. See Figure 3 for full explanation.

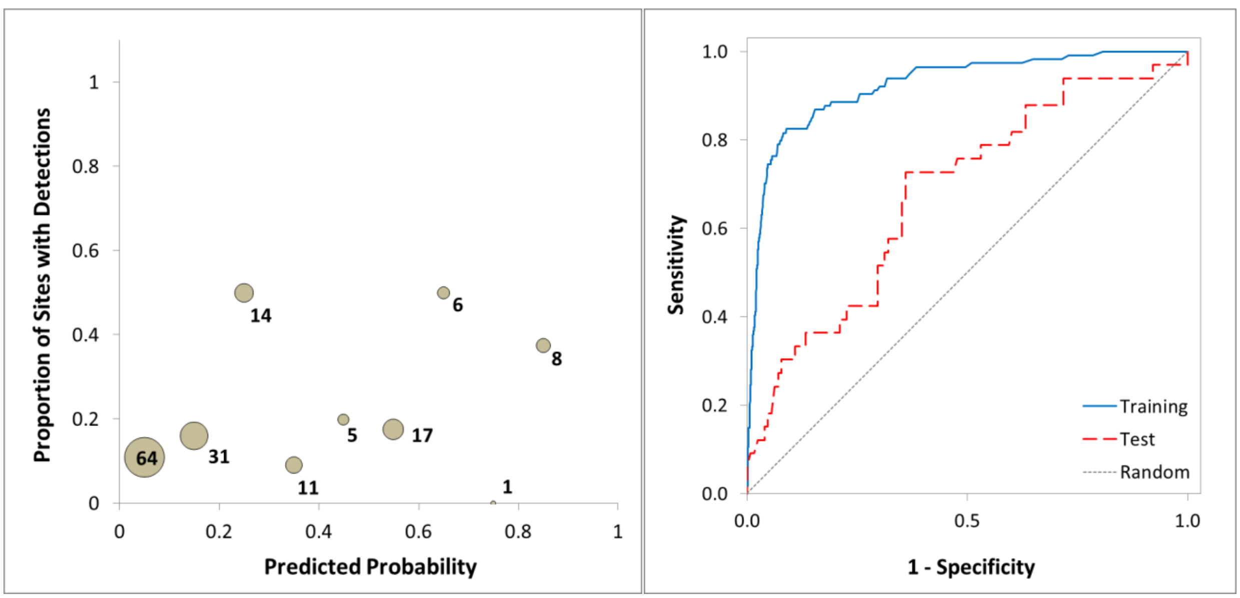


Figure 10. Bubble plot and ROC plot evaluating the summer distribution model for Long-legged Myotis. See Figure 3 for full explanation.

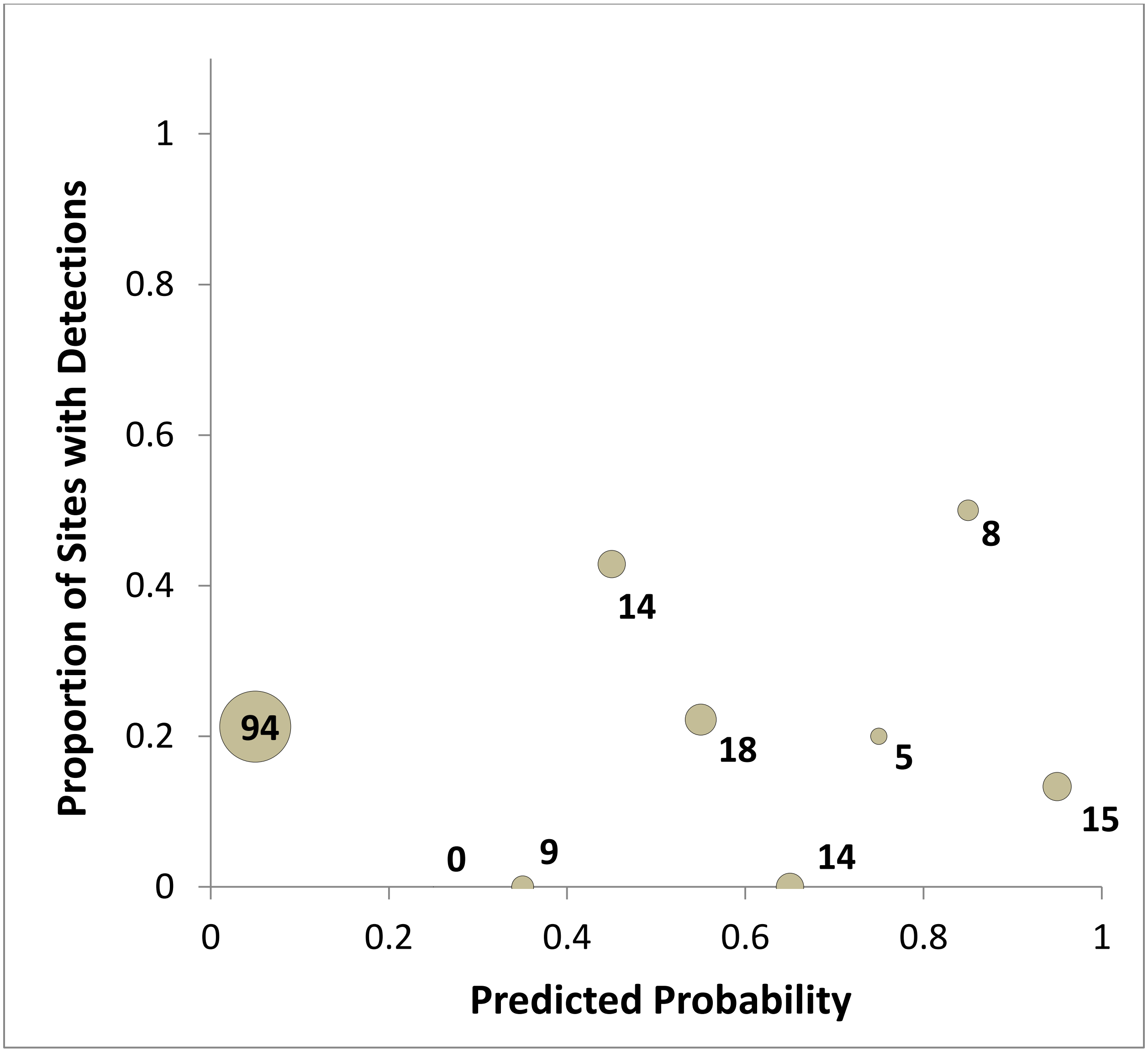


Figure 11: Bubble plot evaluating the fall distribution model for Hoary Bat. See Figure 3 for full explanation.

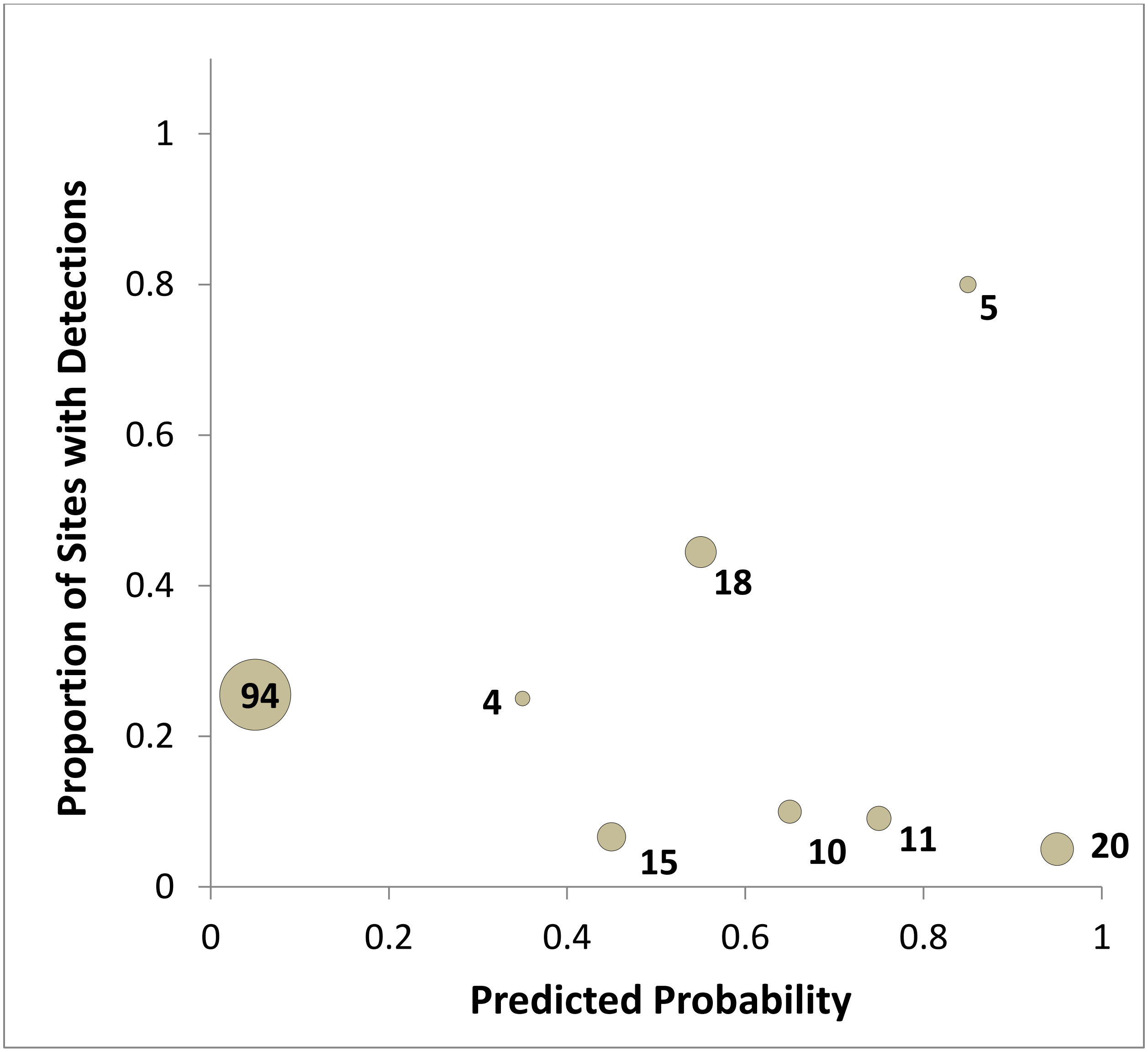


Figure 12: Bubble plot evaluating the fall distribution model for Silver-haired bat. See Figure 3 for full explanation.

APPENDDICES

Appendix 1: 2013 Mist Net Captures

Locality	Survey Date	Species	Capture Time	Sex	Age	Repro	FA	E	Wt	Keel	WDI	Wylam Easting	Wylam Northing
Turtle Rock	7/1/2013	MYVO	22:36	F	A	N	40.8	11.7	9	Yes	0	679007	220132
Turtle Rock	7/1/2013	MYVO	10:35	M	A	N	39.8	11	9	Yes	0	679008	220130
Turtle Rock	7/1/2013	LACI	22:30	M	A	N	54	15	30	Yes	0	679002	220137
Turtle Rock	7/1/2013	EPFU	23:10	M	A	N	47.2	11	18	Yes	0	679008	220132
Turtle Rock	7/1/2013	LANO	23:10	M	A	N	41	14	12	No	0P	679006	220131
Turtle Rock	7/1/2013	EPFU	23:10	M	A	N	47.4	11.5	16.5	Yes	0	679006	220133
Turtle Rock	7/1/2013	EPFU	23:25	M	A	N	45.5	11	12.5	Yes	0P	679007	220132
Turtle Rock	7/1/2013	LANO	23:30	M	A	N	42.7	12	11.5	No	0P	679023	220143
Turtle Rock	7/2/2013	LACI	0:30	M	A	N	52.4	15	32	Yes	0P	679006	220131
Tunnel Road	7/2/2013	LACI	21:30	F	A	L	55.7	11		No	0	672889	305237
Tunnel Road	7/2/2013	EPFU	21:53	M	A	N	46.4	13	16	Yes	0	672888	305235
Tunnel Road	7/2/2013	LACI	23:30	F	A	L	55	13	28	Yes	0P	672890	305236
Tunnel Road	7/3/2013	EPFU	21:23	M	A	N	38.6	11	5	Yes	0	580311	329741
Shirley Mtn. Loop Rd.	7/3/2013	MYLU	9:20	M	A	N	38	10	7	No	0	580310	329740
Shirley Mtn. Loop Rd.	7/3/2013	MYEV	21:20	M	A	N	37	11.5	6	Yes	0	580308	329746
Shirley Mtn. Loop Rd.	7/3/2013	MYEV	21:20	M	A	N	39.5	17	8	Yes	0	580313	329744
Shirley Mtn. Loop Rd.	7/3/2013	MYLU	21:20	M	A	N	38.5	11.5		No	0	580305	329748
Shirley Mtn. Loop Rd.	7/3/2013	MYVO	12:25	M	A	N	38.5	11	8	Yes	0	580312	329743
Shirley Mtn. Loop Rd.	7/3/2013	MYVO	21:30	M	A	N	38.1	10	8	Yes	0	580307	329746
Shirley Mtn. Loop Rd.	7/3/2013	MYLU	21:40	M	A	N	37.4	11	6.5	No	0	580311	329736
Shirley Mtn. Loop Rd.	7/3/2013	MYVO	21:45	M	A	N	38.8	9	6	Yes	0	580313	329742
Shirley Mtn. Loop Rd.	7/3/2013	MYVO	22:50	M	A	N	38.5	10.5	5.5	Yes	0	580312	329743

Locality	Survey Date	Species	Capture Time	Sex	Age	Repro	FA	E	Wt	Keel	WDI	Wylam Easting	Wylam Northing
Shirley Mtn. Loop Rd.	7/3/2013	MYVO	21:55	M	A	N	48.1	11	7	Yes	0	580313	329739
Shirley Mtn. Loop Rd.	7/3/2013	MYLU	23:58	M	A	PL	37.6		8	No	0	580308	329745
Shirley Mtn. Loop Rd.	7/3/2013	MYVO	22:03	M	A	N	37.7	9	7.5	Yes	0	580305	329742
Shirley Mtn. Loop Rd.	7/3/2013	MYEV	22:08	M	A	N	39.3	18	7	Yes	0P	580311	329744
Shirley Mtn. Loop Rd.	7/3/2013	EPFU	22:10	M	A	N	45.5	10.3	16	Yes	0P	580311	329741
Shirley Mtn. Loop Rd.	7/3/2013	MYEV	22:05	M	A	N	37.5	16	7	No	0P	580311	329740
Shirley Mtn. Loop Rd.	7/3/2013	MYEV	22:45	M	A	N	37.7	18	8	Yes	0P	580313	329756
Shirley Mtn. Loop Rd.	7/3/2013	MYVO	23:54	F	A	P	39.2	10	10	Yes	0	580307	329735
Shirley Mtn. Loop Rd.	7/3/2013	MYVO	22:59	F	A	P				Yes	0	580308	329748
Shirley Mtn. Loop Rd.	7/3/2013	MYVO	23:20	M	A	N	37.9	10	8	Yes	0	580328	329745
Shirley Mtn. Loop Rd.	7/3/2013	MYEV	23:20	M	A	N	36.5	14	6.5	Yes	0	580313	329749
Shirley Mtn. Loop Rd.	7/3/2013	EPFU	23:43	M	A	N	46.4	13	18	Yes	0	580315	329732
Shirley Mtn. Loop Rd.	7/4/2013	MYEV	0:04	M	A	N	39.5	18	7	Yes	0	580303	329745
Shirley Mtn. Loop Rd.	7/4/2013	MYVO	11:15	M	A	N	40.2	13	8	Yes	0	580309	329742
Shirley Mtn. Loop Rd.	7/4/2013	MYVO	0:24	M	A	N				Yes	0	580316	329743
Pine Mtn	7/10/2013	MYVO	21:50	F	A	N	39	9	10	Yes	0	374191	204956
Pine Mtn	7/10/2013	MYEV	22:00	M	A	N	41	17	9	No	0	374188	204962
Pine Mtn	7/10/2013	MYVO	22:45	F	A	N	41	9	8	Yes	0	374189	204954
Pine Mtn	7/10/2013	MYVO	22:35	M	A	N	40	9	8	Yes	0	374186	204956
Pine Mtn	7/10/2013	MYEV	22:30	F	A	N				No	0	374189	204958

Locality	Survey Date	Species	Capture Time	Sex	Age	Repro	FA	E	Wt	Keel	WDI	Wylam Easting	Wylam Northing
Pine Mtn	7/10/2013	MYVO	22:45	F	A	N	41	8	10	Yes	0	374190	204961
Pine Mtn	7/10/2013	MYVO	22:45	F	A	N	42	7	10	Yes	0	374187	204959
Pine Mtn	7/10/2013	MYVO	22:45	M	A	N	41	8	8	Yes	0	374190	204961
Pine Mtn	7/10/2013	LANO	20:47	M	A	N	40	9	10	No	0	374190	204964
Pine Mtn	7/10/2013	LANO	23:20	M	A	N				No	0	374189	204955
Pine Mtn	7/10/2013	LANO	23:23	M	A	N				No	0	374188	204956
Pine Mtn	7/10/2013	EPFU	23:15	M	A	N				Yes	0	374191	204954
Pine Mtn	7/10/2013	MYVO	23:18	M	A	N	40.5	11	9.5	Yes	0	374202	204958
Pine Mtn	7/10/2013	MYVO	23:40	F	A	P	41.2	12	12	Yes	0	374188	204957
Pine Mtn	7/10/2013	MYVO	23:50	M	A	N	41	8	9	Yes	0	374190	204957
Pine Mtn	7/11/2013	MYVO	0:03	F	A	P	41.5	11	11	Yes	0	374193	204957
Pine Mtn	7/11/2013	MYLU	11:11	M	A	N	40.6	10	8	No	0P	374186	204960
Pine Mtn	7/11/2013	MYEV	20:20	M	A	N	40.8	11	9	Yes	0	374184	204950
Pine Mtn	7/11/2013	MYEV	11:15	F	A	N	40.5	22	7	Yes	0	374185	204958
Salt Wells Cr	7/11/2013	MYCI	22:00	F	A	P				Yes	0P	379993	236420
Salt Wells Cr	7/11/2013	LACI	22:19	M	A	N	52.6	14	27	Yes	0	379993	236420
Salt Wells Cr	7/11/2013	EPFU	22:50	M	A	N	50.6	14		Yes	0	379992	236420
Salt Wells Cr	7/11/2013	MYCI	22:45	M	A	N	32.7	11	5	Yes	0	379994	236421
Salt Wells Cr	7/11/2013	LACI	23:17	M	A	N	51.5		26	Yes	0	379992	236417
Salt Wells Cr	7/12/2013	MYCI	57:57	M	A	N	34	12	4.5	Yes	0P	379990	236422
Four J Rim	7/12/2013	MYVO	21:40	F	A	L	41	11	9.5	Yes	0	378818	205841
Four J Rim	7/12/2013	MYEV	21:42	M	A	N	41		6	No	0	378805	205842
Four J Rim	7/12/2013	MYEV	21:57	M	A	N	37.5	17	5	No	0	378810	205841
Four J Rim	7/12/2013	MYVO	22:06	M	A	N	40	9	9	Yes	0	378809	205841
Four J Rim	7/12/2013	MYVO	22:15	F	A	P	40.5	12	12	Yes	0	378809	205840
Chicken Creek	7/13/2013	MYCI	22:55	M	A	N	32.8	11	4	Yes	0P	405871	218946
Chicken Creek	7/13/2013	MYCI	23:25	F	A	P				Yes	0	405855	218972
Chicken Creek	7/13/2013	LACI	23:25	M	A	N	57.5	14	28	Yes	0	405860	218973

Locality	Survey Date	Species	Capture Time	Sex	Age	Repro	FA	E	Wt	Keel	WDI	Wylam Easting	Wylam Northing
Chicken Creek	7/13/2013	MYCI	23:25	M	A	N	34.4	12	5	Yes	0P	405861	218973
Four J Rim	7/12/2013	MYVO	22:06	M	A	N	40.7	12	9	Yes	0	378809	205841
Chicken Springs Basin	7/14/2013	MYEV	22:31	M	A	N	39	18	6	No	0	403538	223369
Chicken Springs Basin	7/14/2013	MYEV	22:30	M	A	N	37.7	18	7	No	0	403536	223367
Chicken Springs Basin	7/14/2013	MYEV	22:40	M	A	N	40.9	18	6.5	Yes	0	403537	223366
Four J Rim	7/12/2013	MYVO	22:24	F	A	N	40.5	11	9	Yes	0	378809	205841
Four J Rim	7/12/2013	MYVO	23:00	M	A	N	38.8	9	9	Yes	0	378809	205841
Four J Rim	7/12/2013	LANO	23:53	M	A	N	41.2	12	11	No	0	378809	205841
Chicken Springs Basin	7/15/2013	MYCI	0:15	M	A	N	34.3	11	4	Yes	0	403548	223381
Ely Creek	7/9/2013	MYCA	21:35	M	A	D	30.8	12	4	Yes	0	357619	210880
Ely Creek	7/9/2013	MYCA	21:30	F	A	L	33.1	12	4	Yes	0P	357617	210886
Ely Creek	7/9/2013	MYEV	21:45	M	A	N	39.2	19		Yes	0	357618	210883
Ely Creek	7/9/2013	MYCA	21:46	M	A	N	35.1	12	4.5	Yes	0	357618	210885
Ely Creek	7/9/2013	MYCA	21:49	M	A	N	39.2	11	7.5	Yes	0P	357617	210887
Ely Creek	7/9/2013	MYCA	21:45	M	A	D	33.1	11	4	Yes	0	357619	210881
Ely Creek	7/9/2013	MYVO	22:02	F	A	P	38.2	5		Yes	0P	357619	210883
Ely Creek	7/9/2013	MYCA	22:09	M	A	D	31.5	7	4	Yes	0P	357618	210883
Ely Creek	7/9/2013	EPFU	22:30	M	A	D	46.5	17	16.5	Yes	0P	357618	210881
Ely Creek	7/9/2013	MYVO	23:52	F	A	N	40.3	10	7	Yes	0	357618	210883
Ely Creek	7/9/2013	MYEV	23:05	M	A	N	37.9	15	10	Yes	0	357620	210888
Ely Creek	7/9/2013	MYCI	23:33	M	A	N	32.6	11	4	Yes	0P	357619	210888
Ely Creek	7/9/2013	MYEV	23:40	M	A	D	34.9	15	5	Yes	0	357619	210880
Ely Creek	7/10/2013	MYEV	23:58	M	A	D	38.2	15	6.5	Yes	0	357620	210883
Daniels Creek	7/10/2013	MYEV	21:23	M	A	N	40.1	16	9	Yes	0	355045	205179
Daniels Creek	7/10/2013	MYEV	21:33	M	A	N	40.7	14	5	Yes	0P	355045	205177
Daniels Creek	7/10/2013	MYEV	21:36	M	A	N	36.2	15	6	Yes	0P	355043	205179

Locality	Survey Date	Species	Capture Time	Sex	Age	Repro	FA	E	Wt	Keel	WDI	Wylam Easting	Wylam Northing
Daniels Creek	7/10/2013	MYEV	21:38	F	A	N	38.7	21	6	Yes	0	355042	205179
Daniels Creek	7/10/2013	MYEV	21:46	M	A	N	41.2	19	7	Yes	0P	355043	205181
Daniels Creek	7/10/2013	MYEV	21:48	F	A	P	41.9	19	9	Yes	0P	355043	205179
Daniels Creek	7/10/2013	MYEV	21:58	F	A	L	38.5	19		Yes	0	355043	205178
Daniels Creek	7/10/2013	LACI	22:35	M	A	N				No	0	355042	205176
Lizzie Spring Creek	7/13/2013	LANO	22:00	M	A	D	41.1	10	5	Yes	0P	370385	204084
Lizzie Spring Creek	7/13/2013	MYVO	22:17	M	A	N	40	9	8	Yes	0	370385	204087
Lizzie Spring Creek	7/13/2013	MYVO	22:31	M	A	N	40.6	11	9	Yes	0P	370386	204088
Lizzie Spring Creek	7/13/2013	MYVO	22:40	M	A	N	39.2	12	8	Yes	0	370387	204088
Lizzie Spring Creek	7/13/2013	MYVO	22:40	F	A	P	39.2	10	9	Yes	0P	370385	204088
Lizzie Spring Creek	7/13/2013	LANO	22:46	M	A	D	42.5	13	12	Yes	0	370385	204087
Lizzie Spring Creek	7/13/2013	MYVO	22:58	F	A	P	41.1	14		Yes	0	370388	204088
Lizzie Spring Creek	7/13/2013	LACI	23:02	M	A	N				No	0	370386	204089
Lizzie Spring Creek	7/13/2013	LACI	23:06	M	A	N	52	15	35.5	No	0P	370387	204088
Lizzie Spring Creek	7/13/2013	MYVO	23:32	M	A	D	37.8	11	10	Yes	0	370391	204106
Lizzie Spring Creek	7/13/2013	MYVO	23:37	M	A	N	40.7	9	9	Yes	0P	370388	204085
Lizzie Spring Creek	7/14/2013	MYVO	24:16	F	A	P	41.8	10		Yes	0P	370339	204110
Lizzie Spring Creek	7/14/2013	MYVO	34:34	F	A	N	40.7	10	8	Yes	0	370386	204093
Red Creek	7/14/2013	MYEV	22:00	M	A	N	37.6	15	6	Yes	0P	369852	208765
Bone Draw	7/25/2013	MYLU	21:33	M	A	N	40.3	11	8	No	0	330002	316776
Big Sandy River	7/27/2013	MYLU	22:25	F	A	L	39.5	11	9	No	0	329467	314942

Locality	Survey Date	Species	Capture Time	Sex	Age	Repro	FA	E	Wt	Keel	WDI	Wylam Easting	Wylam Northing
Big Sandy River	7/23/2013	MYVO	22:47	F	A	P				Yes	0P	333313	352309
Big Sandy River	7/25/2013	MYCI	22:10	F	A	N	39.45	11	7	No	0P	341785	373252
Big Sandy River	7/25/2013	LACI	22:10	M	A	N	52.39	10	24	Yes	0	341783	373249
Big Sandy River	7/25/2013	MYLU	22:49	F	A	L	37.85	13	8.5	No	0	341796	373236
Big Sandy River	7/25/2013	MYLU	22:58	F	A	N	38	13	8	No	0P	341784	373249
Big Sandy River	7/25/2013	MYCI	23:54	M	A	N	36.5	10	6	No	0	341784	373253
Little Prospect Mtn	7/26/2013	MYEV	21:30	M	A	N	40.8	19	7	Yes	0P	353700	374898
Little Prospect Mtn	7/26/2013	MYCI	21:30	M	A	N	40.8	14	7	No	0P	353700	374899
Little Prospect Mtn	7/26/2013	MYEV	21:30	F	A	N	39.2	21	7	Yes	0P	353699	374897
Little Prospect Mtn	7/26/2013	MYVO	21:35	M	A	N	40.7	11	8.5	Yes	0P	353697	374898
Little Prospect Mtn	7/26/2013	MYEV	21:40	F	A	N	39.2	19	6.5	Yes	0P	353699	374898
Little Prospect Mtn	7/26/2013	MYEV	21:30	M	A	N	37.7	16	7	Yes	0	353699	374898
Little Prospect Mtn	7/26/2013	MYEV	22:00	M	A	N	39.5	16	5.5	Yes	0	353699	374894
Little Prospect Mtn	7/26/2013	LANO	21:49	M	A	N	42.7	10	12	No	0	353700	374899
Little Prospect Mtn	7/26/2013	MYEV	21:20	M	A	N	39.5	15	5.5	Yes	0	353698	374898
Little Prospect Mtn	7/26/2013	MYVO	21:19	M	A	N	38.1	9	8	Yes	0	353700	374896
Little Prospect Mtn	7/26/2013	MYEV	21:21	F	A	L	39.5	16	8	Yes	0	353700	374899
Little Prospect Mtn	7/26/2013	MYVO	10:02	M	A	N	39.3	12	9.5	No	0	353698	374899

Locality	Survey Date	Species	Capture Time	Sex	Age	Repro	FA	E	Wt	Keel	WDI	Wylam Easting	Wylam Northing
Little Prospect Mtn	7/26/2013	MYEV	22:55	M	A	N	39.4	17	8	Yes	0P	353699	374897
Little Prospect Mtn	7/26/2013	MYEV	22:55	F	A	N	40.6	17	6	Yes	0	353699	374897
Little Prospect Mtn	7/26/2013	MYVO	23:47	F	A	L	41.1	12	9.5	Yes	0P	353692	374903
Little Prospect Mtn	7/28/2013	MYLU	21:10	M	A	N	39.5	13	6.5	No	0	353705	374896
Little Prospect Mtn	7/28/2013	MYVO	21:10	F	A	N	41	11	8	Yes	0	353702	374894
Little Prospect Mtn	7/28/2013	MYLU	21:13	M	A	N	40	13	7	No	0P	353701	374898
Little Prospect Mtn	7/28/2013	MYLU	21:15	M	A	N	39.1	11	7	No	0	353701	374894
Little Prospect Mtn	7/28/2013	MYVO	21:29	F	A	L	40.5	13	9	Yes	0	353705	374895
Little Prospect Mtn	7/28/2013	MYEV	21:32	M	A	N	40.8	16	7	No	0	353704	374895
Little Prospect Mtn	7/28/2013	MYVO	21:33	F	A	L	42	11	9.5	Yes	0	353704	374896
Little Prospect Mtn	7/28/2013	MYEV	21:35	F	A	N	40.8	16.5	6.5	No	0	353705	374896
Little Prospect Mtn	7/28/2013	MYVO	21:35	F	A	P	40.6	11	9	Yes	0P	353704	374892
Circle Creek	8/4/2013	MYVO	21:07	F	A	N	41.15	11	8	Yes	0P	511010	287274
Circle Creek	8/4/2013	MYCI	21:14	F	A	L	35.7	14	4.5	Yes	0	363915	242307
Circle Creek	8/4/2013	MYVO	21:28	F	A	N	42.5	13	8.5	Yes	0P	363915	242308
Circle Creek	8/4/2013	MYCI	21:30	F	A	L	32.7	14	18	Yes	0	363915	242308
Circle Creek	8/4/2013	MYVO	21:32	F	A	L	41.15	13	7.5	Yes	0P	363916	242307
Circle Creek	8/4/2013	MYEV	21:40	F	A	L	37.4	17		Yes	0	363915	242308
Circle Creek	8/4/2013	MYCI	21:45	M	A	N	32.9	11	4	Yes	0	363915	242306
Circle Creek	8/4/2013	MYCI	21:46	F	A	L	34.4	12	3.5	Yes	0	363916	242306
Circle Creek	8/4/2013	COTO	21:40	F	A	L	41.1	33	11.5	No	0	363915	242305
Circle Creek	8/4/2013	MYVO	21:48	F	A	N	40.6	12	7	Yes	0P	363916	242304

Locality	Survey Date	Species	Capture Time	Sex	Age	Repro	FA	E	Wt	Keel	WDI	Wylam Easting	Wylam Northing
Circle Creek	8/4/2013	MYEV	22:00	M	A	N	40.85	23	5.5	Yes	0	363915	242306
Circle Creek	8/4/2013	MYVO	22:21	F	A	PL	41.25	11	8	Yes	0P	363915	242307
Circle Creek	8/4/2013	MYVO	22:18	F	A	N	41.5	12	9	Yes	0	363916	242307
Circle Creek	8/4/2013	MYCI	22:23	M	A	N	33.2	12	5	Yes	0	363915	242307
Circle Creek	8/4/2013	MYCI	22:25	F	A	N	33.2	12	4	Yes	0	363916	242307
Circle Creek	8/4/2013	MYEV	22:20	F	A	L	32.5	17	6	Yes	0P	363915	242308
Circle Creek	8/4/2013	MYVO	22:42	F	A	L	39.6	10	6	Yes	0	363915	242308
Circle Creek	8/4/2013	MYEV	22:45	F	A	L	39.1	20	7	No	0	363916	242307
Circle Creek	8/4/2013	MYEV	22:49	F	A	L	39.5	20	6	Yes	0	363913	242306
Circle Creek	8/4/2013	MYCI	22:55	F	A	L	39.5	13	5	Yes	0	363914	242307
Circle Creek	8/4/2013	COTO	23:10	F	A	L	44.4	35	10	No	0	363914	242311
Circle Creek	8/4/2013	MYEV	22:59	F	A	L	38.8	18	6	Yes	0	363914	242308
Circle Creek	8/4/2013	MYCI	23:01	F	A	N	34.6	10	5	Yes	0	363913	242309
Circle Creek	8/4/2013	MYEV	23:26	F	A	L	39.8	23	6.5	Yes	0P	363916	242311
Circle Creek	8/4/2013	MYCI	23:30	F	A	L	32.9	10	5	Yes	0	363914	242310
Circle Creek	8/4/2013	MYCI	23:30	F	A	N	33.1	10	5	Yes	0	363915	242309
Circle Creek	8/4/2013	MYVO	23:54	M	A	N	39.35	12	7	Yes	0P	363914	242308
Circle Creek	8/5/2013	MYVO	0:05	F	A	N	41	12	7.5	Yes	0	363908	242313
Circle Creek	8/5/2013	MYEV	0:05	F	A	P	40.9	19	7.5	Yes	0	363914	242310
Circle Creek	8/5/2013	MYEV	0:06	F	A	N	38	22	7	Yes	0	363914	242308
Circle Creek	8/5/2013	MYEV	0:23	M	A	N	39.2	19	6	Yes	0	363913	242306
Circle Creek	8/5/2013	MYTH	0:24	M	A	N	37.7	19	5	Yes	0	363914	242308
Pine Grove Creek	8/7/2013	LACI	21:50	M	A	D	52	12	23	Yes	0	262682	363123
Pine Grove Creek	8/7/2013	MYEV	22:43	M	J	N				No	0P	262681	363125
Hogsback Ridge	8/9/2013	MYEV	21:00	M	A	D	36.2	16	7	No	0	268653	345615
Hogsback Ridge	8/9/2013	MYEV	21:56	M	A	N	39.5	17	9	No	0	268626	345603

Locality	Survey Date	Species	Capture Time	Sex	Age	Repro	FA	E	Wt	Keel	WDI	Wylam Easting	Wylam Northing
Hogsback Ridge	8/9/2013	MYEV	22:23	F	A	L	40	18	8	No	0	268626	345604
Dry Basin	8/10/2013	MYVO	21:20	F	J	N	39.7	12	7	Yes	0	272869	363225
Dry Basin	8/10/2013	MYVO	21:56	F	A	L	40.6		9.5	Yes	0	272870	363223
Dry Basin	8/10/2013	MYCI	22:20	M	A	D	36	6	7	Yes	0	272870	363222
Dry Basin	8/11/2013	MYCI	0:05	M	A	N	32.5	12	5	Yes	0	272867	363222
Dry Basin	8/10/2013	LACI	22:50	F	A	N				No	0	272866	363225
Chapel Canyon	8/11/2013	MYCI	22:44	F	A	L	34.5	10	5.5	Yes	0	287113	357735
Chapel Canyon	8/11/2013	MYCI	22:45	M	A	N	31.3	9	4.5	Yes	0	287112	357734
Sweetwater Creek	8/15/2013	MYCI	21:15	M	A	N	33.1	12	5	Yes	0	362076	255818
Sweetwater Creek	8/15/2013	MYCI	21:31	M	A	N	32.85	11	4	Yes	0	362077	255818
Mc Cullen Bluff	8/23/2013	MYLU	21:30	F	A	N	33.65	9		No	0	295047	310559
Mc Cullen Bluff	8/23/2013	MYLU	21:32	F	A	N	35.8	10		No	0	295047	310559
Mc Cullen Bluff	8/23/2013	MYLU	21:33	M	A	N	34.8	12.1		No	0	295047	310559
Mc Cullen Bluff	8/23/2013	MYLU	21:45	M	J	N	35	10	6	No	0	295047	310559
Mc Cullen Bluff	8/23/2013	MYLU	21:59	F	A	N	38.9	11.1	12	No	0	295047	310559
Mc Cullen Bluff	8/23/2013	MYLU	22:00	F	A	N	37.7	10	11.5	No	0	295047	310559
Mc Cullen Bluff	8/23/2013	MYLU	22:01	F	A	N		12.1	12	No	0	295047	310559
Mc Cullen Bluff	8/23/2013	MYLU	22:12	F	A	N	38.6	13	9.5	No	0	295047	310559
Mc Cullen Bluff	8/23/2013	MYLU	22:14	F	J	N	38.8	10.8		No	0	295047	310559
Mc Cullen Bluff	8/24/2013	MYLU	21:55	F	J	N	38	12.8	8.5	No	0	295047	310559

Locality	**Survey Date**	**Species**	**Capture Time**	**Sex**	**Age**	**Repro**	**FA**	**E**	**Wt**	**Keel**	**WDI**	**Wylam Easting**	**Wylam Northing**
Mc Cullen Bluff	8/23/2013	MYLU	22:30	F	A	N	38.7	13.5	9.5	No	0	295047	310559
Mc Cullen Bluff	8/23/2013	MYLU	22:38	F	A	N	38.5	12.5	10	No	0	295047	310559
Mc Cullen Bluff	8/24/2013	MYLU	22:08	F	A	N	40.5		12	No	0	295047	310559
Mc Cullen Bluff	8/24/2013	MYLU	22:15	F	A	N	38.9	12.6	10	No	0	295047	310559
Mc Cullen Bluff	8/24/2013	MYLU	23:40	F	A	N	37.9	14.9	9	No	0	295047	310559
Mc Cullen Bluff	9/7/2013	MYLU	21:25	M	A	N				No	0	294632	310807

Appendix 2: 2013 Acoustic Monitoring Detections

Common Name	**Scientific Name**	**Date**	**Recording Type**	**Easting Wylam**	**Northing Wylam**
Hoary Bat	*Lasiurus cinereus*	07/08/2013	Songmeter	355167	206211
Long-eared Myotis	*Myotis evotis*	07/08/2013	Songmeter	355167	206211
Little Brown Myotis	*Myotis lucifugus*	07/09/2013	Songmeter	353609	211212
Western Small-footed Myotis	*Myotis ciliolabrum*	07/09/2013	Songmeter	353609	211212
Long-eared Myotis	*Myotis evotis*	07/09/2013	Songmeter	353609	211212
Silver-haired Bat	*Lasionycteris noctivagans*	07/09/2013	Songmeter	353609	211212
Little Brown Myotis	*Myotis lucifugus*	07/25/2013	Songmeter	341856	373213
Western Small-footed Myotis	*Myotis ciliolabrum*	07/25/2013	Songmeter	341856	373213
Western Small-footed Myotis	*Myotis ciliolabrum*	07/26/2013	Songmeter	357917	374212
Big Brown Bat	*Eptesicus fuscus*	07/28/2013	Songmeter	355309	374872
Silver-haired Bat	*Lasionycteris noctivagans*	07/28/2013	Songmeter	355309	374872
Little Brown Myotis	*Myotis lucifugus*	07/28/2013	Songmeter	355309	374872
Long-eared Myotis	*Myotis evotis*	07/28/2013	Songmeter	355309	374872
Hoary Bat	*Lasiurus cinereus*	07/28/2013	Songmeter	355309	374872
Big Brown Bat	*Eptesicus fuscus*	08/03/2013	Songmeter	380332	252172
Little Brown Myotis	*Myotis lucifugus*	08/03/2013	Songmeter	380332	252172
Hoary Bat	*Lasiurus cinereus*	08/03/2013	Songmeter	380332	252172
Western Small-footed Myotis	*Myotis ciliolabrum*	08/03/2013	Songmeter	380332	252172
Long-legged Myotis	*Myotis volans*	08/03/2013	Songmeter	380332	252172
Silver-haired Bat	*Lasionycteris noctivagans*	08/03/2013	Songmeter	380332	252172
Long-eared Myotis	*Myotis evotis*	08/04/2013	Songmeter	369768	238856
Western Small-footed Myotis	*Myotis ciliolabrum*	08/04/2013	Songmeter	369768	238856
Hoary Bat	*Lasiurus cinereus*	08/07/2013	Songmeter	263709	363054
Silver-haired Bat	*Lasionycteris noctivagans*	08/07/2013	Songmeter	263709	363054
Pallid Bat	*Antrozous pallidus*	08/07/2013	Songmeter	263709	363054
Long-eared Myotis	*Myotis evotis*	08/07/2013	Songmeter	263709	363054
Western Small-footed Myotis	*Myotis ciliolabrum*	08/07/2013	Songmeter	263709	363054
Little Brown Myotis	*Myotis lucifugus*	08/07/2013	Songmeter	263709	363054
Big Brown Bat	*Eptesicus fuscus*	08/07/2013	Songmeter	263709	363054
Long-eared Myotis	*Myotis evotis*	08/08/2013	Songmeter	263360	354150
Hoary Bat	*Lasiurus cinereus*	08/09/2013	Songmeter	273222	347891
Western Small-footed Myotis	*Myotis ciliolabrum*	08/09/2013	Songmeter	273222	347891
Long-eared Myotis	*Myotis evotis*	08/09/2013	Songmeter	273222	347891
Western Small-footed Myotis	*Myotis ciliolabrum*	08/10/2013	Songmeter	264588	352385
Long-eared Myotis	*Myotis evotis*	08/10/2013	Songmeter	264588	352385
Western Small-footed Myotis	*Myotis ciliolabrum*	08/11/2013	Songmeter	293364	355724

Common Name	Scientific Name	Date	Recording Type	Easting Wylam	Northing Wylam
Long-eared Myotis	*Myotis evotis*	08/11/2013	Songmeter	293364	355724
Western Small-footed Myotis	*Myotis ciliolabrum*	08/12/2013	Songmeter	275396	351721
Little Brown Myotis	*Myotis lucifugus*	08/12/2013	Songmeter	275396	351721
Western Small-footed Myotis	*Myotis ciliolabrum*	08/14/2013	Songmeter	345041	260167
Little Brown Myotis	*Myotis lucifugus*	08/14/2013	Songmeter	345041	260167
Hoary Bat	*Lasiurus cinereus*	08/14/2013	Songmeter	345041	260167
Silver-haired Bat	*Lasionycteris noctivagans*	08/14/2013	Songmeter	345041	260167
Silver-haired Bat	*Lasionycteris noctivagans*	08/15/2013	Songmeter	363037	260135
Western Small-footed Myotis	*Myotis ciliolabrum*	08/15/2013	Songmeter	363037	260135
Western Small-footed Myotis	*Myotis ciliolabrum*	08/16/2013	Songmeter	363073	267666
Little Brown Myotis	*Myotis lucifugus*	08/16/2013	Songmeter	363073	267666
Western Small-footed Myotis	*Myotis ciliolabrum*	08/19/2019	Songmeter	410295	317288
Western Small-footed Myotis	*Myotis ciliolabrum*	08/20/2013	Songmeter	394244	319838
Little Brown Myotis	*Myotis lucifugus*	08/20/2013	Songmeter	394244	319838
Long-eared Myotis	*Myotis evotis*	08/20/2013	Songmeter	394244	319838
Western Small-footed Myotis	*Myotis ciliolabrum*	08/21/2013	Songmeter	306210	224981
Little Brown Myotis	*Myotis lucifugus*	08/21/2013	Songmeter	306210	224981
Western Small-footed Myotis	*Myotis ciliolabrum*	08/22/2013	Songmeter	289814	232580
Long-eared Myotis	*Myotis evotis*	08/22/2013	Songmeter	289814	232580
Little Brown Myotis	*Myotis lucifugus*	08/22/2013	Songmeter	289814	232580
Long-eared Myotis	*Myotis evotis*	08/25/2013	Songmeter	402164	307711
Long-eared Myotis	*Myotis evotis*	09/05/2013	Songmeter	289187	369101
Western Small-footed Myotis	*Myotis ciliolabrum*	09/05/2013	Songmeter	289187	369101
Little Brown Myotis	*Myotis lucifugus*	09/05/2013	Songmeter	289187	369101
Hoary Bat	*Lasiurus cinereus*	09/05/2013	Songmeter	289187	369101
Silver-haired Bat	*Lasionycteris noctivagans*	09/05/2013	Songmeter	289187	369101
Western Small-footed Myotis	*Myotis ciliolabrum*	09/06/2013	Songmeter	267662	357625
Long-eared Myotis	*Myotis evotis*	09/06/2013	Songmeter	267662	357625
Silver-haired Bat	*Lasionycteris noctivagans*	09/07/2013	Songmeter	296872	308520
Western Small-footed Myotis	*Myotis ciliolabrum*	09/07/2013	Songmeter	296872	308520
Long-eared Myotis	*Myotis evotis*	09/09/2013	Songmeter	349363	356622
Long-eared Myotis	*Myotis evotis*	09/10/2013	Songmeter	342392	371147
Little Brown Myotis	*Myotis lucifugus*	09/20/2013	Songmeter	303384	222448
Silver-haired Bat	*Lasionycteris noctivagans*	09/20/2013	Songmeter	303384	222448
Hoary Bat	*Lasiurus cinereus*	09/22/2013	Songmeter	390900	202144
Long-eared Myotis	*Myotis evotis*	09/24/2013	Songmeter	355859	212513
Long-eared Myotis	*Myotis evotis*	07/09/2013	Songmeter	386540	213457

Common Name	Scientific Name	Date	Recording Type	Easting Wylam	Northing Wylam
Long-eared Myotis	*Myotis evotis*	07/10/2013	Songmeter	383346	203245
Silver-haired Bat	*Lasionycteris noctivagans*	07/10/2013	Songmeter	383346	203245
Western Small-footed Myotis	*Myotis ciliolabrum*	07/10/2013	Songmeter	383346	203245
Pallid Bat	*Antrozous pallidus*	07/10/2013	Songmeter	383346	203245
Little Brown Myotis	*Myotis lucifugus*	07/10/2013	Songmeter	383346	203245
Pallid Bat	*Antrozous pallidus*	07/11/2013	Songmeter	388651	202887
Big Brown Bat	*Eptesicus fuscus*	07/11/2013	Songmeter	388651	202887
Western Small-footed Myotis	*Myotis ciliolabrum*	07/11/2013	Songmeter	388651	202887
Little Brown Myotis	*Myotis lucifugus*	07/11/2013	Songmeter	388651	202887
Hoary Bat	*Lasiurus cinereus*	07/11/2013	Songmeter	388651	202887
Long-eared Myotis	*Myotis evotis*	07/11/2013	Songmeter	388651	202887
Long-legged Myotis	*Myotis volans*	07/11/2013	Songmeter	388651	202887
Silver-haired Bat	*Lasionycteris noctivagans*	07/11/2013	Songmeter	388651	202887
Western Small-footed Myotis	*Myotis ciliolabrum*	07/12/2013	Songmeter	400131	215362
Long-eared Myotis	*Myotis evotis*	07/12/2013	Songmeter	400131	215362
Western Small-footed Myotis	*Myotis ciliolabrum*	07/13/2013	Songmeter	403588	223414
Long-eared Myotis	*Myotis evotis*	07/13/2013	Songmeter	403588	223414
Little Brown Myotis	*Myotis lucifugus*	07/14/2013	Songmeter	405088	219026
Western Small-footed Myotis	*Myotis ciliolabrum*	07/14/2013	Songmeter	405088	219026
Long-eared Myotis	*Myotis evotis*	07/14/2013	Songmeter	405088	219026
Western Small-footed Myotis	*Myotis ciliolabrum*	07/27/2013	Songmeter	344095	304601
Long-eared Myotis	*Myotis evotis*	07/28/2013	Songmeter	348741	367244
Little Brown Myotis	*Myotis lucifugus*	08/03/2013	Songmeter	377894	254080
Western Small-footed Myotis	*Myotis ciliolabrum*	08/03/2013	Songmeter	377894	254080
Western Small-footed Myotis	*Myotis ciliolabrum*	08/04/2013	Songmeter	369055	239410
Hoary Bat	*Lasiurus cinereus*	08/04/2013	Songmeter	369055	239410
Western Small-footed Myotis	*Myotis ciliolabrum*	08/06/2013	Songmeter	275156	341382
Little Brown Myotis	*Myotis lucifugus*	08/06/2013	Songmeter	275156	341382
Hoary Bat	*Lasiurus cinereus*	08/07/2013	Songmeter	264734	362373
Western Small-footed Myotis	*Myotis ciliolabrum*	08/07/2013	Songmeter	264734	362373
Little Brown Myotis	*Myotis lucifugus*	08/07/2013	Songmeter	264734	362373
Long-eared Myotis	*Myotis evotis*	08/07/2013	Songmeter	264734	362373
Long-eared Myotis	*Myotis evotis*	08/08/2013	Songmeter	263350	355626
Western Small-footed Myotis	*Myotis ciliolabrum*	08/08/2013	Songmeter	263350	355626
Hoary Bat	*Lasiurus cinereus*	08/08/2013	Songmeter	263350	355626
Long-eared Myotis	*Myotis evotis*	08/09/2013	Songmeter	270471	355558
Western Small-footed Myotis	*Myotis ciliolabrum*	08/09/2013	Songmeter	270471	355558
Little Brown Myotis	*Myotis lucifugus*	08/11/2013	Songmeter	289003	370343
Long-eared Myotis	*Myotis evotis*	08/11/2013	Songmeter	289003	370343

Common Name	Scientific Name	Date	Recording Type	Easting Wylam	Northing Wylam
Western Small-footed Myotis	*Myotis ciliolabrum*	08/11/2013	Songmeter	289003	370343
Long-eared Myotis	*Myotis evotis*	08/12/2013	Songmeter	277990	349702
Little Brown Myotis	*Myotis lucifugus*	08/14/2013	Songmeter	348979	258754
Silver-haired Bat	*Lasionycteris noctivagans*	08/14/2013	Songmeter	348979	258754
Western Small-footed Myotis	*Myotis ciliolabrum*	08/14/2013	Songmeter	348979	258754
Western Small-footed Myotis	*Myotis ciliolabrum*	08/15/2013	Songmeter	362473	251609
Long-eared Myotis	*Myotis evotis*	08/15/2013	Songmeter	362473	251609
Hoary Bat	*Lasiurus cinereus*	08/15/2013	Songmeter	362473	251609
Western Small-footed Myotis	*Myotis ciliolabrum*	08/16/2013	Songmeter	372085	271740
Western Small-footed Myotis	*Myotis ciliolabrum*	08/19/2013	Songmeter	329836	269371
Little Brown Myotis	*Myotis lucifugus*	08/19/2013	Songmeter	329836	269371
Little Brown Myotis	*Myotis lucifugus*	08/20/2013	Songmeter	302588	306017
Hoary Bat	*Lasiurus cinereus*	08/20/2013	Songmeter	302588	306017
Long-eared Myotis	*Myotis evotis*	08/20/2013	Songmeter	302588	306017
Little Brown Myotis	*Myotis lucifugus*	08/21/2013	Songmeter	307001	303002
Western Small-footed Myotis	*Myotis ciliolabrum*	08/23/2013	Songmeter	325453	298747
Little Brown Myotis	*Myotis lucifugus*	08/24/2013	Songmeter	304720	303771
Hoary Bat	*Lasiurus cinereus*	08/24/2013	Songmeter	304720	303771
Silver-haired Bat	*Lasionycteris noctivagans*	08/25/2013	Songmeter	295599	309102
Little Brown Myotis	*Myotis lucifugus*	08/25/2013	Songmeter	295599	309102
Western Small-footed Myotis	*Myotis ciliolabrum*	08/25/2013	Songmeter	295599	309102
Long-eared Myotis	*Myotis evotis*	08/25/2013	Songmeter	295599	309102
Hoary Bat	*Lasiurus cinereus*	08/25/2013	Songmeter	295599	309102
Western Small-footed Myotis	*Myotis ciliolabrum*	09/05/2013	Songmeter	292108	370987
Little Brown Myotis	*Myotis lucifugus*	09/05/2013	Songmeter	292108	370987
Little Brown Myotis	*Myotis lucifugus*	09/06/2013	Songmeter	270176	359449
Silver-haired Bat	*Lasionycteris noctivagans*	09/06/2013	Songmeter	270176	359449
Long-eared Myotis	*Myotis evotis*	09/07/2013	Songmeter	296619	307028
Hoary Bat	*Lasiurus cinereus*	09/09/2013	Songmeter	350335	357029
Hoary Bat	*Lasiurus cinereus*	09/21/2013	Songmeter	400031	217286
Hoary Bat	*Lasiurus cinereus*	09/23/2013	Songmeter	378840	236970
Hoary Bat	*Lasiurus cinereus*	09/24/2013	Songmeter	357416	210308
Silver-haired Bat	*Lasionycteris noctivagans*	07/01/2013	Songmeter	678821	220197
Hoary Bat	*Lasiurus cinereus*	07/01/2013	Songmeter	678821	220197
Long-legged Myotis	*Myotis volans*	07/02/2013	Songmeter	673347	307651
Western Small-footed Myotis	*Myotis ciliolabrum*	07/02/2013	Songmeter	673347	307651
Long-eared Myotis	*Myotis evotis*	07/02/2013	Songmeter	673347	307651
Western Small-footed Myotis	*Myotis ciliolabrum*	07/09/2013	Songmeter	355167	210786

Common Name	Scientific Name	Date	Recording Type	Easting Wylam	Northing Wylam
Silver-haired Bat	*Lasionycteris noctivagans*	07/09/2013	Songmeter	355167	210786
Long-eared Myotis	*Myotis evotis*	07/09/2013	Songmeter	355167	210786
Long-eared Myotis	*Myotis evotis*	07/10/2013	Songmeter	350649	210171
Hoary Bat	*Lasiurus cinereus*	07/10/2013	Songmeter	350649	210171
Western Small-footed Myotis	*Myotis ciliolabrum*	07/10/2013	Songmeter	350649	210171
Western Small-footed Myotis	*Myotis ciliolabrum*	07/11/2013	Songmeter	349912	205958
Hoary Bat	*Lasiurus cinereus*	07/12/2013	Songmeter	365170	203046
Little Brown Myotis	*Myotis lucifugus*	07/23/2013	Songmeter	334120	350991
Western Small-footed Myotis	*Myotis ciliolabrum*	07/24/2013	Songmeter	336733	369728
Long-eared Myotis	*Myotis evotis*	07/28/2013	Songmeter	356203	376805
Western Small-footed Myotis	*Myotis ciliolabrum*	08/05/2013	Songmeter	378103	261782
Long-eared Myotis	*Myotis evotis*	08/10/2013	Songmeter	261316	351619
Hoary Bat	*Lasiurus cinereus*	08/10/2013	Songmeter	261316	351619
Hoary Bat	*Lasiurus cinereus*	08/11/2013	Songmeter	285523	359613
Western Small-footed Myotis	*Myotis ciliolabrum*	08/11/2013	Songmeter	285523	359613
Long-eared Myotis	*Myotis evotis*	08/21/2013	Songmeter	306453	230920
Western Small-footed Myotis	*Myotis ciliolabrum*	08/21/2013	Songmeter	306453	230920
Western Small-footed Myotis	*Myotis ciliolabrum*	08/22/2013	Songmeter	291513	232442
Long-eared Myotis	*Myotis evotis*	08/22/2013	Songmeter	291513	232442
Hoary Bat	*Lasiurus cinereus*	08/23/2013	Songmeter	294171	215973
Western Small-footed Myotis	*Myotis ciliolabrum*	09/06/2013	Songmeter	272863	354209
Silver-haired Bat	*Lasionycteris noctivagans*	09/07/2013	Songmeter	294455	310190
Silver-haired Bat	*Lasionycteris noctivagans*	09/19/2013	Songmeter	277721	220497
Silver-haired Bat	*Lasionycteris noctivagans*	07/01/2013	Songmeter	678821	220197
Long-eared Myotis	*Myotis evotis*	07/01/2013	Songmeter	678821	220197
Hoary Bat	*Lasiurus cinereus*	07/01/2013	Songmeter	678821	220197
Little Brown Myotis	*Myotis lucifugus*	07/01/2013	Songmeter	678821	220197
Hoary Bat	*Lasiurus cinereus*	07/02/2013	Songmeter	672913	305286
Silver-haired Bat	*Lasionycteris noctivagans*	07/02/2013	Songmeter	672913	305286
Little Brown Myotis	*Myotis lucifugus*	07/02/2013	Songmeter	672913	305286
Big Brown Bat	*Eptesicus fuscus*	07/02/2013	Songmeter	672913	305286
Long-legged Myotis	*Myotis volans*	07/02/2013	Songmeter	672913	305286
Long-eared Myotis	*Myotis evotis*	07/02/2013	Songmeter	672913	305286
Western Small-footed Myotis	*Myotis ciliolabrum*	07/02/2013	Songmeter	672913	305286
Fringed Myotis (Statewide)	*Myotis thysanodes*	07/02/2013	Songmeter	672913	305286
Long-eared Myotis	*Myotis evotis*	07/03/2013	Songmeter	577593	330194
Pallid Bat	*Antrozous pallidus*	07/09/2013	Songmeter	386972	211101

Common Name	**Scientific Name**	**Date**	**Recording Type**	**Easting Wylam**	**Northing Wylam**
Long-eared Myotis	*Myotis evotis*	07/10/2013	Songmeter	381545	203183
Western Small-footed Myotis	*Myotis ciliolabrum*	07/10/2013	Songmeter	381545	203183
Hoary Bat	*Lasiurus cinereus*	07/10/2013	Songmeter	381545	203183
Silver-haired Bat	*Lasionycteris noctivagans*	07/10/2013	Songmeter	381545	203183
Pallid Bat	*Antrozous pallidus*	07/10/2013	Songmeter	381545	203183
Little Brown Myotis	*Myotis lucifugus*	07/10/2013	Songmeter	381545	203183
Big Brown Bat	*Eptesicus fuscus*	07/10/2013	Songmeter	381545	203183
Silver-haired Bat	*Lasionycteris noctivagans*	07/11/2013	Songmeter	390136	202858
Western Small-footed Myotis	*Myotis ciliolabrum*	07/12/2013	Songmeter	402621	217545
Western Small-footed Myotis	*Myotis ciliolabrum*	07/12/2013	Songmeter	403427	224682
Little Brown Myotis	*Myotis lucifugus*	07/13/2013	Songmeter	403427	224682
Western Small-footed Myotis	*Myotis ciliolabrum*	07/14/2013	Songmeter	405220	221816
Little Brown Myotis	*Myotis lucifugus*	07/23/2013	Songmeter	347980	337443
Western Small-footed Myotis	*Myotis ciliolabrum*	07/23/2013	Songmeter	347980	337443
Little Brown Myotis	*Myotis lucifugus*	07/25/2013	Songmeter	329461	314629
Western Small-footed Myotis	*Myotis ciliolabrum*	07/25/2013	Songmeter	329461	314629
Western Small-footed Myotis	*Myotis ciliolabrum*	07/27/2013	Songmeter	326298	315420
Long-eared Myotis	*Myotis evotis*	07/28/2013	Songmeter	348614	368858
Pallid Bat	*Antrozous pallidus*	08/03/2013	Songmeter	382848	252668
Little Brown Myotis	*Myotis lucifugus*	08/03/2013	Songmeter	382848	252668
Hoary Bat	*Lasiurus cinereus*	08/03/2013	Songmeter	382848	252668
Western Small-footed Myotis	*Myotis ciliolabrum*	08/03/2013	Songmeter	382848	252668
Silver-haired Bat	*Lasionycteris noctivagans*	08/03/2013	Songmeter	382848	252668
Western Small-footed Myotis	*Myotis ciliolabrum*	08/05/2013	Songmeter	380176	245992
Long-eared Myotis	*Myotis evotis*	08/05/2013	Songmeter	380176	245992
Hoary Bat	*Lasiurus cinereus*	08/07/2013	Songmeter	264838	363935
Long-eared Myotis	*Myotis evotis*	08/07/2013	Songmeter	264838	363935
Western Small-footed Myotis	*Myotis ciliolabrum*	08/07/2013	Songmeter	264838	363935
Little Brown Myotis	*Myotis lucifugus*	08/07/2013	Songmeter	264838	363935
Western Small-footed Myotis	*Myotis ciliolabrum*	08/08/2013	Songmeter	260954	356003
Long-eared Myotis	*Myotis evotis*	08/08/2013	Songmeter	260954	356003
Hoary Bat	*Lasiurus cinereus*	08/08/2013	Songmeter	260954	356003
Little Brown Myotis	*Myotis lucifugus*	08/09/2013	Songmeter	271029	351786
Western Small-footed Myotis	*Myotis ciliolabrum*	08/09/2013	Songmeter	271029	351786
Long-eared Myotis	*Myotis evotis*	08/09/2013	Songmeter	271029	351786
Long-eared Myotis	*Myotis evotis*	08/10/2013	Songmeter	260160	352552
Western Small-footed Myotis	*Myotis ciliolabrum*	08/10/2013	Songmeter	260160	352552
Western Small-footed Myotis	*Myotis ciliolabrum*	08/11/2013	Songmeter	292782	356603

Common Name	Scientific Name	Date	Recording Type	Easting Wylam	Northing Wylam
Long-eared Myotis	*Myotis evotis*	08/11/2013	Songmeter	292782	356603
Western Small-footed Myotis	*Myotis ciliolabrum*	08/12/2013	Songmeter	273056	351868
Little Brown Myotis	*Myotis lucifugus*	08/12/2013	Songmeter	273056	351868
Long-eared Myotis	*Myotis evotis*	08/12/2013	Songmeter	273056	351868
Silver-haired Bat	*Lasionycteris noctivagans*	08/16/2013	Songmeter	363835	282737
Western Small-footed Myotis	*Myotis ciliolabrum*	08/16/2013	Songmeter	363835	282737
Little Brown Myotis	*Myotis lucifugus*	08/19/2013	Songmeter	332413	264005
Hoary Bat	*Lasiurus cinereus*	08/19/2013	Songmeter	332413	264005
Silver-haired Bat	*Lasionycteris noctivagans*	08/19/2013	Songmeter	332413	264005
Western Small-footed Myotis	*Myotis ciliolabrum*	08/19/2013	Songmeter	332413	264005
Little Brown Myotis	*Myotis lucifugus*	08/20/2013	Songmeter	298398	307341
Silver-haired Bat	*Lasionycteris noctivagans*	08/20/2013	Songmeter	298398	307341
Hoary Bat	*Lasiurus cinereus*	08/20/2013	Songmeter	298398	307341
Silver-haired Bat	*Lasionycteris noctivagans*	08/21/2013	Songmeter	303635	305696
Long-eared Myotis	*Myotis evotis*	08/21/2013	Songmeter	303635	305696
Hoary Bat	*Lasiurus cinereus*	08/22/2013	Songmeter	315830	281834
Little Brown Myotis	*Myotis lucifugus*	08/22/2013	Songmeter	315830	281834
Little Brown Myotis	*Myotis lucifugus*	08/23/2013	Songmeter	308947	299641
Silver-haired Bat	*Lasionycteris noctivagans*	08/23/2013	Songmeter	308947	299641
Hoary Bat	*Lasiurus cinereus*	08/23/2013	Songmeter	308947	299641
Long-eared Myotis	*Myotis evotis*	08/23/2013	Songmeter	308947	299641
Pallid Bat	*Antrozous pallidus*	08/23/2013	Songmeter	308947	299641
Western Small-footed Myotis	*Myotis ciliolabrum*	08/24/2013	Songmeter	308176	295671
Silver-haired Bat	*Lasionycteris noctivagans*	08/25/2013	Songmeter	306095	303856
Big Brown Bat	*Eptesicus fuscus*	08/25/2013	Songmeter	306095	303856
Little Brown Myotis	*Myotis lucifugus*	08/25/2013	Songmeter	306095	303856
Long-eared Myotis	*Myotis evotis*	08/25/2013	Songmeter	306095	303856
Hoary Bat	*Lasiurus cinereus*	08/25/2013	Songmeter	306095	303856
Hoary Bat	*Lasiurus cinereus*	09/04/2013	Songmeter	343990	268481
Western Small-footed Myotis	*Myotis ciliolabrum*	09/05/2013	Songmeter	290691	371499
Hoary Bat	*Lasiurus cinereus*	09/05/2013	Songmeter	290691	371499
Little Brown Myotis	*Myotis lucifugus*	09/05/2013	Songmeter	290691	371499
Long-eared Myotis	*Myotis evotis*	09/05/2013	Songmeter	290691	371499
Big Brown Bat	*Eptesicus fuscus*	09/05/2013	Songmeter	290691	371499
Western Small-footed Myotis	*Myotis ciliolabrum*	09/06/2013	Songmeter	266969	356492
Little Brown Myotis	*Myotis lucifugus*	09/06/2013	Songmeter	266969	356492

Common Name	Scientific Name	Date	Recording Type	Easting Wylam	Northing Wylam
Silver-haired Bat	*Lasionycteris noctivagans*	09/07/2013	Songmeter	293493	309898
Little Brown Myotis	*Myotis lucifugus*	09/07/2013	Songmeter	293493	309898
Silver-haired Bat	*Lasionycteris noctivagans*	09/20/2013	Songmeter	303638	227941
Big Brown Bat	*Eptesicus fuscus*	09/21/2013	Songmeter	401726	212258
Hoary Bat	*Lasiurus cinereus*	09/22/2013	Songmeter	392344	205139
Silver-haired Bat	*Lasionycteris noctivagans*	07/01/2013	EchoMeter3	679006	220130
Hoary Bat	*Lasiurus cinereus*	07/01/2013	EchoMeter3	679006	220130
Little Brown Myotis	*Myotis lucifugus*	07/01/2013	EchoMeter3	679006	220130
Little Brown Myotis	*Myotis lucifugus*	07/02/2013	EchoMeter3	672885	305238
Long-legged Myotis	*Myotis volans*	07/02/2013	EchoMeter3	672885	305238
Western Small-footed Myotis	*Myotis ciliolabrum*	07/02/2013	EchoMeter3	672885	305238
Little Brown Myotis	*Myotis lucifugus*	07/09/2013	EchoMeter3	357618	210882
Western Small-footed Myotis	*Myotis ciliolabrum*	07/09/2013	EchoMeter3	357618	210882
Long-eared Myotis	*Myotis evotis*	07/09/2013	EchoMeter3	357618	210882
Silver-haired Bat	*Lasionycteris noctivagans*	07/09/2013	EchoMeter3	357618	210882
California Myotis	*Myotis californicus*	07/09/2013	EchoMeter3	357618	210882
Long-legged Myotis	*Myotis volans*	07/09/2013	EchoMeter3	357618	210882
Hoary Bat	*Lasiurus cinereus*	07/09/2013	EchoMeter3	357618	210882
Western Small-footed Myotis	*Myotis ciliolabrum*	07/10/2013	EchoMeter3	355044	205178
Little Brown Myotis	*Myotis lucifugus*	07/10/2013	EchoMeter3	355044	205178
Long-legged Myotis	*Myotis volans*	07/10/2013	EchoMeter3	355044	205178
Long-eared Myotis	*Myotis evotis*	07/10/2013	EchoMeter3	355044	205178
Hoary Bat	*Lasiurus cinereus*	07/10/2013	EchoMeter3	355044	205178
Long-eared Myotis	*Myotis evotis*	07/13/2013	EchoMeter3	370027	204770
Western Small-footed Myotis	*Myotis ciliolabrum*	08/04/2013	EchoMeter3	363915	242307
Little Brown Myotis	*Myotis lucifugus*	08/04/2013	EchoMeter3	363915	242307
Long-eared Myotis	*Myotis evotis*	08/04/2013	EchoMeter3	363915	242307
Hoary Bat	*Lasiurus cinereus*	08/04/2013	EchoMeter3	363915	242307
Long-eared Myotis	*Myotis evotis*	08/09/2013	EchoMeter3	268653	345615
Western Small-footed Myotis	*Myotis ciliolabrum*	08/09/2013	EchoMeter3	268653	345615
Western Small-footed Myotis	*Myotis ciliolabrum*	08/10/2013	EchoMeter3	272869	363225
Little Brown Myotis	*Myotis lucifugus*	08/10/2013	EchoMeter3	272869	363225
Long-eared Myotis	*Myotis evotis*	08/10/2013	EchoMeter3	272869	363225
Long-legged Myotis	*Myotis volans*	08/10/2013	EchoMeter3	272869	363225
California Myotis	*Myotis californicus*	08/10/2013	EchoMeter3	272869	363225
Hoary Bat	*Lasiurus cinereus*	08/10/2013	EchoMeter3	272869	363225
Big Brown Bat	*Eptesicus fuscus*	08/10/2013	EchoMeter3	272869	363225
Long-eared Myotis	*Myotis evotis*	08/11/2013	EchoMeter3	287113	257735

Common Name	**Scientific Name**	**Date**	**Recording Type**	**Easting Wylam**	**Northing Wylam**
Western Small-footed Myotis	*Myotis ciliolabrum*	08/11/2013	EchoMeter3	287113	257735
Little Brown Myotis	*Myotis lucifugus*	08/11/2013	EchoMeter3	287113	257735
Hoary Bat	*Lasiurus cinereus*	08/11/2013	EchoMeter3	287113	257735
Western Small-footed Myotis	*Myotis ciliolabrum*	08/16/2013	EchoMeter3	370261	280689
Western Small-footed Myotis	*Myotis ciliolabrum*	08/23/2013	EchoMeter3	295902	232313
Western Small-footed Myotis	*Myotis ciliolabrum*	08/24/2013	EchoMeter3	321132	243843
Western Small-footed Myotis	*Myotis ciliolabrum*	08/25/2013	EchoMeter3	398466	306302
Hoary Bat	*Lasiurus cinereus*	08/25/2013	EchoMeter3	398466	306302
Western Small-footed Myotis	*Myotis ciliolabrum*	09/05/2013	EchoMeter3	287081	357700
Little Brown Myotis	*Myotis lucifugus*	09/05/2013	EchoMeter3	287081	357700
Little Brown Myotis	*Myotis lucifugus*	09/07/2013	EchoMeter3	294632	310807
Little Brown Myotis	*Myotis lucifugus*	09/19/2013	EchoMeter3	281587	222991
Western Small-footed Myotis	*Myotis ciliolabrum*	09/19/2013	EchoMeter3	281587	222991
Western Small-footed Myotis	*Myotis ciliolabrum*	07/25/2013	Anabat	329971	316833
Little Brown Myotis	*Myotis lucifugus*	07/25/2013	Anabat	329971	316833
Pallid Bat	*Antrozous pallidus*	07/25/2013	Anabat	329971	316833
Little Brown Myotis	*Myotis lucifugus*	07/27/2013	Anabat	329446	314945
Long-legged Myotis	*Myotis volans*	07/27/2013	Anabat	329446	314945
Hoary Bat	*Lasiurus cinereus*	07/28/2013	Anabat	353705	374897
Little Brown Myotis	*Myotis lucifugus*	07/28/2013	Anabat	353705	374897
Western Small-footed Myotis	*Myotis ciliolabrum*	07/28/2013	Anabat	353705	374897
Long-eared Myotis	*Myotis evotis*	07/28/2013	Anabat	353705	374897
Little Brown Myotis	*Myotis lucifugus*	08/21/2013	Anabat	302592	305605
Silver-haired Bat	*Lasionycteris noctivagans*	08/21/2013	Anabat	302592	305605
Western Small-footed Myotis	*Myotis ciliolabrum*	08/22/2013	Anabat	295047	310559
Little Brown Myotis	*Myotis lucifugus*	08/22/2013	Anabat	295047	310559

Appendix 3: Key to Wyoming Bats

Key to the Bats of Wyoming: GYE Version

Doug Keinath, WYNDD Zoologist

#	If this is true …	… then go to …
1a	Tail extends 1/3 or more beyond rear edge of uropatagium.	2
1b	Tail does not extend more than barely beyond rear edge of uropatagium	3
2a	Forearm > 50mm. [Large bat. Ears join at forehead. Pale-brown to black fur.]	Nyctinomops macrotus
2b	Forearm < 50mm. [Smallish bat. Ears almost joined at forehead. Gray-brown fur.]	Tadarida brasiliensis
3a	Conspicuous pair of white spots on shoulders and one on rump contrast with black dorsal fur. Pink ears.	Euderma maculatum
3b	Lacks white dorsal spots.	4
4a	At least anterior half of dorsal surface of uropatagium heavily furred.	5
4b	Dorsal surface of uropatagium mostly naked or scantily furred.	7
5a	Distinct white patches of fur at dorsal bases of thumbs and often on shoulders. Dorsal surface of uropatagium fully furred.	6
5b	No white patches of fur at dorsal bases of thumbs or on shoulders. Dorsal surface of uropatagium ranging from half to fully furred. Black dorsal fur with silver tips. Black face and uropatagium.	Lasionycteris noctivagans
6a	Light colored ear distinctively edged in black. Dorsal hairs dark gray and tipped with a broad band of white giving a hoary colored appearance. Forearm 46-58mm.	Lasiurus cinereus
6b	Light colored ear never edged in black. Fur bright reddish-orange to yellow in males and tending toward light brownish – grayish in females. Dorsal hairs never dark gray and tipped with white, though possibly frosted. Forearm 35-45mm.	Lasiurus borealis
7a	Dorsal fur lighter at base (pale yellow-blond) than tips (brown). Pale translucent ears 25-33mm long. Forearm 50-55mm. Blunt snout.	Antrozous pallidus
7b	Dorsal fur darker at base than tips. Fur color, ear and forearm lengths highly variable.	8
8a	Prominent pair of lumps above nose on each side of muzzle (see picture). Ear length 30-39mm. Slate-gray fur.	Corynorhinus townsendii
8b	No lumps on nose.	9
9a	Very small bat (mass ≤ 6g; forearm usu. < 33mm). Tragus relatively short and not sharply pointed.	10
9b	Larger (mass > 6g; forearm usu. > 33mm). Tragus longer and somewhat pointed.	11
10a	Small-bodied (3-6g). Tragus short (<5mm), blunt, and club-shaped. Body fur medium to pale brown in contrast to jet black face and ears. Tail membrane sparsely furred on anterior third of dorsal surface. Forearm 27-33mm.	Pipistrellus Hesperus
10b	Hair distinctively tricolored (dark base / light middle / dark tip). Lighter ears and no distinct face mask. Leading edge of wing noticeably paler than rest of membrane. Forearm 30-35mm.	Pipistrellus subflavus
11a	Large, medium to dark brown with keeled calcar. First upper premolar ≥ ½ canine length (see Fig. 11a). Forearm 42-51mm (wingspan 325-350mm). Tragus rounded.	Eptesicus fuscus
11b	Smallish bat. First upper premolar less than ¼ as tall as canine (see Fig. 11b).	12 (myotis spp.)

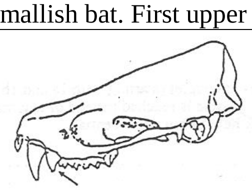


Fig. 11a. First upper premolar ½ as tall as canine (*Eptesicus fuscus*)

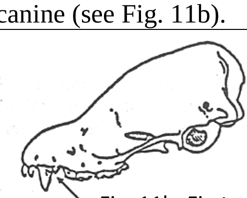


Fig. 11b. First upper premolar < ¼ as tall as canine (*Myotis spp.*)

Myotis species

#	If this is true …	… then go to …
12a	Calcar keeled. (see Fig. 12a)	13
12b	Calcar NOT keeled. (see Fig. 12b)	15

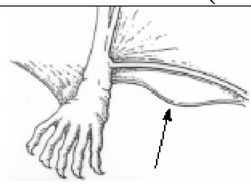


Fig. 12a. Keeled calcar (go to 12)

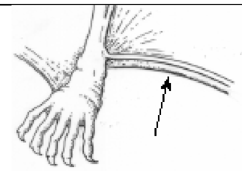


Fig. 12b. Keel absent (go to 14)

Keeled calcar

#	If this is true …	… then go to …
13a	Forearm 38-42mm (wingspan 250-270mm). Body fur uniformly dark brown or grayish brown with no distinctively darker face mask. [Underside of wing furred from side to elbow.]	Myotis volans
13b	Forearm 29-36mm. Body fur medium to very light tan or reddish brown with clearly darker face mask. [Underside of wing not furred from side to elbow.]	14
14a	Thumb length < 4.2mm. Tail does NOT extend beyond uropatagium. Braincase has an abruptly rising profile (convex forehead). Length of bare snout ≈ width across nostrils. Dorsal fur dull, pale colored, with slightly-contrasting dark brown face mask.(Fig. 14a)	Myotis californicus
14b	Thumb length > 4.2mm. Tail often extends slightly beyond uropatagium. No distinct rise in braincase profile (sloping forehead). Length across snout ≈ 1.5 times width across nostrils. Dorsal fur slightly shiny, pale colored, and sharply contrasting with black face mask. (Fig. 14b)	Myotis ciliolabrum

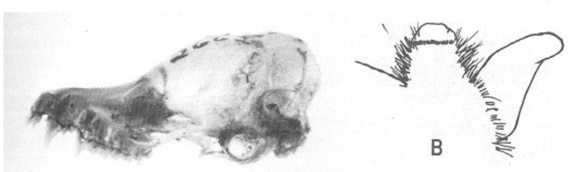


Fig. 14a. *M. californicus:* Rising braincase. Length of bare snout ≈ width across nostrils.

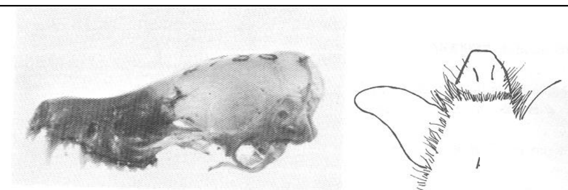


Fig 14b. *M.ciliolabrum*: Shallow braincase. Length across snout ≈ 1.5 times width across nostrils

Long Ears

#	If this is true …	… then go to …
15a	Distinct fringe of hair extending 1.0-1.5mm beyond edge of uropatagium (picture). Ears darkly pigmented and 16-20mm long. Belly fur light. Forearm 39-46mm.	Myotis thysanodes
15b	Fringe absent (no more than scattered hairs on edge of uropatagium).	16
16a	Ear length ≥17mm.	17
16b	Ear length ≤ 16mm.	18
17a	Ears, wings, and uropatagium are blackish and opaque. Ear length 17-24mm (WY: 17-23mm, but usu. ~20mm). Ears extend past end of nose when laid down. Fur light brown with hairs black at base. [May have an inconspicuous fringe of hairs on the posterior uropatagium.]	Myotis evotis
17b	Ears, wings, and uropatagium are brownish and translucent. Ear length 15-19mm (WY: 15-16mm).	Myotis septentrionalis
18a	Dorsal body fur brown to reddish-brown, long and glossy. Forearm usually 36.5-40.5mm (BC Range: 33.0-40.3mm). Ears dark, 14-16mm long, with short tragus. Forehead with a gradual slope (Fig. 18a), skull usually greater than 14mm. Ventral fur light-tipped but never white. Many foot hairs extend beyond toes.	Myotis lucifugus
18b	Dorsal body fur brown to reddish-brown, short and dull. Forearm usually 32-36mm (BC Range: 30.0-38.0mm). Ears paler, 12-14mm long. Forehead with steep slope (Fig. 18b), skull usually less than 14mm. Ventral fur with whitish tips.	Myotis yumanensis

Fig. 18a. *M. lucifugus*: Forehead with gradual slope

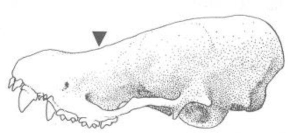
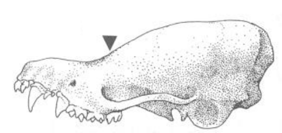
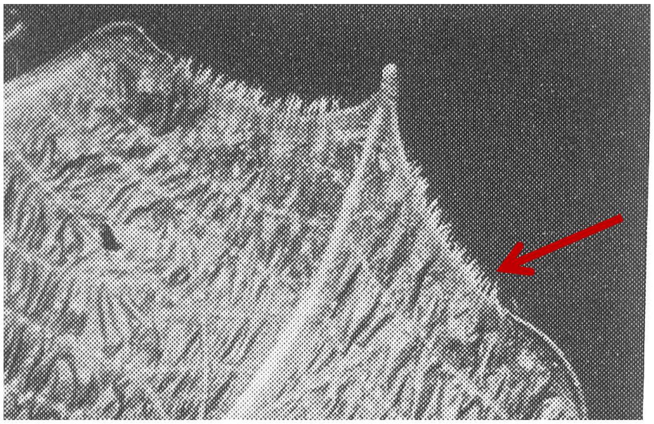
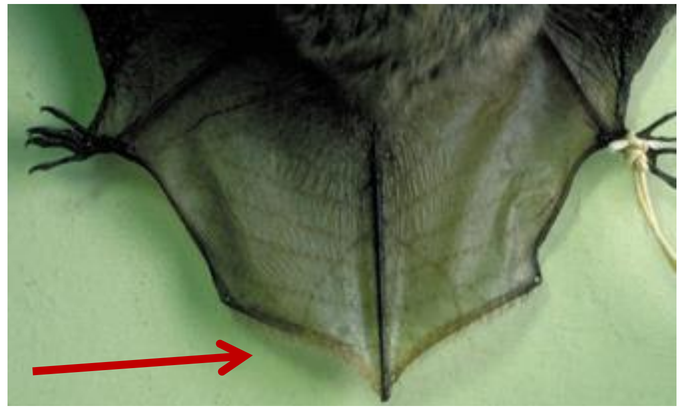


Fig. 18b. *M. yumanensis*: Forehead with steep slope



Supplementary Images for the Wyoming Bat Key

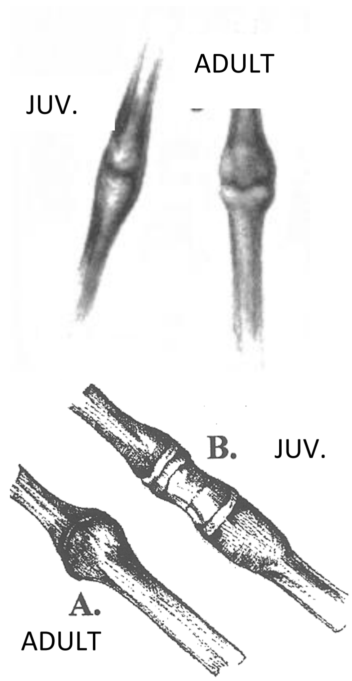




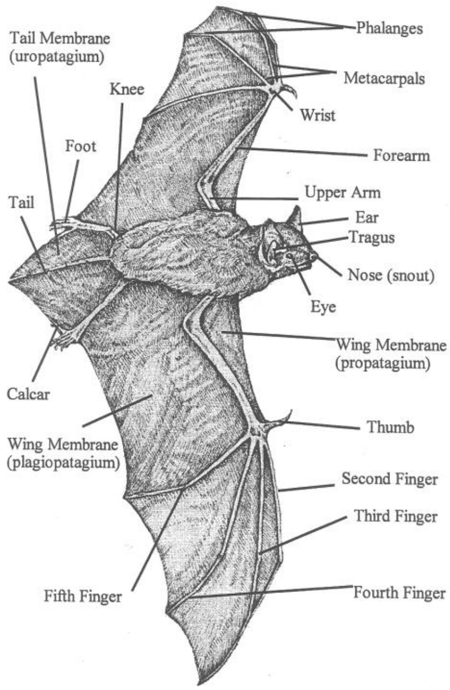
Uropatagial fringe of *Myotis thysanodes*

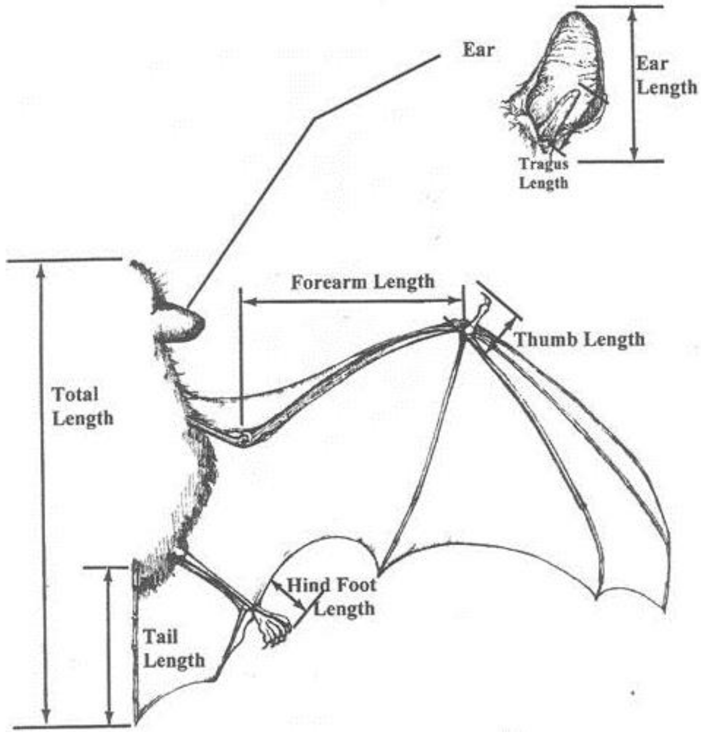
Face and tragus of *P. hesperus*

Nose folds of *C. townsendii*



Finger joint of juvenile (tapered, epiphesial plates visible) and adult (nobby and opaque) finger joints, as seen by illuminating the wing from behind (From Nagorsen and Brigham, 1993)





Bat Anatomy (from AZ bat conservation workshop)

Standard Bat Measurements (from The Bats of Texas)

Appendix 4: Anabat Classification Key to Wyoming Bats

Wyoming ANABAT Call Key (2011)

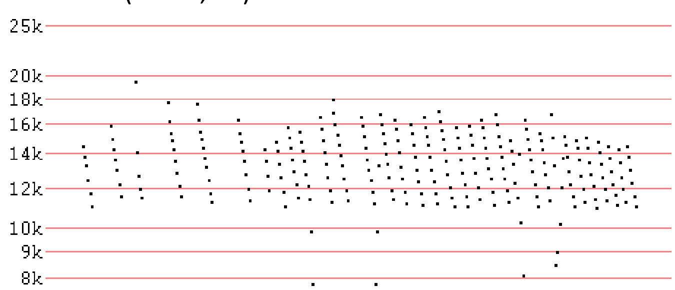
Developed by

Douglas A. Keinath

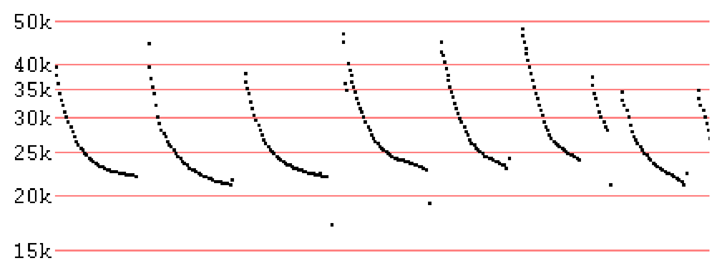
NOTE: Anabat® is a system designed to help users find and identify echolocating bats by digitally recording those calls and plotting them on a computer (for more information see: http://users.lmi.net/corben/anabat.htm #Anabat%20Contents). Before employing this key, users should be familiar with general principals of call analysis (e.g., http://users.lmi.net/corben/glossary.htm #Glossary). With such background information, this key can be used to roughly classify calls. Questionable calls, calls of difficult to distinguish species, or calls that represent new occurrences in an area should always be viewed by local Anabat® experts. In Wyoming, people should contact the Wyoming Natural Diversity Database (Doug Keinath: 307-766-3013, dkeinath@uwyo.edu) or the Wyoming Game and Fish Department (Martin Grenier).

Fmin (kHz)	Description	ID
< 10	1. Calls steep and sparse. Usually beginning above 10 and ending below 8. Calls can be heard audibly with unaided ear; sounds like two pebbles being struck together.	EUMA
16 – 20	2. Calls usually low slope & can be hook-shaped. Calls tend to jump around in Fmin, but typically ~20k or lower. Calls tend to vary in curvature throughout the sequence. Often give several calls at a higher freq, but with same shape.	LACI
~ 25	Fmin ~25 and with distinct tail. Two possibilities (LANO or EPFU), which are difficult to distinguish from each other, especially in clutter. Many call files must be reported simply as "**aB25k**"	a25k
	3. Calls are more bilinear than EPFU. Slope of tail is more variable than EPFU. Min Δslope often ~10 and Δslope plots usually "dribble off" rather than forming "fish-hook" ends. Calls rarely fall below 25k. Calls very regularly spaced ("metronome").	LANO
	4. Calls are more curvilinear than LANO, but can be more bilinear when they are short in sweep (i.e., ~25-40). Slope of tail is very consistent. On flat calls, Δslope plots may show many calls with "fish-hook" ends. Fmin often not uniform, with some calls falling below 25k. Calls sometimes irregularly spaced ("heart beat").	EPFU

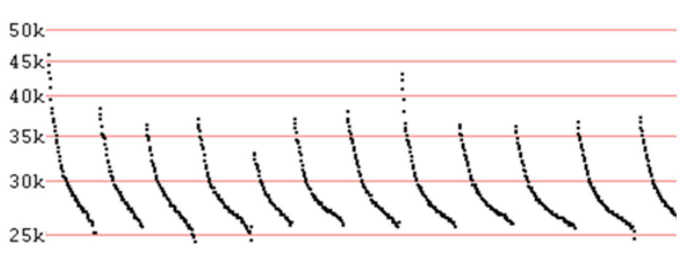
1. EUMA (Div16, F7)



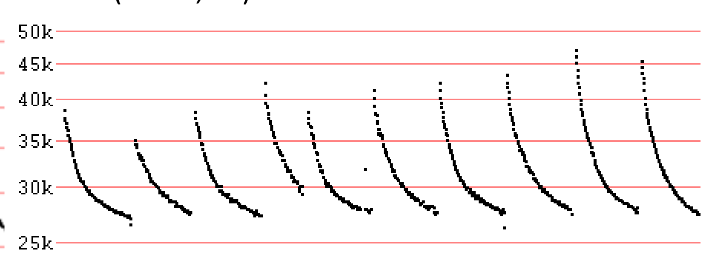
2. LACI (Div16, F7; stock file)



3. LANO (Div16, F6)

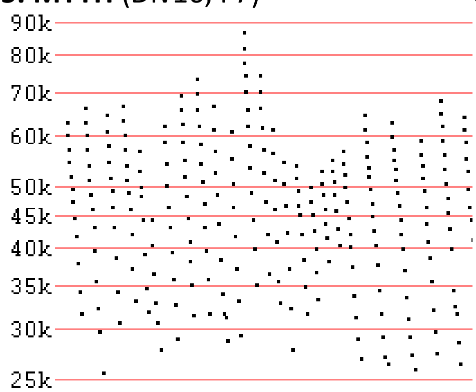


4. EPFU (Div16, F6)

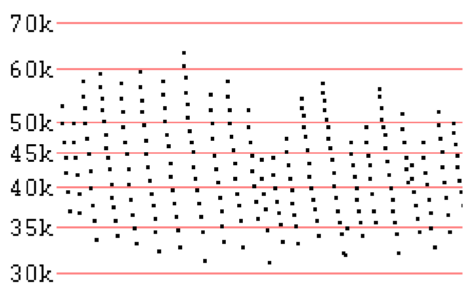


Fmin (kHz)	Description	ID
~ 25 - 30	F-min 25 – 30 and calls very steep with little tail. Four possibilities (MYTH, MYEV, COTO, ANPA). If sequences are not long and clean, many of these can be difficult to tell apart and must then be reported simply as "**aB30k**".	aB30k
	5. Calls very steep (Δslope ≥ 100) with huge freq. range (usu. > 50 and up to 20-100 in same call) and no tail. Variable Fmin with some calls usu. dropping to or below 25.	MYTH
	6. Calls very steep (Δslope usu > 150; often 300) and very sparse, with no tail. Fmin usu ~35, but varies within sequence, seldom dropping below 30. Freq range usu ~30.	MYEV
	7. Calls steep, but often slightly more curved than MYTH or MYEV and somewhat "thicker". Very little tail, but sometime "dribbling off" in a "lazy S" shape. Fmin ~30k and Fmax ≥50. Can also be difficult to tell from EPFU in clutter, which will usu. have time between calls of <100ms	ANPA
	8. Calls steep, weak, have ***two harmonics***. Fmin usu ~30, but can be ≤25. Harmonic-break often bet. 40-50. Sometimes only one harmonic captured: Upper can look like 50k myotis; lower can look like steep 25k getting thinner at tail	COTO
	9. Unique in its variability; calls vary between flat to steep in same sequence. Flat calls usually sweep 28-25 kHz, while steep usually sweep 60-27kHz. Behavior: open habitat, flying straight for moths and large insects.	TABR

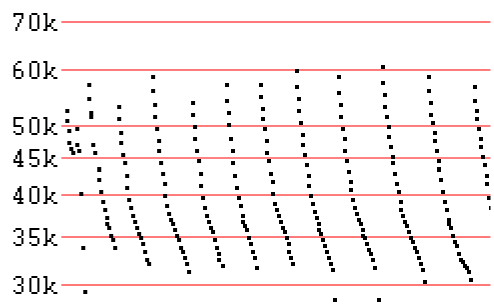
5. MYTH (Div16, F7)



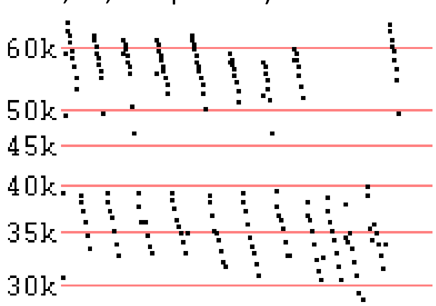
6. MYEV (Div16, F7)



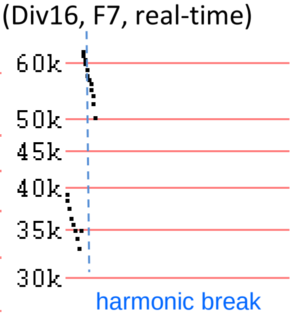
7. ANPA (Div16, F7)



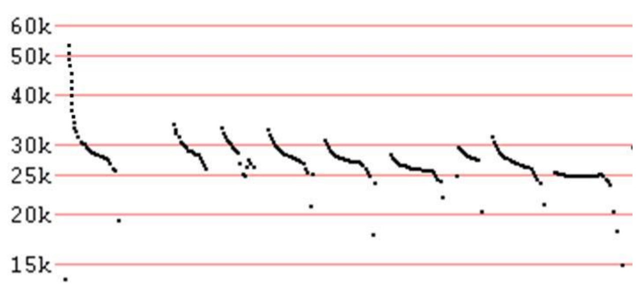
8a. COTO
(Div16, F7, compressed)



8b. COTO
(Div16, F7, real-time)

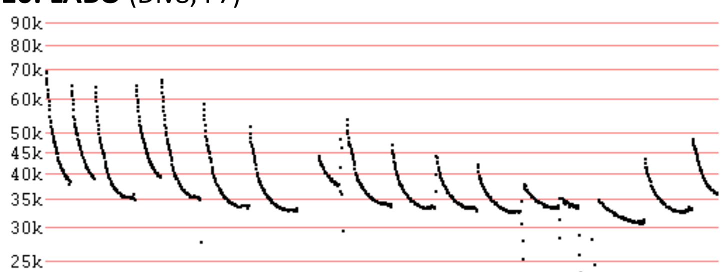


9. TABR
(Div16, F7, stock file)

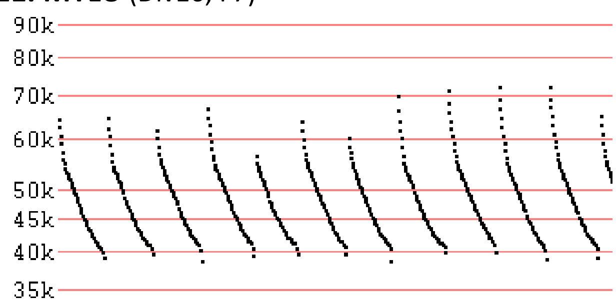


Fmin (kHz)	Description	ID
~ 27 - 35	10. Calls increases in frequency at end, creating a slight hook shape (like hoary bat). Calls sweep steeply from over 50k to just below 40k, with numerous calls often shifted downward so Fmin can be as low as 27k.	LABO
~ 40	Fmin usually at 40k, with some potentially falling above or below. Four possibilities (MYLU, MYCI, MYSE, MYVO). 40k myotis are very difficult to distinguish from each other, especially in clutter. Many call files must be reported simply as "**aM40k**".	aM40k
	11. Gently curved slope throughout call (but often get more bilinear in clutter and may "dribble off" at the end). Clean calls often sweep from ~100 to just over 40. On clean calls, Δslopemin can be as low as 40, but usually higher. Sometimes alternate curved call with a more linear one. <u>Behavior</u>: MYLU classically feed over water, which can result in "wobbly" calls."	MYLU
	12. Calls steep and regularly have a small "toe" at or just before the end, resulting in a "golfclub" or "S" shaped call. Even with a toe, calls usually have Δslopemin near 80. Clean calls usually straighter than MYLU, but can be more curvilinear than MYVO. Calls can have a wobble in the middle of the call (usually ≤50k). <u>Behavior</u>: MYCI feed around vegetation, like MYCA.	MYCI 
	13. Calls look similar to MYEV, but lower frequency limit is roughly 40kHz. Calls typically sweep from 80kHz to just over 40kHz. Clean calls are straighter than MYLU and MYCI and less vertical than MYVO. <u>Behavior</u>: MYSE feed around vegetation, often forests, gleaning and aerially pursuing insects.	MYSE
	14. Calls steep often with "wiggly look"; like MYLU in clutter, but greater call spacing. Calls tend to be more linear (or bilinear) than MYLU and have less "toe" than MYCI. Calls can have a wobble high in the sweep (usually ≥50k). Δslope is usually high (~100) but can drop to ~60. Difficult to distinguish from other 40k myotis	MYVO

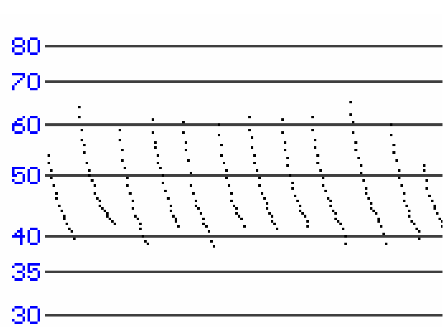
10. LABO (Div8, F7)



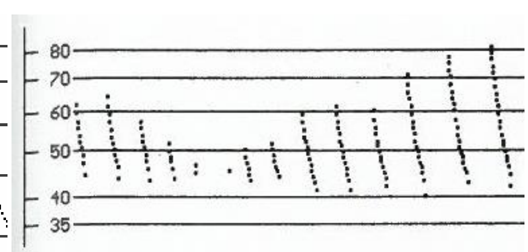
11. MYLU (Div16, F7)



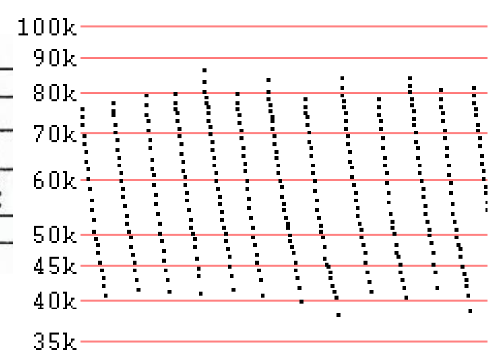
12. MYCI (Div16, F7)



13. MYSE (from Adams 2003)

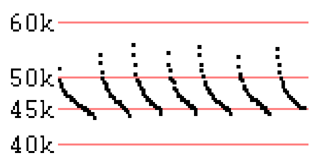


14. MYVO (Div 16, F7)

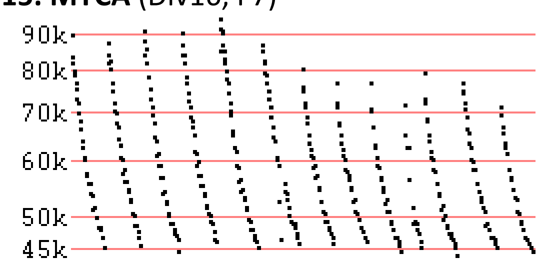


Fmin (kHz)	Description	ID
~50	15. Usually starting around 50 and often ending below (~45). Thick calls with flat tails often with a drooping tail. Duration>5.0ms.	PEHE
~ 50	Steeper than PIHE and usu. Fmin at or just below 50k. Single calls can drop to 40k, but not whole series (consistently above 43k). Difficult to distinguish from each other, especially in clutter, and many must be reported simply as "**aM50k**".	aM50k
	16. Often show calls dropping below 50k (~45k). Call shape similar to MYLU, but thicker tail. Calls often "dribble-off", rather than having constant toes. Dribble calls can have Δslope down to 40. In a series, there is often one call that is flatter than the rest. *Behavior*: MYYU often feed over water.	MYYU
	17. Calls frequently have a flat "toe" at the end, rather than dribbling off. Toed calls usually have Min. Δslope of 30ish. "Dribbling calls" usually have Min. Δslope greater than MYYU (i.e., above 40). Behavior: MYCA typically feed by hugging vegetation.	MYCA

14. PEHE (Div16, F7)



15. MYCA (Div16, F7)



16. MYYU (Div 16, F7)