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Oral Presentation Abstracts

UNRAVELING ZERO CROSSING AND FULL SPECTRUM – WHAT DOES IT ALL MEAN?

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Full spectrum and zero-crossing recording technologies have been used to record and analyze the echolocation calls of bats for decades. More recent advances in analysis software combine these technologies by extracting zero crossing information from full spectrum recordings using different combinations of signal processing techniques. The purpose of this paper is to explain the physics behind full spectrum and zero crossing technologies and modern hybrid algorithms for bat biologists and ecologists to better understand and appreciate the advantages, disadvantages, and modern capabilities of available technology. We first look at zero crossing and full spectrum recording technologies, how they work, and their relative advantages and disadvantages. We then explore a simple technique for extracting zero crossing data from full spectrum recordings using band-pass filtering and adaptive thresholds. Finally, we explore advanced signal processing techniques including Gaussian noise reduction, echo cancellation, call tracing, adaptive filtering and interpolation to study how they can be used to enhance a full spectrum signal in order to extract richer zero crossing data. We conclude that while zero crossing recordings do have some advantages in limited circumstances, it is far better to record bats in full spectrum and use modern signal processing techniques to enhance the signal before either analyzing the data with full spectrum tools or extracting zero crossing information and then analyzing the data using zero crossing or hybrid tools.

A PRELIMINARY ASSESSMENT OF THE CURRENT DISTRIBUTION OF THREE WHITE-NOSE SYNDROME IMPACTED BAT SPECIES IN VIRGINIA

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Severe population declines in cave-hibernating bat species from White-nose syndrome (WNS) across the East has led to the proposed listing of the northern long-eared bat (*Myotis septentrionalis*) and additional status reviews of the eastern small-footed (*Myotis leibii*) and tri-colored bat (*Perimyotis subflavis*). Although cave survey data and mist-net records indicate changing distribution and abundance of WNS-sensitive species, efforts to document current bat species distribution are lacking for many areas. Understanding the current distribution of WNS-impacted bat species relative to both their historical and future distributions, however, will allow management efforts to be regionally targeted, and will help supplement information from

cave surveys. We used acoustic surveys to document the current distributions of northern long-eared bats, Indiana bats (*Myotis sodalis*), and tri-colored bats in the Commonwealth of Virginia. We used multi-night site visit data to generate false-positive occupancy models in an *information theoretic* approach to predict the species' distributions relative to physiographic factors. Our preliminary analysis indicates that northern long-eared bat presence exhibits a curvilinear relationship with elevation and varies among regions such that probability of presence is greater in the Coastal Plain and Mountains than in the Piedmont. Tri-colored bat probability of presence also exhibited a curvilinear relationship with elevation, but presence was not influenced by physiographic region. Probability of Indiana bat presence was best predicted by our null model, which suggests that this species currently is unlikely to occur across the state, although small, local populations are known from winter cave counts. As the WNS-zoonotic disease continues to spread, it will be important to continue monitoring the changing distribution of impacted bat species.

INDIANA BATS DON'T ALL ROOST IN INDIANA! VARIATION IN ROOST AND LANDSCAPE CHARACTERISTICS ACROSS THE SPECIES' RANGE

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The majority of seminal Indiana bat studies that have informed management of the species throughout its distribution were conducted in the core of the species' range (i.e., Indiana and Illinois). However, the characteristics of both roosts and landscapes used by Indiana bats are likely to vary throughout the species' range. For example, Indiana bats roost in large hardwood snags and shagbark hickories in Midwestern fragmented forests, while Indiana bats in the Southern Appalachian roost in tall softwoods in contiguous forests. Our objective was to determine the extent of variation in roosts and landscapes used by roosting Indiana bats in different ecoregions. We used standardized roost data contributed by biologists throughout the species' range. We calculated landscape characteristics using a combination of GIS, Python scripts, and Fragstats. We compared roost and landscape characteristics between ecoregions as delineated by the USFWS and the EPA. Preliminary results suggest that roost (DBH, % bark remaining), plot (% plot canopy closure, # live trees, # snags), and stand (distance to water) scale roost characteristics (USFWS ecoregions: $df = 78$, $p < 0.001$, EPA ecoregions: $df = 117$, $p < 0.001$) and landscape characteristics (forest coverage, forest patch size and shape; USFWS ecoregions: $df = 84$, $p < 0.001$, EPA ecoregions: $df = 189$, $p < 0.001$) vary by ecoregion. These results suggest it may not be effective to use a "one-size-fits-all" set of preferred roost characteristics to manage for Indiana bats across the species' distribution; instead, it may be necessary to define specific characteristics for optimal and suitable roost habitat at multiple scales for different regions in the species' range.

LITTLE BROWN BATS IN SOUTHEAST ALASKA HIBERNATE IN HOLES: IMPLICATIONS FOR THE SPREAD OF WHITE-NOSE SYNDROME

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Little brown bats in eastern North America typically hibernate in caves and mines, often in large numbers, however few large hibernacula have been identified in the western part of their range and none have been found west of the Rocky Mountains. We used radiotelemetry to identify hibernation roosts of little brown bats in Southeast Alaska. We captured and radio-tagged adult little brown bats in September and early October in Juneau, Alaska and radio-tracked them daily from the air and on the ground. We located 10 hibernation roosts on 2 nearby ridge systems; distances from the capture site to the roost ranged from 1.3 to 24.1 km. Two roosts were under root wads on level ground at elevations ≤ 86 m. Eight roosts were located on steep, forested hillsides at elevations ranging from 128 to 452 m; 3 were rock roosts located in colluvium, 3 were associated with large rock outcrops, and 2 were in rocky soils. At least 1 roost was used in successive years. We compared winter temperatures and relative humidity inside (~0.3 – 0.5 m from the opening) and outside of 4 roosts located in 2013. Relative humidity dropped as low as 40-60% outside of roosts, but remained near 100% within the roosts throughout the winter. Average temperatures were also higher and more stable inside the holes (-1.04 to 2.03 °C) than outside (-2.33 to -0.63 °C). If roosting solitarily in holes in the ground is a common overwintering strategy of little brown bats in the west, western populations should be much less vulnerable to White-nose Syndrome than their eastern counterparts.

AFFECT OF FOREST OPENING LANDSCAPE CHARACTERISTICS AND VEGETATION STRUCTURE ON BAT OCCUPANCY

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In the Central Hardwoods ecoregion, early successional habitat (ESH) is declining due to farmland abandonment and suppression of wildfire. As a result, populations of many ESH dependent species have declined. These declines have generated concern among scientists and land managers and have led many to ask how best to restore ESH. Bats, while not dependent on ESH, frequently use ESH for foraging and therefore may be affected by ESH restoration. Our objective was to determine bat occupancy of forest openings in relation to landscape and vegetation characteristics. We placed Anabat SD2 detectors at the center and edge of 21 forest openings in the Nantahala National Forest, NC ranging in size from 0.2 – 18.5 ha from June – August 2014. iButton temperature loggers were paired with each detector and vegetation structure was measured at each detector. Recorded calls were identified with the aid of Kaleidoscope Pro. ArcGIS was used to determine opening area, elevation, and distance to nearest waterbody. Program PRESENCE was used to estimate detection probabilities and probability of site occupancy for big brown (*Eptesicus fuscus*)/silver-haired (*Lasionycteris*

noctivagans) bats, hoary bats (*Lasiurus cinereus*), and *Myotis* species. The most highly supported model for big brown/silver-haired bats and hoary bats was the null model. The most highly supported model for *Myotis* spp. included distance to nearest water source. Occupancy of all species was negatively related to distance from water and distance from edge and positively related to area but all relationships had high variability. These data suggest that the landscape characteristics and vegetation structure of forest openings do not affect bat occupancy. However small bats, such as *Myotis* species, are affected by the position of openings on the landscape.

TESTING OF ACTINOBACTERIA ISOLATED FROM TWELVE WESTERN BAT SPECIES AGAINST *PSEUDOGYMNOASCUS DESTRUCTANS*: CLUES TO POTENTIAL NATURAL DEFENSES OF BATS

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We monitored cave microclimates in 15 New Mexico bat hibernacula over 3 winters (2011-2013) to determine if these sites had conditions appropriate for the growth of *Pseudogymnoascus destructans*, the fungal pathogen responsible for the death of approximately 6 million bats in the eastern United States (U.S.). Complementing this project we swabbed bats to characterize the naturally occurring bacterial and fungal microbiota that reside on fur and membranes of bats captured in caves and at water sources in New Mexico and Arizona. This revealed the presence of many *Actinobacteria,* a bacterial phylum known for its secondary metabolite (e.g. antibiotic and antifungal) production. Different bat species varied in the abundance of *Actinobacteria* present on bats, leading us to hypothesize that some bat species may possess natural defenses against pathogens. To test this hypothesis in relation to *P. destructans*, we swabbed bats at El Malpais National Monument (ELMA) southwest of Grants, NM; Fort Stanton Cave near Capitan, NM; Bureau of Land Management (BLM) Caves 45 and 55 in south-central NM; and in Parashant National Monument in northwest Arizona. Swabs were immediately used to inoculate a suite of culture media that select for *Actinobacteria*, supplemented with chemicals to isolate *Actinobacteria*. Our preliminary tests suggest that microbiota, especially *Streptomyces* spp., present on bats have the potential to produce anti-fungal chemicals that can inhibit *P. destructans*. These results may shed light on differences seen in the vulnerability of different bat species to *P. destructans* in the eastern U.S. This information is preliminary and is subject to revision. It is being provided to meet the need for timely 'best science' information. The assessment is provided on the condition that neither the U.S. Geological Survey nor the United States Government may be held liable for any damages resulting from the authorized or unauthorized use of the assessment.

INFLUENCE OF PRESCRIBED FIRE ON BAT PRESENCE AND ACTIVITY IN THE BIG SOUTH FORK

NATIONAL RIVER AND RECREATION AREA

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While prescribed fire is known to maintain forest health and minimize disease, little is known about its impact on bat activity. Past studies suggest reduction in vegetation from burning may increase access and foraging efficiency for bats. Our objective was to investigate bat activity in relation to burn history and vegetation structure in Big South Fork National River and Recreation Area, in Kentucky and Tennessee. We compared use of forest sites with varying burn histories (frequency, severity, and burn year) to adjacent unburned forest sites. We used AnabatII detectors to acoustically monitor activity levels for ≥ 2 nights during the 2014 maternity season across 22 paired treatment and control areas. All trees and snags >1.4 m tall and >3 cm diameter at breast height (DBH) in a 0.1 ha circular plot around each detector were identified and measured. We recorded 4079 bat passes at 66 sites. Echolocation files were separated into high (≥36 kHz) and low (≤35 kHz) phonic groups using a combination of AnalookW software and manual examination. The mean number of total bat passes and the mean number of high and low frequency calls were significantly higher in burned than unburned sites. As stem density was significantly lower in burn sites compared to controls, and bat activity was significantly higher in stands with lower stem densities, differences in activity between burns and controls appear related to differences in stem densities. Additional analyses among burned sites suggest that interactions between stand type and burn parameters affect stem density. Although further analyses of the structural effects of burning and the influence of metrological factors are needed, prescribed fire and its subsequent effect on forest structure appear to have increased the suitability of forested sites for bats in our study area.

DESCRIBING THE SOCIAL BEHAVIOR OF THE INDIANA BAT AT DAY ROOST SITES

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Bats are highly social, but we do not fully understand how behaviors facilitate sociality. The study of bat social behavior was limited until recently due to technological limitations. Most of bat behavior is imperceptible to our senses, including both their use of ultrasound and their nocturnal activities. Since 1997, Indiana State University has monitored a population of endangered Indiana bats (*Myotis sodalis*) near Indianapolis, Indiana. During the maternity seasons (May-August) of 2013 and 2014, we recorded Indiana bat roost site behaviors with passive emergence count observation, video (Sony Nightshot HandyCams and IR lights), and acoustics (Pettersson D500X acoustic detectors). The objective of this study is to compile a catalog of visual and acoustic behaviors seen at Indiana bat day roost sites. Thus far, we have

detected four general and 29 specific types of visual behavior, and 5 general types of acoustic behavior. Visual behaviors include behaviors similar to those categorized as "checking behavior" and agonistic behaviors seen in other bat species. A bat that is "checking" approaches a roost's surface and then may circle, land on or briefly enter the roost and then flies away; this behavior has also been observed for little brown bats (*Myotis lucifugus*). Behaviors that fell into the "checking" category make up the vast majority of documented behaviors during video observation. Within the documented acoustic behaviors there are calls similar to those documented in several previous studies for *M. lucifugus*. In *M. lucifugus* calls of similar structure were used in the contexts of agonistic, echolocation, infant isolation, and disturbance. These are some the first systematic observations of social behavior for Indiana bats. Understanding the social behaviors of these highly social bats is crucial to gaining a full understanding of their life cycle and daily requirements.

OBSERVATIONS OF ROOST SELECTION BY *MYOTIS SEPTENTRIONALIS*

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The northern long-eared bat (*Myotis septentrionalis)* was recently proposed to be listed as federally endangered, but data regarding the summer ecology and habitats used by this species are limited. Understanding summer roosts used is key to developing conservation efforts that contribute to recovery of this species once it is listed. From May to August 2014, we radio-tracked 42 northern long-eared bats to roosts in the Midwest (Missouri, Michigan, Nebraska, Ohio, Iowa) and Northeast (New York, Pennsylvania, West Virginia) regions of the United States. Ninety-six roosts were located, and characteristics and environmental data for each roost were collected and summarized. Observations were made of average foraging distances from fifty-three roost trees in West Virginia and Ohio. We found that roost types and environmental conditions of each roost varied remarkably among different individuals as well as within an individual bat, regardless of age or sex. In a few instances, lactating female bats showed a marked difference in their roost selection from other reproductive statuses. Males and non-reproductive females were similar in their roost choices. There was also no correlation between size of tree and size of colony in the tree. Pregnant females also tended to be captured closer to their roosts than other reproductive statuses. Our observations confirm that the northern long-eared bat is a generalist in terms of roost selection, and the task of designating critical habitat for this species may prove to be more cumbersome than expected.

TRANSITIONING FROM TRADITIONAL DATA TO DIGITAL DATA MANAGEMENT

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Data management is an all-encompassing aspect of the job when working with bats. Time is wasted copying over data from field notebooks and datasheets into computer databases. Data can get lost or entered incorrectly. And the importance of this data have never been more

important. With mass bat population declines, due in large part to white-nose syndrome (*Pseudogymnoascus destructans*) and habitat loss, it is vital to accurately gather as much data as possible. As it stands, every state has its own database, yet everyone wants the same information. A unified database can be achieved, saving everyone time and simplifying data entry. Chiro1 was created with the idea in mind that working with bats can be challenging, data management should not have to be. It allows the user to simplify data collection on digital tablets to allow for a more secure, faster, and more reliable way to handle all your information needs.

A COMPARISON OF METHODS FOR ACTIVE ACOUSTIC SAMPLING OF MIDWESTERN BATS

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Within the last decade, active acoustic sampling of bats using vehicles has grown in popularity as a method to monitor bat activity trends. This method of acoustic monitoring involves driving on roads with a microphone affixed to the top of the vehicle. Currently, the literature lacks empirical studies exploring different methodologies for conducting these road surveys. During summer 2013, we conducted acoustic road transects on three routes in northcentral Indiana using a traditional road survey (called a "smooth" method), a road survey where the vehicle stopped for 1 minute at every half mile of the survey route (called a "start-stop method"), and with an individual using a bicycle. Each survey used an ANABAT SD2 detector with an extended microphone attachment. Across all surveys, we were able to identify 844 recorded calls to species. Using a MANOVA, we tested whether there was a significant difference in bat detections based on method or time of night. For total bat species, we found no significant difference. We ran a GLM with a Poisson distribution on bat detections for each genus, which revealed that the start-stop method resulted in significantly more detections of bats in the genus *Myotis* ($p < 0.01$), *Lasiurus* ($p < 0.001$), and *Eptesicus* ($p < 0.01$). Utilizing a start-stop method of active acoustic monitoring may increase detections of target species while reducing the inflation of call numbers found in passive sampling, which may be desirable for some monitoring goals.

NEST BOX OCCUPANCY OF THE ENDANGERED CAROLINA NORTHERN FLYING SQUIRREL IN HIGH-ELEVATION HABITATS IN THE SOUTHERN APPALACHIAN MOUNTAINS

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The Endangered Carolina Northern Flying Squirrel (CNFS; *Glaucomys sabrinus coloratus*) is a rare subspecies occurring on highly disjunct sky islands in the southern Appalachian Mountains. Long-term monitoring of this subspecies is being conducted using nest box surveys. Although

nest box occupancy for CNFS is relatively high in suitable habitat (ψ = 0.8 with >30% overstory conifer), other factors influencing occupancy, such as annual mast production and weather, have not been examined. We used nest box data from 69 sites monitored during varying periods from 1996-2014 in western North Carolina. We analyzed the effects of habitat quality, mast year, and weather on nest box occupancy of CNFS. Utilizing a multi-season occupancy modeling framework in Program PRESENCE, we used a two-step method to determine detection probability (p), colonization (γ), extinction (ε), and occupancy probability (ψ). After determining covariates for p, γ, and ε, we modeled all possible combinations of 6 covariates thought to influence occupancy (N = 64 models). Preliminary analysis indicate that increased annual winter precipitation and survey effort positively influenced detection probability. Nest box occupancy increased in areas of greater habitat quality (i.e., increased presence of conifer), lower canopy height, and in sheltered landforms with more northernly aspects. These preliminary results support our previous research on CNFS habitat selection on the stand and landscape scale within western North Carolina.

FORAGING ECOLOGY OF INDIANA AND NORTHERN LONG-EARED BATS IN A MANAGED FOREST ECOSYSTEM

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Since 2006, bat research has been conducted in 9 forest management units on the Hardwood Ecosystem Experiment (HEE) in central Indiana, a 100-year project in its infancy. Most research to date has focused on mist-netting, acoustics, and roost tree selection. Our objective was to better understand spatial foraging habits of Indiana (*Myotis sodalis*; MYSO) and northern long-eared (*M. septentrionalis*; MYSE) bats in a managed forest with 3 different management unit types across a 19,000 ha area. . In 2008, uneven-aged units received patch cuts and single tree selection, and even-aged units received clearcutting or shelterwood harvests in selected plots. Control units received single-tree selection prior to 2006, but will not be treated for the next 91 years. We tracked 21 ♀ MYSE, 2 ♀ MYSO, and 1 ♂ MYSO for 3-4 nights and collected 65 ± 5 locations/individual using radio telemetry. For MYSE 95% fixed kernel density estimates (KDEs) averaged 115 ± 12 ha (n=21 bats), whereas MYSO KDEs were >twice the size, at 301 ± 66 ha (n=3 bats). Of the 24 bats tracked, 11 foraged in part within uneven-aged management units, one foraged in an even-aged management unit, 5 foraged within a control unit, and all were captured at small forest ponds. We will overlay KDEs with forest type, elevation, slope curvature, and distance to roads, ponds, and edges and perform a probabilistic weighted compositional analysis to rank order of resource use. MYSO traveled farther from roost sites to forage, while MYSE stayed closer to roost sites and used forested slopes. Several MYSE and MYSO foraged in recently harvested or regenerating areas. Bats' use of cut areas suggests that timber harvest may have a neutral or positive effect on bat foraging space. Strategies to promote forest heterogeneity at multiple spatial scales may promote foraging habitat for both *Myotis* species.

POTENTIAL EFFECTS OF WIND ENERGY DEVELOPMENT ON INDIANA BAT POPULATION DYNAMICS

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The United States is increasing the production of energy from wind turbines as a method to decrease greenhouse gas emission and other types of pollution. These turbines have caused wildlife mortalities, including deaths to the federally endangered Indiana bat. The effect of these deaths on the population of the species is believed to have been minimal, but this may change as more wind turbines are built. We constructed a spatial model to examine current effects of wind energy development on Indiana bat population dynamics. We found minimal effects for current levels of take, but it is worth noting that there is little current overlap between the Indiana bat's range and wind farm development. We also examined different levels of take with our model. We found the greatest risk of population- level decline emerged only when meta-population dynamics were examined. Thus, small levels of take may be important because they may cause the extirpation of individual maternity colonies. Future research will include considering the synergistic effects of white-nose syndrome on the population dynamics of this endangered species.

HABITAT ASSOCIATION AND SEASONALITY OF LITTLE BROWN BATS (*MYOTIS LUCIFUGUS)* IN THE CHUGACH NATIONAL FOREST, SOUTHCENTRAL ALASKA.

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The ecology of bats and bat roosting locations in Alaska is largely unknown, though Little Brown Bats (*Myotis lucifugus*) are found in southcentral and southeast Alaska, and associated with both natural and manmade structures. As White-nose syndrome decimates populations of *M. lucifugus* throughout the eastern United States, effective management and conservation of the Alaskan population becomes increasingly crucial. The USFS and ADF&G are collaborating to increase the awareness of bat species and habitat use across the Chugach National Forest (CNF), identify interspecies interaction, characterize winter hibernation behaviors, and increase understanding of how management activities may affect bats. As part of this larger effort, University of Alaska Anchorage biologists have begun work aiming to discover the ecological criteria that create a bat habitat, and to characterize wintering behaviors of *M. lucifugus* in the CNF. Acoustic monitors deployed at random points stratified by vegetative criteria will determine habitat factors that are useful to bats. Once roosts are located, radiotransmitters will be attached to bats in late fall to follow individuals to their winter hibernacula, so as to determine the distance of migration, duration of winter hibernation, and size of roost. Understanding habitat criteria and wintering strategies of *M. lucifugus* throughout the CNF will elucidate the urgency of their conservation and how best to do so. Furthermore, this work,

being at the forefront of bat research in southcentral Alaska, aims to provide foundation for future bat work throughout the state.

PRELIMINARY RESULTS OF A LONG-TERM MARK-RECAPTURE STUDY OF SMALL MAMMALS OF PRARIE RIDGE ECOSTATION, A RESTORED NATURAL AREA IN URBAN, CENTRAL NC

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With a history of heavy use, first as a military training site, then in agriculture, in 2004 the North Carolina Museum of Natural Sciences began converting a 38.5 acre tract to what is now Prairie Ridge Ecostation. Most recently, the majority of the tract was comprised of fescue fields and used for cattle grazing. The area has been partially transformed into native tall grass prairie, bottomland forest and arboretum, ponds, and a stream. Though undeveloped forest and pastures exist nearby, four-lane roads lie just to the west and south edges of Prairie Ridge and commercial and residential development are encroaching on all sides. In the summer of 2011 we began a long-term mark-recapture project to monitor small mammal populations of Prairie Ridge. We established three permanent grids of 50 traps each in three distinct field types: bottomland, fescue, and switchgrass. Trapping occurs seasonally, with trapping sessions conducted in January, April, July, and October. To date, 1166 uniquely numbered ear tags have been applied to hispid cot rats (*Sigmodon hispidus*), 67 to white-footed mice (*Peromyscus leucopus*), 19 to house mice (*Mus musculus*), 16 to eastern harvest mice (*Reithrodontomys humulis*), and 3 to woodland voles (*Microtus pinetorum*). Additionally, 30 southern short-tailed shrews (*Blarina brevicauda*) were captured but not tagged. Findings are preliminary and both the study and analyses are ongoing. We are seeing seasonal variation and significant difference among field types ($p < 0.05$).

GRAY BAT MIGRATION IN MISSOURI: METHODS FOR MONITORING MOVEMENT

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Bat migration has been difficult to study due to low recapture rates and difficulty tracking captured bats across long distances. This research approaches the problem of studying bat migration using a variety of methods (band returns, radio telemetry, acoustic monitoring, and Doppler radar). We are studying two major aspects of gray bat (*Myotis grisescens*) migration – the connections between seasonally occupied caves and the phenology of migration. To study the connections between and among gray bat caves in Missouri, over 1100 fluorescent bands were deployed across the state at both hibernacula and maternity caves. By combining this information with historic band return data, we are creating a map of movements between caves. Several band returns from this study have been recorded thus far, and we anticipate more band returns in the future. In addition, eight female gray bats at a hibernaculum were radio-tagged with VHF transmitters. Two of these bats were relocated near a maternity cave 7.8 miles away 8 days later. To study the phenology of migration, bat detectors have been placed

at sites across the region. For several sites, a timeline of gray bat activity was created. In addition, we are also exploring the possibility of studying migration phenology using NEXRAD weather radar data from a maternity colony.

YEAR ROUND ACTIVITY OF PERIPHERAL BAT POPULATIONS IN THE NORTH CAROLINA COASTAL PLAIN

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Within a species' distribution are core populations containing most individuals. Under threats to persistence, the core populations receive the conservation attention. However, when a species is significantly threatened in the core of its range, as seen with White Nose Syndrome (WNS) and many bat species, shifting efforts to peripheral populations can be an effective conservation strategy. Warm temperatures along the Atlantic Coastal Plain may allow peripheral coastal bat populations to remain active through winter, thus decreasing their susceptibility to WNS or mortality associated with migration events. The objective of our study was to determine the year round activity, and specifically winter activity, of peripheral bat populations along the North Carolina Coastal Plain. We set up four Song Meter recording stations along a 295 kilometer north-south transect in the Coastal Plain (peripheral), and two Song Meter recording stations in the Piedmont (non-peripheral), of North Carolina. Recordings were made from sunrise to sunset, for two years. Although we found that bat activity was lower during the winter at all sites, the odds of recording a bat during winter were higher at peripheral sites when compared with non-peripheral sites. In addition the peripheral coastal plain sites had higher bat activity at any given winter temperature, when compared to non-peripheral piedmont sites. Lastly, the coastal plain sites appeared to be an overwintering ground for migratory bat species. We show that peripheral populations of bats, including *Myotis septentrionalis*, on the North Carolina Coastal Plain have increased levels of winter activity compared to those found in the North Carolina piedmont. We suggest that peripheral populations of bats on the North Carolina coastal plain have a unique winter biology that is important for species conservation in the face of winter mortality associated with both WNS and migration.

MODELING ENCOUNTERS BETWEEN MIGRATING BATS AND WIND PROJECTS

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There is growing concern over incremental impacts of anthropogenic origin including wind energy development. We have developed a simulation model to aid evaluation of the potential impacts from individual wind projects on Indiana bats during seasonal migrations between hibernacula and maternity colonies. The model relies on publicly-available sources of data on hibernacula locations and population sizes, migration patterns, and maternity colony habitat

characteristics, while recognizing that colony locations are generally unknown. Within simulations, maternity colony sizes and the number of bats "contributed" by each hibernaculum to each maternity colony are randomly generated. Then, colonies are randomly placed within suitable habitat, with constraints such that locations satisfy a minimum inter-colony distance criterion and mimic distance and direction distributions of migration data. Hibernacula are connected to colonies by straight migration paths, with width of several kilometers (typically, 5 – 20 km) intended to account for uncertainty in actual migration pathways. An "encounter" is defined as any overlap of a migration path with the wind project. By design, encounters represent *potential* interactions of migrants and a project, but not any aspect of direct impact such as collision risk. Results from simulations for several individual wind projects in different Recovery Units indicate that encounters are generally infrequent though distributed among a large number of hibernacula and maternity colonies. Also, the number of bats migrating within encountering paths typically represents a small proportion of the Recovery Unit population. If take has already been estimated by other methods, results from this model can be used to estimate the allocation of take among hibernacula and/or maternity colonies. Software is being further developed as a desktop tool for use by the U.S. Fish and Wildlife Service. In addition, our approach may be useful to wind energy development companies seeking to minimize risk to migrating bats.

INFLUENCE OF EXTRISIC ENVIRONMENTAL VARIABLES ON BODY TEMPERATURE OF FEMALE INDIANA BATS IN SUMMER ROOSTS

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As technology advances, so does our ability to study and understand bat thermoregulation; however, in North America, the majority of studies done in situ have occurred at northern latitudes. Our objective was to describe general patterns of bat thermoregulation for Indiana bats in the southeastern U.S and to examine how reproductive condition, group size, roost characteristics, air temperature, and barometric pressure related to body temperature of roosting bats. In 2012, through the use of temperature sensitive transmitters, Lotek dataloggers, and a weather station we gathered roosting temperature data for Indiana bats (*Myotis sodalis*) in the southern Appalachians. We were able to gather full bat-days (sunrise to sunset) for 6 female Indiana bats (5 adults and 1 juvenile). Air temperature was the primary variable correlated with bats' body temperatures while at roost ($P < 0.01$), with few differences detected among reproductive classes in terms of thermoregulatory strategies. Our findings have led to a better understanding of the thermoregulation strategies of Indiana bats and may guide efforts to create suitable natural and artificial roosting habitat.

EFFICACY OF USING AN ACOUSTIC LURE IN BAT NETTING EFFORTS IN INDIANA

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Due to bat species becoming increasingly difficult to detect in the wild primarily because of anthropogenic factors, we tested the efficacy of using an acoustic lure to increase capture success. Need for increased detection is especially true for species that have been heavily affected by white-nose syndrome (WNS), such as the Indiana bat (*Myotis sodalis*), little brown bat (*Myotis lucifugus*), and northern long-eared bat (*Myotis septentrionalis*). We conducted our study at 3 locations in southern Indiana known as Purdue Agricultural Centers during summer 2014. We set up 7 mist-netting sites at each property, netting 2 times at each, both with the use and absence of an UltraSoundGate Player BL acoustic lure. The lure played recordings of *Myotis*, *Eptesicus*, and *Lasiurus spp*. distress calls from Europe and North America on a loop through the mist net night. A total of 24 bats were caught using the lure, while 47 were caught without the use of the lure. We ran a zero-inflated Poisson regression on number of bats captured per 15 minutes to test whether the lure produced a difference in capture rate of bats overall and among each genus. For overall bat captures, we did not detect significant differences between presence and absence of the lure ($p = 0.813$, $df = 8$). When split among the genera *Myotis, Eptesicus,* and *Lasiurus,* we did detect significant differences in capture rates between presence and absence of the lure for *Myotis* ($p < 0.001$, $df = 8$) and *Eptesicus* ($p < 0.001$, $df = 8$). For *Myotis*, the presence of the lure increased the capture rate, but for *Eptesicus*, the presence of the lure decreased the capture rate. Use of an acoustic lure may be a valuable tool to increase capture success of target species, but may bias results of inventory or monitoring studies.

USE OF BAT ECHOLOCATION AND CONSERVATION BIOLOGY TO TEACH THE PROCESSES AND CONCEPTS OF SCIENCE IN "FLIPPED CLASSROOM" UNDERGRADUATE COURSES

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Bats have been used extensively in informal nature education in nearly every sort of setting, from National Parks, National Wildlife Refuges and US Forests, to many state and local nature centers, worldwide. Bat researchers regularly participate in these outreach events, hosting bat forays and demonstrations of the use of bat detectors. During the past 2 years, I have integrated bat echolocation and conservation biology into a variety of "flipped classroom" undergraduate courses and a graduate journal review seminar and report here on student learning outcomes. At Loyola University, we have developed an innovative introductory non-science majors course (replacing standard survey courses) that engages students in 4-6 week modules taught by different science faculty using active learning approaches. My module focuses on bat echolocation and its application to conservation biology. Students engage in Spallanzani's studies, the Griffin/Galambos studies, modern biosonar studies, as well as case studies of bat/moth jamming, bat/bat jamming, bat/frog predation, bat food habits and applications to assessing biodiversity and conservation status. They analyze ANABAT data sets and pose their own questions about seasonal occurrence and activity patterns. Pre- and Post-

class SALG surveys showed significant increases in student self-assessment of understanding and skills of scientific experimental design and the role of peer review, as well as knowledge of animal echolocation, evolution, and ecology and their application to conservation biology. Several of the case studies have been used in courses ranging from non-science majors to graduate seminars demonstrating that active learning can be implemented at many different levels.

DETECTION AND CHARACTERIZATION OF *MYOTIS LEIBII* SUMMER ROOSTS IN VIRGINIA

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The distribution and habitat selection of the eastern small-footed bat (*Myotis leibii*), an emergent rock roosting-obligate, is poorly known. To address this, we modeled detection probabilities and measured characteristics of *Myotis leibii* roosts. We compared detection probabilities of three survey methods (acoustic surveys with automated call identification, visual searching of emergent rock crevices, and mist-netting) at sites where *Myotis leibii* were historically present. Our results suggest that acoustic surveys with automated call identification perform poorly for documenting presence on talus slopes (detection rate of 0%) relative to visual searching or mist-netting. *Myotis leibii* are known to emit broadband, high frequency echolocation calls that are readily degraded by atmospheric attenuation, clutter, wind, and the directionality of the bat call. We hypothesized that these factors, plus signal reflection and lower echolocation rates over talus slopes limited acoustic survey success. In contrast to acoustic surveys, both mist-netting and visual searches of emergent rock have basal detection rates of at least 75%. Success during visual searches varied slightly among observers, but detection probability during visual searches increased with each additional site visit. *Myotis leibii* roosts we located were overwhelmingly within small rock crevices, but there was no apparent preference for horizontal or vertical crevice orientation. Mean roost entrance width was variable, but roost depth was consistently and substantially shallower than, and not correlated with, maximum crevice depth. Roost temperature consistently was within a narrow range, but was positively correlated with external roost temperature. Total volume of the rock used varied tremendously among our samples and may not be a major factor in roost selection. Although we did not quantify relative exposure of the roost above surrounding rocks, anecdotal observations suggest that this may play a role in roost site selection.

SEX-SPECIFIC FORAGING HABITS OF THE EVENING BAT (*NYCTICEIUS HUMERALIS*) IN THE OZARK REGION OF NORTH-CENTRAL ARKANSAS

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Although many studies address the roosting ecology of forest-dwelling bats, little is known about the foraging habits for abundant, forest-dependent species. There is even less knowledge

pertaining to behavioral differences between male and female bats. During summers 2013 and 2014, I thus monitored the sex-specific foraging habits of the evening bat (14 males & 10 females) in the Ozark National Forest, Sylamore Ranger District of north-central Arkansas. I used fixed kernel (FK) with least squares cross validation and minimum convex polygon (MCP) methods to estimate the space-use patterns of male and female evening bats during their nightly foraging bouts. Evening bats, primarily males, used multiple core foraging areas. Females exhibited larger FK foraging ranges (852 ± 198 ha) than males (332 ± 85 ha), likely reflecting differences in energetic requirements or habitat availability (i.e., female roosts). MCP estimates were not different between sexes but varied among years. Similarly, FK foraging range estimates were significantly larger in 2014 (739 ± 163 ha) than 2013 (323 ± 106 ha) possibly due to differences in annual precipitation and resource availability. Results suggest that differences in foraging habits between males and females do exist. Further research is needed to produce better informed habitat management decisions.

PRELIMINARY RESULTS OF THE EFFECTS OF UTILITY-SCALE SOLAR ENERGY PROJECTS ON BATS

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Utility scale solar energy projects, primarily photovoltaic (PV) projects, are being built throughout much of North America and in many nations around the world, but little is known about their effects on bats. We present preliminary data from investigations of post-construction effects at an operating 250-MW solar photovoltaic (PV) project and a 337-MW concentrating solar project. Fatality surveys detected no bat fatalities during 24 survey months at the 250-MW PV project. Fourteen months of surveys at the 337-MW solar concentrating project detected no singed fatalities from exposure to solar flux or fatalities associated with heliostat collisions. Bat fatalities were detected at air cooled condenser units, but acoustic deterrents are expected to reduce these fatalities. At the 250-MW facility, we deployed 26 bat detectors from July 2012 through Dec 2013. We used general linear models to analyze the effects of operating arrays on the activity of bats as a group and for each bat species. All bats as a group, the Brazilian free-tailed bat, and the canyon bat had higher activity within operating arrays compared to preconstruction and conservation lands (0.80, SE= 0.167, $P<0.05$; 0.43, SE=0.203, $P<0.05$; and 0.41, SE=0.152, $P<0.01$, respectively). The pallid bat decreased its activity in array areas (-0.23, SE=0.078, $P<0.01$). The resulting increases in activity may be due to the edge habitat created by the panel arrays, but the low flying pallid bat may avoid the arrays due to fencing.

BAT OCCUPANCY IN BOTTOMLAND HARDWOOD FORESTS MANAGED FOR WILDLIFE IN THE MISSISSIPPI ALLUVIAL VALLEY

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Wildlife-forestry has been advocated for management of bottomland hardwood forests on public conservation lands within the Mississippi Alluvial Valley (MAV) and involves managing forests to achieve forest structure described as desired forest conditions (DFCs) for wildlife. Although songbirds may respond positively to management actions (e.g. timber harvests), little research has been directed at the effects on other species, including bats. To examine bat community response, we surveyed forest stands treated to achieve DFCs for wildlife and reference forest stands over two summer field seasons: 2013 and 2014. We conducted vegetation surveys to measure characteristics within stands and sampled bats using stationary full-spectrum acoustic recording devices over 6 consecutive nights. We identified echolocation calls to species using a combination of SonoBat™ software and manual verification of call sonographs. We used generalized linear mixed models to identify treatment effects on numbers of bat calls recorded. Results were mixed. In 2013, generally more big brown bat calls and silver-haired bat calls were recorded in treated units, while in 2014 more evening bat calls and eastern red bat calls were recorded in treated units.

SEEKING SILVER IN SOUTHEAST BRITISH COLUMBIA MINES: HIBERNATION ECOLOGY OF SILVER-HAIRED BATS

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The silver-haired bat, *Lasionycteris noctivagans*, is generally considered a 'migratory-hibernator,' migrating to areas where it overwinters with periods of dormancy. It is not known to what extent this bat is susceptible to White Nose Syndrome as its winter ecology is poorly known; however, this species has been found *Pseudogymnoascus destructans* positive in the east. In B.C. Canada, it has long been hypothesized that this species may not be migratory given its year-round detection in the province; however, intra-provincial or short distance migrations could not be ruled out. I studied silver-haired bats at two mines in SE B.C. from 2009 – 2014. Using temperature-sensitive transmitters in winter, I documented the arousal patterns of both sexes, and of adults and young-of-year. I also determined that silver-haired bats hibernate in mines, rock-crevices, trees and snags, often switching roosts during the winter period. By banding individuals at these 2 mines in both summer and winter, I documented the first evidence of year-round residency at mines by male silver-haired bats. Recaptures of both males and females banded as juveniles and recaptured as adults in subsequent years confirms roost fidelity. Evidence of winter mating was found in some January and February captures. Patterned acoustic recordings by silver-haired bats at these two mine sites could be described as "songs" and may be associated with mating behavior given their predominance during fall and winter.

ADAPTIVE AUTOMATED BAT CALL FILE IDENTIFICATION FOR A MULTIPLE SPECIES OCCUPANCY PROJECT

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Beginning in 2013, we initiated a multi-year occupancy modeling project in North Missouri targeting all nine bat species known to occur. The study area is composed of 120 sites sampled a minimum of nine times a year with multiple-microphone acoustic detectors (Wildlife Acoustics, SM2BAT+). This produces a large dataset of call files to be analyzed in an accurate and consistent manner. Additionally, each species affords unique challenges to identification, owing to their particular foraging strategies and echolocation parameters. To assess the efficacy of our data analysis methodology by species, we analyzed call files from a subset of our sites using multiple settings in automated call analyses software and compared to visual confirmation by a trained bat acoustic identifier. These sites were also mist-netted for bat presence to corroborate identification. Results varied depending on characteristics used to classify call files; both false positives and negatives occurred. However, species could be identified to a reliable degree of accuracy using individualized settings. To achieve quality, independently repeatable results from automated call analyses for a multiple species project, studies should use and report a combination of settings for identification catered to each expected species.

IMPACTS OF WHITE-NOSE SYNDROME IN KENTUCKY: SUMMER DEMOGRAPHICS OF BAT SPECIES PRE- AND POST-WNS

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White-nose syndrome (WNS) has caused high mortality in cave-dwelling bats in the northeastern United States; however, impacts in more southern states are unclear. No signs of high mortality were observed in the first two years of known incidence of WNS in Kentucky; but fatalities were expected to increase in 2014. The purpose of our research was to determine if summer captures of the most common species, big brown bat (*Eptesicus fuscus*), eastern red bat (*Lasiurus borealis*), northern long-eared bat (*Myotis septentrionalis*), and tri-colored bat (*Perimyotis subflavus*) differed pre- and post-WNS in Kentucky. We used statewide bat capture records from summer Indiana bat surveys conducted from 2007-2014 in Kentucky. We pooled data into two disease periods: pre-WNS (2007-2010) and post-WNS (2011-2014). Regression analyses indicated significantly more captures of *E. fuscus* and fewer captures of *M. septentrionalis* post-WNS. The proportion of male and female bats captured differed pre-post WNS, with capture frequency of female *L. borealis* and *E. fuscus* being significantly greater post- compared with pre-WNS. The proportion of lactating females was significantly greater post-WNS for each species except *P. subflavus.* In contrast, juvenile recruitment appeared to decrease, with proportionately fewer juvenile *L. borealis* and *M. septentrionalis* captured post- compared with pre-WNS. To date, impacts of WNS on WNS-susceptible bat species in Kentucky appeared to be greatest for *M. septentrionalis*, with the number of captures and the proportion of juveniles being lower post-WNS. In contrast, total captures and the proportion of lactating females was greater post-WNS for *E. fuscus*. No measurable impacts occurred to date for *P. subflavus.* Our results suggested notable declines of *M. septentrionalis* in the summer landscape three years post WNS-detection in Kentucky, while other WNS-susceptible species, like *E. fuscus* and *P. subflavus*, increased or remained stable.

MONTANA'S BAT ACOUSTIC SURVEILLANCE EFFORTS

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Montana's bat species face a wide array of conservation issues that threaten the long-term viability of populations; the potential arrival of White-Nose Syndrome (WNS) may be the single greatest threat. A collaborative effort was initiated in the fall of 2011 to document year-round spatial and temporal activity patterns of Montana's bats prior to WNS arrival. In the last 3 and a half years, we have deployed a network of over 60 Song Meter ultrasonic acoustic detector/recorder stations programmed to record bat passes from sunset to sunrise year-round. Through January of 2015, these recording stations have resulted in more than 4.0 million full spectrum sound files containing around 12 terabytes of information. Processing and automated analyses have been completed for all sound files and all information is being managed in a single SQL database in order to facilitate call review and data summarization. Over 30,000 bat passes have been reviewed by hand using an updated Montana bat call characteristics key to definitively confirm the presence of species during each month of the year, identify the lowest temperatures at which individual bat species are active, and track overall bat activity at each station, regardless of species. Highlights to-date include: 1421 new records of monthly species presence throughout the state, numerous first records of species' activity during the fall, winter, and spring months, numerous first records of species in regions with previously limited bat survey effort, documentation of nightly activity patterns throughout the year with regular winter activity documented for a few resident species and documentation of the year-round presence of species previously considered migratory.

NORTH AMERICAN BAT CONSERVATION ALLIANCE STRATEGIC PLAN

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The North American Bat Conservation Alliance (NABCA) is an informal federation of groups interested in bat conservation in North America, including federal, state/provincial and local government agencies; industries; non-government organizations; individual scientists and biologists; and concerned members of the public. The role of the Alliance is to facilitate coordination and communication among parties; to develop and maintain a North American Bat Conservation Plan that identifies conservation priorities and strategies; and to prepare and guide Action Plans to implement the priorities identified in the Plan. NABCA is not a formal membership organization; rather, it is envisioned as a structure to enhance the effectiveness of existing organizations by encouraging open communication and cooperation among groups; by identifying continental conservation priorities and strategies to address them; and by creating a cohesive continental voice to enhance support for bat conservation. A brief history of NABCA

will be presented, results of a conservation survey of >200 bat biologists across the continent will be summarized, and a draft of the North American Bat Conservation Plan will be introduced.

HOME RANGE AND HABITAT USE OF FORAGING GRAY BATS (*Myotis grisescens*) FROM FOUR MATERNITY SITES IN NORTHERN ARKANSAS

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Gray bats (*Myotis grisescens*) were listed as endangered in 1976 because of declining populations resulting from cave disturbance. The Gray Bat Recovery Plan recommends further study on foraging habits and home range. Yet, little data exist partly because gray bats have large home ranges, making ground-based tracking methods problematic. Accordingly, our objective was to assess gray bats' foraging habits using aerial telemetry. In 2014, two maternity sites (near Newark and Batesville, AR) were harp-trapped, and 50 adult lactating gray bats were radio-tracked from a Cessna 182 Skylane to gather 563 locations from June 15-July 15. Fixed-kernel density with least square cross validation was used to determine home range (95% of locations) and core foraging area (50% of locations) of a sub-sample of 14 individuals with ≥15 independent locations. Minimum Convex Polygon (MCP) was also used for comparative purposes with past published studies. Mean 95% home range was 362.2 km² (SE= 24.9 km²), 50% core foraging area was 83.2 km² (SE= 6.7 km²), average MCP was 171.6 km² (SE= 8.8 km²). For Newark (n=253 locations), home range was 349.3 km², with a 44.3 km^2-core foraging area, whereas MCP was 546.6 km². At Bone cave, tracked later in the rearing period (n=310 locations), home range was larger (1006.9 km² with core foraging area of 146.2 km²; MCP was 1293.4 km²). Each individual used 1-3 core foraging areas. Bats were often located over water, traveling by creek or river. With such large home ranges, management strategies for gray bats should go beyond protecting roost sites to include waterways and riparian areas for travel and foraging on sensitive aquatic insect species.

USING SIMULATED MICROSATELLITE LOCI TO TEST THE EFFICACY OF GENETIC METHODS TO DETECT POPULATION DECLINES

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Having accurate and precise estimates of effective population sizes are crucial to making efficacious conservation decisions. Species at risk of decline face potential losses of heterozygosity, which can impair a species' ability to adapt to changing conditions. Eastern red bats (*Lasiurus borealis*) are experiencing ongoing population losses due to wind turbine collisions and other anthropogenic factors. To test the power of genetic studies in detecting

recent population declines, simulated microsatellite loci data sets were created based on the characteristics of eastern red bats and then analyzed using MSVAR. Estimates of current effective population size, ancestral effective population size, time since decline, and mutation rates produced by MSVAR were compared to known parameters used to create the data. While the MSVAR software yielded highly accurate and precise estimates of ancestral effective population sizes, current effective population size was overestimated by an order of magnitude or more in nearly all simulations. M-ratios and theta determined for simulated data sets also failed to effectively detect population decline. Based on these results, we urge caution in using genetic data as a monitoring tool for populations experiencing recent declines, even when those declines represent the loss of a large proportion of the population.

ASSESSING BATS' USE OF SWIMMING POOLS AS AN ALTERNATIVE WATER SOURCE IN THE UNITED STATES

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Anecdotal reports suggest that as clean natural water becomes scarce, bats are using man-made water sources to satisfy their drinking needs. Our aim is to determine the prevalence of bats' use of swimming pools as an alternative water source, the prevalence of bat mortality in swimming pools, if certain pool features make them more/less accessible to bats, if there are landscape and/or climate factors that influence both bats' use of swimming pools and bat mortality in swimming pools, and if management action is being taken to reduce wildlife mortality in swimming pools. We created an online survey with 29 questions for pool owners and users across the U.S. The survey was open in 2013 and 2014, with 575 responses nationwide by December 31, 2015. Most responses were from the eastern U.S. as well as the west coast and southern states, with gaps in northern Great Plains and Rocky Mountain regions. Many respondents observed bats around their pools, and of those observing bats, a majority have seen bats drink from their pool. Respondents have also reported finding drowned bats in their pool. As habitat loss and urbanization pressure bats to roost in or near human dwellings, swimming pools could become a main water source for these bats. If swimming pools have negative effects on bats, this could raise conservation concerns for species already at risk. Results will be compiled and analyzed to gain knowledge on this novel interaction between wildlife and urban society.

CONSERVATION GENETICS APPROACHES TO IDENTIFY POPULATION-LEVEL MOLECULAR DIVERSITY OF BATS AT CONTINENTAL SCALE

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Bat diversity in North America is being rapidly exhausted due to direct and indirect consequences of human activity. As bat population decreases, loss of genetic diversity reduces

their adaptability to changes in the environment. For most bat species we have no information of the genetic structure and diversity of their populations, and conservation genetic efforts in bats should be directed to prevent a lack of genetic adaptability and a potentially risk of extinction. Here, I made a review on published data, the use of novel genetic tools, and highlighted priorities on conservation genetics to understand patterns of population structure, assess growth or decline of local populations, and estimate evolutionary arrays in natural populations of bats. Results showed a lack of molecular studies in the most diverse country (Mexico), and excess of studies in the northern most countries. Mainly studies have been focused on population genetics studies (i. e. microsatellites, SNP´s, or mitochondrial markers), but the use of the entire genome (i. e. transcriptomes, proteome, etc.) will be largely used in future researches. Conclusions directed that monitoring and managing bat populations, we must include genetics studies to maintain the pattern of genetic diversity in genes.

DIURNAL BAT FLIGHTS

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Observations of bats travelling during the day are rare in the literature, and this is especially true for bats in North America. Research has focused on hypotheses that attempt to explain why bats would avoid flying during the day; however diurnal flights could pose some potential benefits. Here we report observations of Indiana bats (*Myotis sodalis*) and a northern long-eared bat (*Myotis septentrionalis*) taking diurnal flights in the Appalachian Mountains. From 2009 to 2014 we observed a total of 11 individuals taking daytime flights: ten Indiana bats (nine females and one male) in the Smoky Mountains and one male northern long-eared bat in central West Virginia. Is this sort of diurnal activity truly aberrant or is this a natural, though perhaps uncommon behavior that warrants further investigation? We present hypotheses that may explain this behavior, discuss data that may have bearing on the hypotheses, and provide direction for future research.

EFFECT OF PARTURITION DATE ON ADULT FEMALE SURVIVAL IN THE LITTLE BROWN BAT

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The little brown bat (*Myotis lucifugus*) faces possible extinction due to white-nose syndrome. Like other animals with slow life histories, *M. lucifugus* population growth is strongly affected by adult female survival. Unfortunately, we know very little about the factors that impact adult female survival in this species. Previous studies indicate that juvenile survival is lower for pups born later in the season, presumably because they have less time to store fat before hibernation. We hypothesized that mothers who give birth later would also have lower survival, then conducted a four-year study at a maternal colony to test this hypothesis. We estimated

parturition dates, banded and recaptured females, used program MARK to model survival, then ranked models using Akaike Information Criterion. Our results determine whether parturition date affects adult female survival, which provides a basis for development of management strategies that could help lower extinction risk for *M. lucifugus*.

LOCATING CAVES USING REMOTE SENSING – COLOR INFRARED VS THERMAL IMAGING

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Management concerns pertaining to karst openings are multidisciplinary and range from water quality, water quantity, to the various animals that utilize them during their life cycle. But, in order to manage karst openings one first has to know where they are located. This presentation explores the possibility of using available satellite data to locate known springs compared to an airborne thermal imaging system. Locating caves in order to protect any troglobite or trogloxene species is a concern to fish and wildlife agencies. Using remote sensing may be a more effective means of finding karst openings than ridge walking or word of mouth. This may enable researchers to cover larger areas with less manpower. Non-traditional groups have recently begun searching for caves; these include the National Aeronautic and Space Administration (NASA) and the United States Department of Defense (DOD).
Natural Resources Conservation Service (NRCS) infrared satellite imagery at a scale of 1m x 1m was used for testing. Multispec image analysis software, using a supervised classification, was employed to test the hypothesis at Blanchard Springs Caverns near Fifty-six, AR. A helicopter mounted FLIR thermal imaging system was tested to see if it could locate known caves with or without a spring emergence. The test flight was flown on January 7, 2014 over 3 known karst openings; ambient temperature was -13°C.
Test results for the color infrared photography were promising using the supervised classification. However, the scale of 1m x 1m is to course too find smaller karst openings, this may improve as imagery at a smaller scale becomes available. The FLIR mounted thermal imaging system yielded better results for locating smaller karst openings. But, a better understanding of karst weather is needed to predict when the karst opening is “breathing”. However, either method may help direct ground crews searching for openings.

BEHAVIOR AND STRATEGIES OF MIGRATING INDIANA BATS (*MYOTIS SODALIS*)

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Migration strategies vary between and among species groups and are influenced by ecological and physiological factors. In this study, we evaluated the migration strategy used by the federally endangered Indiana bat (*Myotis sodalis*), a regional migrant found throughout the eastern United States. During 6 spring migration seasons (2009–2014), we actively radio-tracked female *M. sodalis* from 5 caves in Tennessee, primarily using aerial telemetry to document the behavior of spring migrating bats, and to determine the location of maternity areas. The mean distance from hibernacula to summer grounds (n = 11) was 175.6±31.2 km (range: 74.7 – 368.1

km). Mean traveling flight speed during migration for 9 bats was 12.8±0.5 km/hr which was significantly faster than mean foraging speed (4.5±0.6 km/hr). Bats flew 59.8±7.2 km per night on average (range: 11.8 – 153.3 km) during which they stopped every 1.4±0.2 hrs (range: 0.1 – 7.8 hrs) to use 3.4±0.4 stopovers per night (range: 1 – 10). Stopovers were nocturnal foraging areas, single-day roosts, or multi-day roosts. Such variation was attributed to environmental conditions and feeding requirements. Nightly migration movement ceased completely once temperatures dropped below 10°C, indicating a minimum migration temperature for *M. sodalis*. Diurnal bat body temperature generally mirrored ambient temperature patterns indicating that bats entered torpor daily. On nights with inclement weather (low temperatures or rain), bats remained in torpor and did not migrate. Our findings indicate that *M. sodalis* uses a combination of multistep migration (stopping periodically en route) and torpor-assisted migration (entering diurnal torpor to reduce fuel consumption). Information about habitat use at stopovers is still lacking, but documentation of migration behavior will provide valuable information for future conservation and recovery strategies for this endangered species.

USING MULTISPECIES GENETIC LANDSCAPES TO INFORM THE SPREAD OF WHITE-NOSE SYNDROME

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White-nose syndrome (WNS) is an epidemic affecting hibernating bats across eastern North America. As WNS spreads across North America, analyses of the phylogeography and genetic demography of known host species and other potential future hosts are increasingly important in providing baseline data regarding population size, demographic trends, patterns of population substructure, and estimates of gene flow. From these data, we may evaluate the importance of observed population declines from a historical perspective and infer likely paths of disease spread. For example, phylogeographic analyses of *Perimyotis subflavus* indicate that the predominant pattern of gene flow in the host mirrors the spread of WNS along and out from the Appalachians, suggesting that similar analyses in populations along and ahead of the disease front may allow us to predict future patterns of disease spread. Similar analyses in *Myotis lucifugus* indicate that landscape features such as the Allegheny Plateau may serve as semi-permeable barriers to gene flow among hibernating colonies, which might explain the delayed introduction of WNS into much of Ohio and Michigan. Several research groups are currently engaged in phylogeographic studies of individual species. While we agree that such analyses are important for understanding and predicting the impact of WNS, we argue that a multispecies approach is necessary for a better understanding of the spread of a disease that is remarkably broad in its host preference. Single-species analyses must be combined with information regarding multispecies roost behaviors and modes of fungal transfer to create multispecies epidemiological models. This approach is particularly important if WNS continues to spread across the continent and encounter novel host species. We encourage increased

collaboration across research groups and urge the integration of ecological, behavioral, and genetic data to model both intra- and inter-specific transmission.

USE OF AERIAL RADIO TELEMETRY TO DETERMINE HOME RANGE FOR THE NORTHERN LONG-EARED BAT (*MYOTIS SEPTENTRIONALIS*) IN TENNESSEE

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Although several past studies have investigated the roosting range of the northern long-eared bat, these studies were conducted in the northern portion of the species' range and few included foraging areas into an overall home range estimate. The objective of this study was to determine home ranges, including nightly foraging areas, for female northern long-eared bats on Arnold Air Force Base in Coffee County, Tennessee. To document foraging areas, bats were captured using mist-nets, fitted with radio transmitters, and tracked from the air using a Cessna 172 aircraft fitted with strut-mounted Yagi directional antennas. Foraging data were collected for three pregnant or lactating bats resulting in 126 individual foraging points. These foraging points were used to determine total foraging area (95% fixed kernel), intermediate foraging area (75% fixed kernel), and core foraging area (50% fixed kernel) for each bat and for all bats combined. The largest home range, which included four roost trees and three nights of foraging data, was 129.8 ha. Our study reports the first home range information, including roosts and foraging areas, for the northern long-eared bat in middle Tennessee. Collection of foraging behavior using aerial telemetry proved to be advantageous in the amount of data collected and efficiency compared to traditional ground based telemetry methods.

USE OF BRIDGE ROOSTS BY EASTERN SMALL-FOOTED BATS IN THE ARKANSAS OZARKS

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The eastern small-footed bat (*Myotis leibii*) is rare in Arkansas with only 111 known records in 17 counties in the Ozark and Ouachitas mountains. Prompted by a presentation at the 2013 SBDN meeting, a survey of bridges with concrete guardrails in the presumed range of the species was conducted April-October in 2013 and 2014. Small-footed bats were found in 21 bridges of this design in 8 counties. Bats were detected in 90% of occupied bridges on the first or second survey.

BAT ASSEMBLAGE AND SELECTION OF MATERNITY ROOSTS IN A POST-WILDFIRE FORESTED LANDSCAPE

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Ponderosa pine (*Pinus ponderosa*) forests in the southwestern U.S. have increased in density over the last 100 years following EuroAmerican settlement and subsequent changes in fire suppression, logging, and livestock grazing. These changes dramatically increased the size, severity, and frequency of wildfires. Wildfires rarely kill animals, but can have immediate consequences to bat populations by altering vegetation and thus roosting and foraging opportunities. Because no studies in the Southwest documented effects of wildfire on bats, we studied roosts and water sources used by bats on the 217,721-ha Wallow Fire that burned in 2011. Our objective was to describe landscape- and microsite-level roosting habitat used by reproductive female bats 2- and 3-years post-wildfire. We captured bats at water sources and used radio transmitters to locate maternity roosts for 4 species. We identified 67 roosts for 55 bats. For ponderosa pine snag roosts (n = 50), we measured habitat characteristics and paired each roost with a randomly-selected comparison snag. Snag roosts used by bats had larger dbh, less bark, and were more decayed with exfoliating bark. Bats used snags with up to 100% bole char, although one species, Arizona myotis (*Myotis occultus*), selected unburned ponderosa pine snags (<18% bole char). Microsite features appeared to influence roost selection more than landscape features. Some species may adapt to temporal changes caused by wildfire but others sensitive to high-severity fires, like the Arizona myotis, may decline. Species such as long-legged myotis (*M. volans*) that use fire-killed trees will encounter a pulse of roost structures for up to 10 years post-fire until snags fall; it may then take hundreds of years for forests to provide snags large enough for bat use. We suggest that in the long-term, habitat for bats will decline if we cannot manage large, high-severity wildfires in the Southwest.

INSIGHTS FOR CONSERVATION OF NORTHERN LONG-EARED BATS *(MYOTIS SEPTENTRIONALIS)* DERIVED FROM A MULTI-YEAR STUDY AT FORT KNOX, KENTUCKY

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With continuing population declines as a result of white-nose syndrome, and potential listing as a federally threatened species, it is increasingly important to consider conservation measures for northern long-eared bats (*Myotis septentrionalis*). Although the proposed 4d rule exempts forest management activities from US Fish and Wildlife Service oversight, other activities (e.g. military land use, mineral extraction) may require consultation and subsequent minimization and mitigation. Unfortunately, few data on appropriate conservation measures for the northern long-eared bat exist. We conducted a large scale, manipulative experiment on the impacts of roost removal for the northern long-eared bat at the Fort Knox Military Reservation, Kentucky that provides conservation insights for the species. In particular, our work shows that primary roost loss in the hibernation season will not cause maternity colonies to abandon roosting areas or cause a subsequent collapse in social structure the following year. Loss of ~25% of non-primary roosts does not apparently affect space use, but may have negative impacts on social structure. The intensive nature of our study also provides guidance for documenting maternity colony size, spatial extent, and the number of roosts used. Averaging across colonies that we

tracked, the number of roosts located per bat was positively related to the number of days a bat was tracked, but tracking >10 bats generally did not add new roosts or show greater space use. Based on movements between sequentially used roosts while accounting for reproductive condition, and on colony roosting area size, our results suggest that the 4(d) rule proposed 0.25 mile buffer around any located roost may be insufficient to protect all roosts used by a maternity colony. Finally, analysis of multi-year roost selection with >200 roosts indicates that single year roost selection data is insufficient to adequately describe roost selection at a given site.

A COMPARISON OF UPLAND TO LOWLAND ACOUSTIC DETECTOR SITES IN TWO STATE PARKS IN THE NATIONAL SCENIC RIVERWAYS

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As part of a mammalian biodiversity survey, several Anabat II bat detectors were placed across Current River State Park and the newly established Camp Zoe State Park. Detectors were placed near rivers and ponds, in both upland and lowland areas. Calls were analyzing with BCID and Kaleidoscope using the default species settings. We compared the diversity of bat species detected at each site, and compared the abundance of calls and the average calls per day of sites in different habitats. We also analyzed how the composition of bat calls changed over time. Overall, the average number of calls recorded per day were higher at sites near sites with flowing water than sites near ponds. Gray bats were the most frequently detected species, this is likely due to the proximity of a major colony. By understanding the diversity, abundance, and phenology of bats in different habitats, we hope to understand how the bat community is utilizing the landscapes in our study sites, which will hopefully inform management decisions at two parks that are undergoing major renovation.

NEW INSIGHTS ON THE DISTRIBUTION, ECOLOGY, AND OVERWINTERING BEHAVIOR OF THE LITTLE BROWN MYOTIS (MYOTIS LUCIFUGUS) IN ALASKA

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We initiated the citizen science-based Alaska Bat Monitoring Project in 2004 to investigate the distribution, habitat use, and seasonal ecology of the Little Brown Myotis in Southcentral, Central, and Western Alaska. As of 2012, we received reports of bats from 252 unique locations across the focus area, including Kotzebue, White Mountain, Saint Michael, and the Semidi Islands, which represent significant range extensions for bats in the state. Ninety-seven percent of 111 roosts were located in human structures. Maternity colonies were identified in 48 locations, all in human structures. The majority of observations were reported in late July, August, and September, but we received observations every month of the year. We received reports of bats associated with buildings unless observed flying outdoors; no hibernacula in

natural substrates were documented. Timing and locations of winter observations imply that bats in the most northerly areas are likely non-migratory and overwinter in human structures, while winter observations in Southcentral Alaska suggest both migratory and non-migratory behavior. Despite the limitations and bias inherent in the data set, these reports represent a significant contribution to our understanding of the distribution and ecology of the Little Brown Myotis in Alaska and provide a basis for future directed research efforts.

BAT ACTIVITY IN A POST-WILDFIRE LANDSCAPE

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Frequency and size of wildfires have dramatically increased in southwestern ponderosa pine (*Pinus ponderosa*) forests in the U.S. These changes result from an increase in tree density since EuroAmerican settlement because of fire suppression efforts and increased livestock grazing. Changes in vegetation resulting from wildfires affect habitat use by bats but this is not well documented. We hypothesized that burn severity would affect bat activity and used the 2011 Wallow Fire (217,721-ha) in eastern Arizona as our study area. Previous studies examined the effects of prescribed fire on bats; we found 1 published study examining the effects of wildfire on bat activity in the western U.S. We collected echolocation calls from 21 sites randomly selected within the fire boundaries. At each site, we monitored bat activity in each of four burn severity classes (0% – 25%, 26% – 50%, 51% – 75%, and 76% – 100% basal area [BA] loss) using SM3Bat acoustic detectors (n = 84 locations). We sampled each location twice: during the dry (June-July) and wet (July-August) season in 2014. We used SonoBat 3.0 to classify calls to species and calculated an activity index by adjusting the calls per species by number of hours that calls were collected at each location. We grouped *Myotis* species because they could not always be identified to species; other species were examined separately (e.g., silver-haired bat [*Lasionycteris noctivagans*]). We conducted a multi-scale analysis of landscape structure, quantifying fire severity and vegetation around each location at a specified scale (e.g., from 100 m to 1000 m radius). Burn severity affected use. The *Myotis* group used low burn severity (0-50% BA loss) areas but silver-haired bats selected areas with high burn severity (>50% BA loss). In the short term, patchy forest landscape created by large, intense wildfires provided habitat for different species of bats.

THE NEWEST THREAT TO BAT CONSERVATION: SLOPPY ACOUSTIC MONITORING AND ANALYSIS

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The species decisions generated by any echolocation auto-identification software program should be considered “suggested” classifications. Expert Manual Vetting is the only method to confirm bat presence from acoustic surveys. An “expert” is a qualified biologist with knowledge

of bat echolocation call characteristics and the limitations imposed by species having overlapping echolocation call repertoires. With the increase in bat surveys that rely upon acoustic-only methods, Expert Vetting has exposed issues ranging from flawed detector hardware, auto-classifiers outputting obvious and absurd misidentifications, and researchers misinterpreting results. This leads to erroneous reports on species presence, stemming from: (1) misplaced trust in the automated process, and (2) inexperience with interpreting spectrographic content. The vital input from manually vetting echolocation calls is essential for accuracy in reporting acoustic survey results, but in the hands of a novice, it can do more harm than good, leading to serious management and mitigation problems.
Novice acoustic analysts often attempt confident classification decisions for as many recordings as possible. Experienced users proceed more conservatively on species identifications. They have a greater appreciation of the unique call characteristics among species and can recognize atypical sequences or hardware issues that reduce confidence in classifications or encourage false-positive results. We reviewed a collection of full-spectrum recordings novices labeled "Species of Interest," and our Expert Vetting could not confirm any of the species decisions. We use this information as a "case study" to present guidance on interpreting acoustic software outputs when performing file-by-file expert manual vetting for species-of-interest. We identify common pitfalls of manual vetting, and what each recording really represents and why. A more comprehensive version of this program is available at:
http://www.batmanagement.com/acoustichelp/acoustichelp.html

SPECIES FROM FECES: A TOOL FOR GENETICALLY IDENTIFYING BATS

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Bat guano is a relatively untapped reservoir of information, having great utility as a DNA source because it is abundant in caves and mines even when bats are not present, and is stationary and easy to collect. Three technologies have come of age that together enable species identity from guano: reliable DNA typing from feces, DNA barcoding (species-specific genetic identifiers), and bioinformatic analysis. Taking advantage of these advances, we have developed a mini-DNA barcode assay that targets a segment of mitochondrial gene cytochrome oxidase I that we have found to be highly discriminatory among Chiroptera globally, readily accommodates fecal DNA, and selectively targets bat but not prey DNA. We have successfully validated our system from feces of 25 bat species (e.g., identification of *Myotis septentrionalis, Eptesicus fuscus, Corynorhinus townsendii*), with aged fecal pellets (up to 3 months old), and

with individual and pooled guano pellets, such that questions can target individuals (using specific fecal pellets) or populations and communities (long-term roost sites). Other benefits of our Species from Feces tool is in confirming field identification, especially of morphologically similar species. In several instances our genetic approach revealed misidentification of mist-netted species. We are currently developing a searchable website that will allow users to determine the discriminatory power of our markers for species that interest them. Although our Species from Feces tool has immediate application in the U.S., where bats are under threat from White-Nose Syndrome, it is also a potentially powerful application worldwide. For example, it can be used to determine presence of bat species that are vulnerable or facing extinction.

A TECHNIQUE TO ESTIMATE LOCAL POPULATION SIZE OF EASTERN SMALL-FOOTED BATS DURING SUMMER

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Typical efforts to monitor bat populations in North America rely on winter hibernacula counts, but this method may be ill-suited for eastern small-footed bats (*Myotis leibii*). Observations suggest small-footed bats have been affected by white-nose syndrome but it is unclear to what extent the disease has impacted their populations. We piloted visual surveys on 3 talus slopes in Virginia as a technique to estimate abundance of Small-footed Bats during summer. Local population size was calculated using random circular quadrats during July of 2013 and 2014. In each quadrat, we counted the number of bats and suitable crevices present and estimated population size using two methods. Bats were easily documented with visual searches. Estimates from quadrats suggested the largest (3 ha) talus slope had a maximum population of 196–343 bats, depending on the model used. Estimates from 2013 were similar to those from 2014, suggesting the method is consistent. Monitoring of Small-footed Bats on rock outcrops during summer should be explored as a way to resolve uncertainty over population trends. This technique should be tested at suitable habitats in other parts of the range of Small-footed Bats as soon as possible.

SPRING TIME ROOSTING ECOLOGY OF ENDANGERED VIRGINIA BIG-EARED BATS IN NORTH CAROLINA AND TENNESSEE

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The southernmost population of the endangered Virginia big-eared bat (*Corynorhinus townsendii virginianus*) occurs in NC and TN. The state of NC first identified winter hibernacula for the species in the 1980s. However, prior to this study we had no information on locations and characteristics of maternity sites used by this population. Our goal was to locate maternity roosts and to identify factors important in roost site selection. From March–May 2013 and 2014, we radio-tracked 42 female Virginia big-eared bats to 27 roosts in NC and 6 roosts in TN. We recorded landscape and

roost-scale characteristics for each roost. In 2013, we discovered the primary maternity roost used by this population, a cave 14 km NNW of the primary hibernaculum that is used by ≥ 350 adult bats. Across the landscape, bats roosted in spacious caves (n=13), relatively open rock structures (n=9), and buildings (n=11). Roosts were mostly at lower elevations (□=1033 ± 40 m, range 658–1422 m) than the hibernaculum (1421 m), which was also used as a maternity site. Most roosts (n=27) had multiple entrances. Size/complexity and airflow of natural rock roosts were important factors in maternity roost site selection for this population and, thus, these factors deserve investigation in future roost habitat studies for this species. Also, because Virginia big-eared bats roosted in buildings, it will be important to reach out to homeowners and developers in our study area. In NC, optimal roosting habitat for Virginia big-eared bats is a relatively large cave with stable internal temperature and little airflow, and located within southern Appalachian cove and oak forests. Identifying potential roost structures with characteristics similar to roosts we found and protecting known roost sites should enable managers to protect critical maternity habitat for Virginia big-eared bats in NC and TN.

PREY SELECTION OF SEVERAL COMMON BAT SPECIES OF A BOTTOMLAND HARDWOOD FOREST IN EAST TEXAS

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The most common methods for determining diet of bats include manual examination of fecal material for insect fragments and examination of discarded fragments under feeding posts or roosts. Both of these methods are biased to larger prey and/or prey with hard exoskeletons. Barcoding analysis of DNA from fecal samples reduces this bias. Our primary objective was to determine prey selection for several common bat species of bottomland hardwood forests by comparing dietary composition to prey availability at Old Sabine Bottom Wildlife Management Area. We extracted DNA from fecal pellets collected from bats captured during mist-netting between early June and early August 2013. We performed end-point polymerase chain reactions (PCR) using primer pairs developed for the cytochrome c oxidase subunit I (COI) gene. These PCR products were sequenced and resulting sequences were aligned and compared to reference sequences in the Barcode of Life Data System (BOLD) to obtain finest taxonomic designation (generally family or lower) for each sequence. We identified 9 species from 3 orders consumed by tri-colored bats (*Perimyotis subflavus*), 9 species from 4 orders consumed by Seminole bats (*Lasiurus seminolus*), 7 species from 3 orders consumed by evening bats (*Nycticeius humeralis*), and 11 species from only 2 orders consumed by Eastern red bats (*L. borealis*). Coleoptera was always the most abundant order available by biomass but was rarely consumed by Seminole or eastern red bats. However, it comprised a substantial portion of prey identified from tri-colored and evening bat samples. A significant portion of prey identified from all species was lepidopteran, while only a small portion of the available biomass was of

this order. Although dipteran species were a negligible portion of the available biomass, a large number of the prey identified in samples from all species were from this order.

URBAN IMPACTS ON WHITE-TAILED DEER FAWN SURVIVAL

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Urban populations of white-tailed deer (*Odocoileus virginianus*) are increasing in many areas throughout their range. Expansion of urban development and residential suburbs provide white-tailed deer with suitable habitat that is conducive to rapid increases in population growth along with increased risk of deer-vehicle collisions, personal property damage, and elevated incidences of zoonotic diseases. Assessment of fawn survival and cause-specific mortality is important for understanding the population dynamics in these areas. Comparisons between populations of fawn white-tailed deer in urban, suburban, exurban, and rural areas may provide additional insight about the factors that affect these populations. We captured and radio-collared 119 fawns (66 urban, 9 suburban, 8 exurban, 36 rural) in 2013 and 2014. Fawn survival was monitored during the first 6 months of life using radio-telemetry. Primary cause of mortality was vehicle collisions in urban areas, and coyote predation in suburban, exurban, and rural areas. We found that probability of survival increased as density of homes at birth sites increased. This information may help explain the population density differences in urban and rural areas, and help determine which management strategies may be the most effective.

A COMPARISON OF URBAN AND EXURBAN BAT COMMUNITIES IN A POST WHITE-NOSE SYNDROME LANDSCAPE

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Research on urban bats generally focuses on human-wildlife conflict and zoonotic disease, while little is known about bat ecology and habitat use in the urban landscape. Furthermore, the spread of White-Nose Syndrome (WNS) is fatally impacting many species, including urban-dwellers, across northeastern North America, and was first discovered in northern Illinois during winter 2012-2013. We sought to examine how species abundances and distributions differ within and between urban and exurban areas, to understand how urban ecosystems influence bat communities. From 2012 to 2014, we examined the presence and relative activity of bat species using passive acoustic monitoring systems in the Chicago metropolitan area. Acoustic monitors (SM2BAT+; Wildlife Acoustics) were deployed during two sampling periods (July/August and September/October) at 18 parks, golf courses and forest preserves in both urban Cook and exurban Kane counties. We detected a maximum of 7 species across sites in both urban and exurban landscapes, while golf courses and parks were among the most species diverse. Overall, we recorded more calls at urban sites than at exurban sites, and bat detections

decreased in the later sampling session, likely because bats were beginning to migrate to their winter sites. We found substantial species differences across sites, both within and between treatment groups. Of species impacted by WNS, we observed greater activity levels in urban sites than in exurban sites, including *Myotis lucifugus*, one of the most heavily impacted species. As bat species in Illinois begin to face the potential impacts of this rapidly spreading disease, our preliminary results will inform future monitoring and conservation efforts of populations in the Chicago area.

THE SIMULATED EFFECTS OF TIMBER HARVEST ON SUITABLE HABITAT FOR INDIANA AND NORTHERN LONG-EARED BATS

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Bat conservation in the eastern United States requires the ongoing production of important summer habitat for both diurnal roosting and nocturnal foraging and commuting. Forest management via silviculture can direct forest succession to retain and develop important habitat features. The large scale spatiotemporal effects of timber harvest on habitat for bats are not obvious but can be investigated with simulation models. We used a forest succession model (LANDIS-II) to simulate future forest conditions on Indiana State Forests under different harvest regimes. We simulated 9 harvest scenarios ranging from a complete cessation of timber harvest to intensive timber extraction. We applied previously created models of nocturnal and diurnal habitat occupancy for both Indiana and northern long-eared bats. We found that suitable nocturnal habitat was maximized for Indiana bats but minimized for northern long-eared bats under low intensity timber harvest scenarios. Among moderate intensity timber harvest scenarios, both species exhibited the greatest amount of suitable nocturnal habitat when timber harvest applications focused on regenerative openings. The quantity of suitable diurnal habitat trended in the opposite direction of nocturnal habitat with selection harvests favoring suitable roosting habitat. Overall suitable habitat was primarily driven by the degree of suitable diurnal habitat rather than nocturnal habitat for both species. This highlights the complex nature of managing multiple habitat needs for more than one species and illustrates the importance of understanding habitat requirements associated with different life history needs. Our results can inform forest management to preserve and encourage suitable habitat for multiple imperiled bat species.