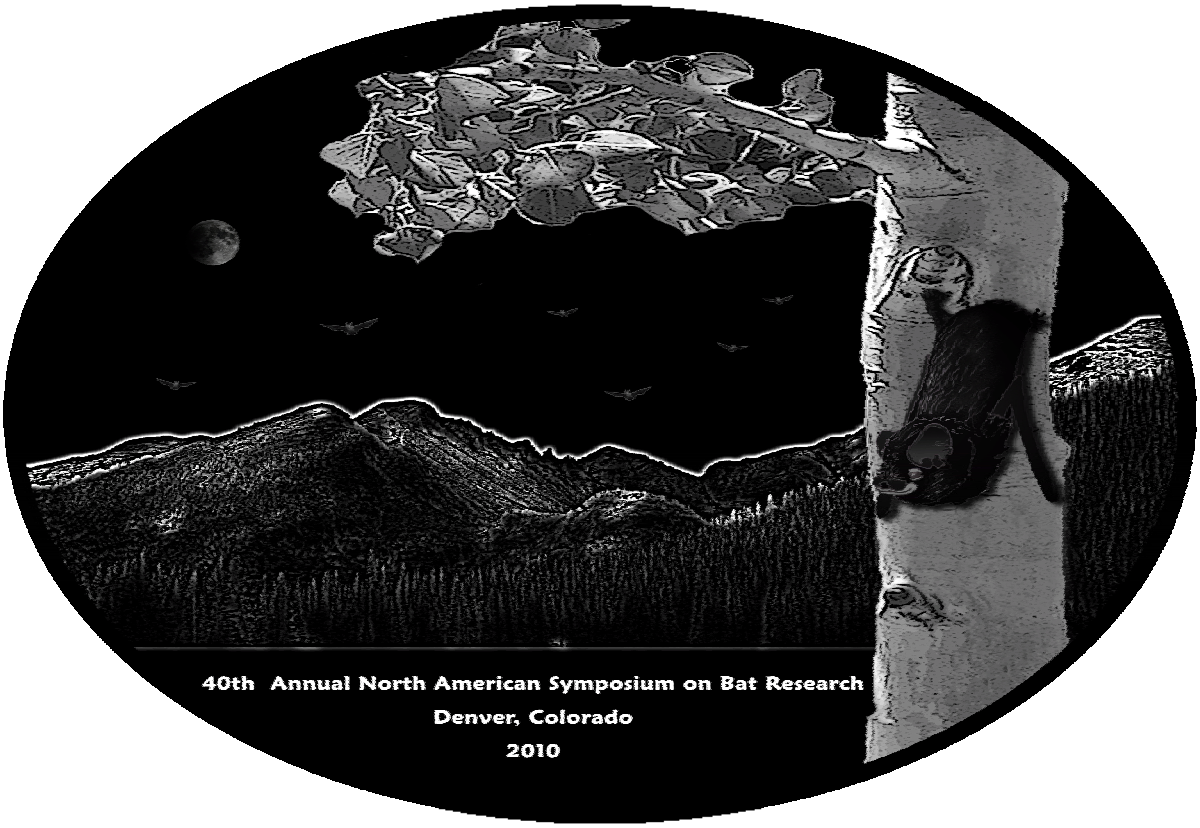
ABSTRACTS

North American Symposium on Bat Research



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Presentations at the 40th Annual Meeting of the North American Society for Bat Research, Denver, Colorado 27-30 October 2010.

Abstracts for platform and poster presentations are listed alphabetically by first author's last name.

Spatio-temporal Variation in Bat Activity in Ontario and How Sampling Method Impacts its Depiction
Amanda M. Adams. University of Western Ontario, London, ON

Effective management and conservation strategies for biological communities require a thorough understanding of structure and function. The structure of a community, the number of species, and the distribution of those individuals can vary dramatically both temporally and spatially. When attempting to characterize the structure of a community it is important to consider the advantages and limitations of various sampling techniques. When and how to sample is a question that is typically decided by time availability, manpower, and equipment limitations, with the majority of bat surveys occurring during the initial peak in activity (within 3 hours of sunset). The degree of temporal variability will determine if sampling in the beginning of the night is adequate and, if so, for which species. My research addresses how much sampling and what techniques are most effective for representing bat activity levels in a temperate location and to what extent different practice can give different representation of the same community.

The Evolution of Flight in Bats: Ontogeny and TAIL Locomotion Reveal New Insights
Rick A. Adams. University of Northern Colorado, Greeley, CO

Current scenarios outlining the evolution of flight in bats have little-to-no empirical support. Using ontogeny of flight as a surrogate for evolutionary patterns, I employed high-speed videography to investigate functional dynamics of flight development to parse out potential transitional stages from a nonvolant to volant mammal. The recent discovery of extensive and complex use of the uropatagium during flight (Tail-Assisted-Inertial-Lift, or TAFT) in vespertilionid bat and its relationship to body mass ($R^2 = 0.33$, $R = 0.58$, $P < 0.05$), along with morphological adaptations indicating an ancient evolution of this flight mode, compel a new consideration of flight ancestry for bats. Integrating data on ontogeny, morphology, and performance with mechanics and kinematics of TAIL locomotion and associated adaptations, I put forth a new interpretation and a unique hypothesis concerning the origin of flight in mammals.

"Being a Bat's Friend" and Walt Disney: Love at First Ultrasound
Paolo Agnelli, Giacomo Maltagliati, Laura Ducci, Marco Riccucci, and Stefano Cannicci. Museum of Natural History, Section of Zoology La Specola, University of Florence, Italy; Gruppo Italiano Ricerca Chirotteri (GIRC), Department of Evolutionistic Biology Leo Pardi, University of Florence, Florence, Italy.

The goals of the project initiated in 2006 by the Natural History Museum of Florence "*BAT BOX – Un pipistrello per amico*" (Being a Bat's Friend), are to raise the appreciation of bats in Italy and to encourage everybody to provide roosting habitat through the use of bat boxes. Thanks to Coop, a large Italian retail outlet, it has been possible to create a good model for a bat box and to distribute it throughout Italy. In the past four years, about 25,000 artificial wooden roosts for bats have been released and sold at cost both to private citizens and public entities. In 2010, Disney Italy joined the project; they changed the layout in order to give children and adults a greater opportunity to learn more about bats. Disney has created the comic "Paperino e il pipistrello Kiro" (Donald Duck and Kiro the bat) to enhance a positive image of bats such as agents of biological control through mosquito predation. Many people were (and are) happy to cooperate. The monitoring data has confirmed a growing success of colonization depending on the length of time since bat box installation: the bat boxes placed in 2007 are occupied 18.7% in the first year, 31.9% in the second, and up to 40.0% at the end of the third (2009). A similar trend is recorded for the artificial roosts positioned in 2008. The permanence time is therefore one of the main elements influencing the colonization. The height above the ground and the hours of sun that the artificial roost receives during the day are positively correlated to bat box occupancy. The lack of homogeneity of the collected data has unfortunately limited the potential practical usefulness of the connected analysis. In 2011 a new and better model of wooden bat boxes and another experimental model made with inert material and recycled plastic are planned as well, in addition to new comics adventures about Kiro.

Summer Thermal Regulation of Desert Kuhl's Bat *Pipistrellus kuhlii*

Abdulaziz Alagaili. King Saud University, Riyadh, Saudi Arabia

Most studies of thermal regulation have examined bats responses to summer heat in regions where temperature fairly exceed 40 Cº, but not to extreme heat as in deserts. As seasonal climate fluctuation poses a challenge to bats in central Saudi Arabia, Kuhl's bat, *Pipistrellus kuhlii* was studied for daytime body temperature fluctuations including the phenomenon of torpor. Temperature-sensitive transmitters were attached to nine bats over a seven-day period in late July. At dawn, Kuhl's bats entered a state of torpor in a manner similar to temperate bats as body temperature reduced from a normothermic level (~37°C) to a resting temperature of 26 to 31°C (air temp. 28°C, roost temp. 24°C). However, increases in air temperatures as morning progressed led to increases in roost temperature, thus body temperatures of bats rose reaching 32 to 35°C by noon. At 15:00, body temperatures of bats reached the normothermic level and surpassed it to a range from 35 to 42°C (air temp. 43.5°C, roost temp. 37°C), thus forcing them to emerge from roosts before dusk when it was still daylight and immediately sought water.

Acoustic Sampling: A Comparison of Detectors and Automated Software

C. Ryan Allen, Shannon Romeling, and Lynn Robbins. Missouri State University, Springfield, MO

Acoustic detectors have been used for monitoring flight activity of bats since Griffin discovered echolocation in 1940. Recently, significant progress has been made in the areas of portability, weather resistance, and the collection and storage of large data sets over extended periods of time. This progress includes the continued development of new and potentially more accurate means of collecting the information contained within each call sequence, as well as more accurate and repeatable ways to identify the species making these calls. The two main categories of detectors used to collect these data are zero-crossing analysis and full spectrum detectors. This study included three commonly used detectors; Anabat (Titley Electronics, Inc.), AR-125 (Binary Acoustic Technology), and SM2 (Wildlife Acoustics). Side by side comparisons were conducted for 43 nights during 2010 throughout Missouri. Data collected were used to compare average memory consumption, total files collected, total bat passes, quality of the call sequences, and reported call parameters. In addition, two automated call identification software packages were used for comparison; BCID (Bat Call Identification, Inc.) and Sonobat 3 NE (Sonobat). Call files recorded at the same time and location were initially identified by three experienced investigators and then run through the automated software systems. Furthermore, full spectrum calls from the SM2 recorder were converted into zero-crossing call files allowing the systems to analyze the same files. Accuracy rates, species composition, and processing times were measured for each block of files. The results of this study are of growing importance with the recent explosion in bat research due to large scale wind farms and white-nose syndrome.

Paraphyly and speciation within bulldog bats (Chiroptera: Noctilionidae)

Faisal A. Anwarali Khan, C. Miguel Pinto, and Robert J. Baker. Department of Biological Sciences, Texas Tech University, Lubbock, TX; Department of Mammalogy, American Museum of Natural History, New York, NY

Assessing species' boundaries or phylogroups using multifaceted approaches from independent genetic markers would be an appropriate method to identify independent evolutionary units. Under this framework, intrageneric relationship and species limits within Bulldog bats, genus *Noctilio* with an emphasis on *Noctilio albiventris* were explored using 4 datasets: cytochrome-*b* (cyt-*b*), cytochrome c oxidase-I (COI), Amplified Fragment Length Polymorphisms (AFLPs), and morphology. We genetically analyzed 51 samples of *Noctilio* from two currently recognized species: *N. albiventris* and *N. leporinus*. In cyt-*b* and COI gene phylogenetic analyses, *N. albiventris* form a paraphyletic clade, containing the gigantic species *N. leporinus*. Moreover, 5 monophyletic clades were documented, 4 associated with *N. albiventris* with > 5% genetic distance and a single clade for *N. leporinus*. Clades within *N. albiventris* are morphologically indistinguishable but they mostly have different geographic distributions, matching with all the recognized subspecies in *N. albiventris*: *N. a. minor*, *N. a. affinis*, *N. a. albiventris*, and *N. a. cabrerai*. Although we recovered all the clades from mitochondrial DNA in AFLP analysis (nuclear DNA), there are two individuals from different clades that were positioned differently. These individuals are from Guyana. These localities lie in the periphery of the geographic range of subspecies suggesting that these sites may represent a contact zone with gene flow between different maternal lineages. Genetic divergences in the mitochondrial genes (>5%) that are congruent with geographic distribution, and the paraphyly of *N. albiventris* (sensu lato) suggest that currently recognized subspecies within *N. albiventris* should be recognized at the specific level.

A digestive perspective on nectar-feeding specialization in phyllostomid bats

Jorge Ayala-Berdon and Jorge Schondube. Centro de Investigaciones en Ecosistemas, Universidad Nacional Autónoma de México, Apartado Postal 27-3(Xangari), 58089, Morelia, Michoacán, México

Floral nectar is one of the simplest foods in nature. It varies widely in sugar concentration, affecting the physiology and behavior of nectar-feeding animals. When nectar sugar concentration decreases, animals increase their food intake. In this behavior, named intake response, animals tend to achieve compensatory feeding. However, this behavior could be limited by physiological constraints. We hypothesized that the digestive capacities of bats affect their ability to acquire and store energy, and could modify the way they use the floral resources present in their environment. To test this idea we measured the intake responses and changes in body mass of the members of a community of nectar-feeding bats: *Choeronycteris mexicana*, *Leptonycteris curasoae* and *Glossophaga soricina*. We expected differences in the intake responses of the three species, with changes in body mass being independent of sugar concentration in bats achieving compensatory feeding, but positively correlated to sugar concentration in bats exhibiting physiological constraints. The three bat species presented different intake responses. Only *C. mexicana*, was able to achieve compensatory feeding. *G. soricina and L. curasoae* increased their sugar intake with sugar concentration. *C. mexicana* increased body mass independently of sugar concentration, while *G. soricina* presented a positive correlation between these two variables. Based on our results we generated a model relating digestive capacities and use of food resources in the field. In this model the physiologically-specialized bats (those able to perform compensatory feeding) should act as ecologically generalist capable of feeding on a wide range of nectar concentrations, while less-physiological specialized bats should act as ecologically specialists that use only concentrated nectars. Interestingly, bats that achieve compensatory feeding seem to be able to use a larger diversity of plants as food sources, supporting the idea that digestive traits affect the way these animals use food resources in the field.

Observations on the Reproductive Ecology and Post-Natal Growth of the Silver-Haired Bat (*Lasionycteris noctivagans*)

Erin Baerwald, Dayna Goldsmith, Brandon Klüg, and Paul Faure. University of Calgary, Calgary, Alberta, Canada; McMaster University, Hamilton, Ontario, Canada

Silver-haired bats (*Lasionycteris noctivagans*), hoary bats (*Lasiurus cinereus*), and eastern red bats (*L. borealis*) all roost in trees and are assumed to be long-distance migrants, thus, they are frequently lumped together into a migratory tree-bat group. However, silver-haired bats differ from the other members of this group in roosting ecology, phylogeny, and likely in their migratory or seasonal behaviour. *Lasionycteris noctivagans* are not solitary foliage-roosters, but generally form small maternity colonies in tree-cavities or hollows. Whereas *L. cinereus* and *L. borealis* belong to the tribe Lasiurini, *L. noctivagans* belong to the tribe Nycticeiini, and are therefore more closely related to big brown bats (*Eptesicus fuscus*) then they are to *L. cinereus*, for example. Therefore, we were interested in the relative influences of phylogeny, roosting ecology and migratory or seasonal behaviour on the reproductive ecology and postnatal growth of silver-haired bats. We maintained three pregnant female *L. noctivagans* and the ensuing four offspring in captivity. We determined postnatal growth rates by measuring forearm length and body weight of known-age juveniles. We also characterized patterns of fur- growth and isolation calls of the pups. We then compared litter size, growth rate and fur-growth patterns to that of *L. cinereus, E. fuscus* and *M. lucifugus*. One of the three females aborted underdeveloped triplets, while the other two females successfully birthed twins. One of those two females also bore a stillborn triplet. Preliminary data suggest that *L. noctivagans* twins have larger forearms and greater mass (in proportion to average adult size) than *L. cinereus* twins, but are smaller than *E. fuscus* twins and M. *lucifugus* singletons.

Comparing the Anatomy and Kinematics of Bat Handwings

Joseph Bahlman, Hannah Lippe, Sydney Scott, Elena Albright, Kenneth Breuer, and Sharon Swartz. Brown University, Providence, RI

Bat wings are derived from the mammalian forelimb and retain most of the bones and joints of basal mammals. Bat wings have at least 22 joints with at least 16 in the dactylopatagium. Many joints confers the ability to manipulate wing shape to an extraordinary degree and consequently modulate the aerodynamic performance of the wings. All known vertebrate synovial joints have, at minimum, an antagonistic pair of muscles crossing the joint to control motion, and we expect bat wings to retain this condition to realize the full potential for controlling 3D morphology. To test this prediction, we compared muscle attachments for all muscles crossing joints in the

dactylopatagium for twelve species of bats from five families, representing both Yinpterochiroptera and Yangochiroptera. Data for eight species were taken from published literature and four additional species from dissection. Additionally, we analyzed kinematics of handwing joints based on high speed video (1000 fps) for 4 of the species, and compared motion of specific joints with predictions based upon muscle anatomy. Our results show that every species examined had at least one joint that lacked muscles on the flexor and/or extensor side. All pteropodids had two interphalangeal joints without muscles on at least one side of the joint, and Yangochiropterans had an average of 4.9 joints without a muscle on at least one side. These joints were interphalangeal joints. Kinematic analysis showed that despite the lack of muscular actuators, these joints still flex and extend with each wingbeat in a manner similar to joints that retain muscles. We propose that the distinctive mechanics of bat wing membrane skin plays a critical role in transferring force between digits and has facilitated the evolutionary loss of heavy musculature. This pattern of controlled joint motion in the absence of muscle is a unique chiropteran adaptation for flight.

Speciation dynamics in bats

Robert J. Baker, Peter A. Larsen, and María R. Marchán-Rivadeneira. Texas Tech University, Lubbock, TX

Studying speciation is a difficult endeavor, because a vast number of variables can contribute to genetic isolation and protection of the integrity of the gene pools of the two speciating populations. Proposed mechanisms or models of speciation (i.e. allopatric, centrifugal, ecological, parapatric, peripatric, reticulated, sympatric, etc.) frequently overlap and are intriguing and complicated. Furthermore, application of these models to empirical data is frequently messy. To emphasize this observation, we provide an example of the complexity of the speciation process within a single group of non-model organisms, fruit-eating bats of the genus *Artibeus* (Chiroptera: Phyllostomidae). Our data indicate that at least three speciation processes (allopatric, ecological, and hybrid speciation) have contributed to species-level diversity currently recognized within the genus. Each of these processes has resulted in distinct signatures (or wing prints) that could only have been discovered through detailed genetic and morphometric analyses. What types of data are needed to elucidate these wing prints? Examples include: diversification time estimates, sister taxon status, sympatry, evidence of reciprocal monophyly in genomic, nuclear or mitochondrial genes, genetic distance values, presence/absence of hybridization, karyotypic uniqueness, presence/absence of morphological distinctness (size vs. shape or unique characters or presence of unique diagnostic characters), ecological tolerance, phylogroups, and behavioral observations. We hypothesize that detailed genetic studies of other recently evolved Chiropteran genera will document a similarly complex pattern of speciation to that observed in *Artibeus*. A common theme will be recognition of a greater number of species rather than a reduction of currently recognized species into a single species level taxon.

Variation in Offspring Sex Ratio of Big Brown Bats (*Eptesicus fuscus*)

Robert Barclay. University of Calgary, Calgary, AB

Life history theory predicts that offspring sex-ratio should be 1:1, unless there are different costs or benefits of producing one sex over the other. For example, sexual dimorphism that develops during dependence on the mother, may favour production of the less costly sex. Most studies of bats have found an equal sex ratio at birth and few have related sex ratio variation to seasonality, age of the mother, or other factors that may favour a skewed sex ratio. My students and I gathered data on juvenile big brown bats at three nursery colonies in Medicine Hat, Alberta over nine years. In this population, most females produce litters of one. I used site-specific growth curves of known-aged young to estimate the birth date of 899 juveniles, and examined sex-ratio variation relative to age of the mother (estimated by tooth wear), and birth date. Overall, the sex ratio was 1. The mother's age did not influence pup sex ratio. The timing of births varied considerably from year to year depending on spring weather, with the median birth date ranging from 21 June to 14 July. In early years, there was a significantly female-biased sex ratio early in the year, and a male-biased ratio later. In late years, there was no such seasonal variation, indicating that sex ratio varied with absolute date, not simply the stage of the reproductive period. Overall, the sex ratio of young born before 22 June was female biased (61.3%, n=150), while the ratio of those born after was male biased (53.8%, n=749). Some first-year females reproduce, and one explanation for the sex-ratio variation is that selection favours production of female young early in the year when they have the opportunity to enter hibernation with sufficient fat reserves to emerge in spring in good enough condition to reproduce.

Distribution, Abundance, and Habitat Use of Bats In North Dakota

Paul Barnhart and E.H. Gillam. University of North Dakota, Fargo, ND

In North Dakota, no baseline survey of bats has ever been conducted across the state, hence state and federal wildlife agencies have no information about this large group of mammals. As ND bat populations inevitably decline due to human development, extensive construction of wind energy facilities, and the pending spread of white-nose syndrome to the state, it is imperative to document key characteristics of bat populations so that an appropriate state conservation plan can be developed. Our research focuses on an extensive baseline survey of bats in North Dakota using acoustic monitoring and direct capture via mist-nets. Specifically, we are assessing the current distribution of the nine bats species reported from North Dakota, and determining the locations and types of key habitats used by each species. We are primarily focusing on "hotspots" around the state that include high quality bat habitat. Data were collected in the summers of 2009 and 2010. We will discuss our findings to date and how this information will be used to develop a state conservation plan for bats, as well as lay the ground work for future studies on the bats of North Dakota.

Relationships Among Bonneted Bats (Genus *Eumops*): a Molecular Test of Morphological Hypotheses

Sarah N. Bartlett, M. M. McDonough, and L. K. Ammerman. Angelo State University, San Angelo, TX; Texas Tech University, Lubbock, TX

The genus *Eumops* (bonneted bats) consists of 15 species and is more variable (both morphologically and karyotypically) than other genera in the family Molossidae. *Eumops* species range in forearm size from 37 to 83mm and the monophyly of the genus is supported by morphological data. The objective of our study was to use molecular data to test the relationships among *Eumops* species that have been proposed by cladistic analysis of morphological data. We included 12 species of *Eumops* and 4 outgroup genera (*Tadarida, Nyctinomops, Molossus,* and *Promops*) in our analysis. We analyzed DNA from the mitochondrial genome. A total of approximately 1674 base pairs from the ND1 gene (33 taxa studied) and cytochrome b gene (27 taxa studied) was collected. Bayesian analyses partitioned by codon position were performed on both individual and combined data sets. Divergences (GTR + I + G) ranged from 1.4% to 39% among the species of *Eumops*. Based on BEAST analysis of cytochrome b data, the genus originated around 15 MYA, divergence events between species ranged from 14.9 MYA (14.22-15.69) to 0.7 MYA (0.39-1.23), with most events occurring within the last 10 million years. Significant phylogenetic groupings were evaluated by Bayesian posterior probabilities for each gene. Significant disagreement between the two data sets was observed only in the position of *E. hansae*. Generally, the relationships supported by molecular data were not consistent with morphological hypotheses although some sister-groupings did agree with those previously proposed by morphological data. Our analyses provided additional resolution to the phylogeny of bonneted bats.

Dietary Overlap: Links between the invasive coqui frog (*Eleutherodactylus coqui*) and the endemic Hawaiian hoary bat (*Lasiurus cinereus semotus)* on the Island of Hawai`i

Riley F. Bernard, William Mautz, Frank Bonaccorso, and Christopher M. Todd. University of Hawai`i at Hilo Hilo, HI; Pacific Island Ecosystems Research Center, United States Geological Survey, Hawai`i Volcanoes National Park, HI

The Hawaiian hoary bat (*Lasiurus cinereus semotus*), known locally as the Ōpe`ape`a, is the only endemic terrestrial mammal on the Hawaiian Islands and is federally listed as endangered due to the limited knowledge of the species. Basic data regarding the ecological requirements and behaviors of the bat are minimal. Due to its relative obscurity to the people of Hawai`i, any knowledge gained in its study will benefit the ecology of the islands both biologically and culturally. Although this bat is a foraging generalist, it is still quite vulnerable to competition. In 1988, one of the most prominent vertebrate invasions on the Island of Hawai`i took place. The coquí frog (*Eleutherodactylus coqui*) an extreme sit-and-wait predator native to Puerto Rico, has seen an incredible population explosion within the lower elevations on Hawai`i. Due to its voracious appetite and incredibly dense populations, the coqui frog has the potential to reduce arthropod populations, specifically aerial arthropods such as Coleoptera, Lepidoptera and Isoptera, which are primary food sources of the Hawaiian hoary bat. Dietary analyses of the Hawaiian hoary bat presented elsewhere in this symposium, indicate that the most represented orders found are Lepidoptera and Coleoptera, with a small representation of Isoptera present. Here, I present preliminary data on the diet contents of the Hawaiian hoary bat and coqui frog to determine the degree of dietary overlap between these two

species. I hypothesize that coqui frogs consume a significant percent of aerial arthropods imperative to the Hawaiian hoary bat's diet and that as coqui frog populations continue to spread into higher elevations, the degree of dietary overlap will steadily increase. Coqui frog data collection from November 2009 to June 2010 at two low elevational sites indicate that several of the most common arthropod orders consumed are that of Isoptera, Coleoptera, and Lepidoptera, respectively.

Impacts of Wind Energy Facilities on North Dakota Bats: Biological and Social Implications

Lucas J. Bicknell, C. Biga, and E.H. Gillam. North Dakota State University, Fargo, ND

Wind energy is quickly becoming a critical technology for providing Americans with renewable energy and reducing fossil fuel dependence. The consideration of both biological and social issues related to wind energy development will provide a framework for effectively meeting human energetic needs while conserving species biodiversity. Biological implications of wind farm impacts on bats in North Dakota are especially dire, as the high wind energy potential in the state has led to rapid construction of many wind facilities, yet very little is known about local bat populations and how they may be affected by major landscape modifications. Pre-construction acoustic monitoring was conducted with Anabat detectors during the 2009 fall migration period at a proposed wind energy facility in south-central ND. We identified a high number of calls from eastern red bats, *Lasiurus borealis,* one of three bat species that have especially high mortality rates at wind facilities. Post-construction acoustical monitoring and mortality surveys were conducted at an established turbine facility in the same county during the 2010 fall migration period. The information acquired from this research will be used to identify potential needs for mitigation measures to reduce bat habitat loss and mortality. We are also currently conducting a public opinion telephone survey to assess public attitudes toward wind energy and wildlife issues at two turbine facilities located over seven additional counties in North Dakota. The survey is comprised of several measurement scales and is being used to measure public awareness of wind energy issues, including general attitudes toward bats and wildlife, and public concern for, and understanding of, the importance of biodiversity conservation.

Comparison of Three Acoustic Surveying Techniques for Detection of Adirondack Bat Species Richness and Foraging Activity

Larisa J. Bishop-Boros. State University of New York College of Environmental Science and Forestry, Syracuse, NY

I present results of acoustic bat surveys conducted at Huntington Wildlife Forest, in the central Adirondacks, NY. Determining bat species composition is common in acoustical surveys, but no comparison between acoustical surveying methods has ensured these techniques are equivalent. Transects have been developed throughout the Adirondack Park to monitor for the effects of White Nose Syndrome on *Myotis* populations through mobile surveying. This investigation uses four Anabat II detectors to compare the efficiency of mobile surveys to traditional active and passive techniques. I identified nine species acoustically over 43 nights at 12 stations along four routes, on the basis of call signatures using Analook and Bat Call Identification (BCID) software. Only calls recorded within three hours after sunset were analyzed, and calls were averaged each night as number detected per hour, for each technique. Significant differences between techniques were found using an ANOVA test in minitab (P-level < .001 for both Technique and Species, and interaction of species richness x method, P = .002). Mobile recording detected five species, (55% of the species detected by either passive or active), but did detect a greater number of big brown (*Eptesicus fuscus)* and hoary bat *(Lasiurus cinereus*) calls. Passive and active detected significantly more little brown bat (*Myotis lucifugus*) and Indiana bat (*Myotis sodalis)*calls. Passive detectors recorded the greatest activity but significantly more unknown calls and noise files. Results indicate active detectors record proportionately more identifiable calls due to longer call sequences and higher-quality recordings, but fewer total calls. Results suggest difference in methodology may yield different species richness, call quality, and activity data. Standardized survey methods for obtaining reliable information on bat populations are particularly crucial as the federally endangered Indiana bat is an Adirondack resident.

Hawaiian gourmand: moths, and beetles, and stink bugs, oh my! What a Hawaiian hoary bat will eat

F. Bonaccorso, R. Bernard, C. Todd, T. Zinn, C. Pinzari, and B. Yuen. Pacific Island Ecosystems, U. S. Geological Survey; Tropical Conservation Biology and Environmental Sciences, University of Hawaii at Hilo; and Hawaii Cooperative Studies Unit, University of Hawaii at Hilo

We document the diet of the Hawaiian hoary bat, *Lasiurus cinereus semotus,* on the island of Hawai'i where the mean body mass of adult females is 19.3 ± 2.5 g and the mean for males of 15.0 ± 1.2 g is significantly smaller (two-tailed t-test, p <.0001). Given the sexual dimorphism in body mass among adults we test the null hypothesis that there is no partitioning of food taxa at the ordinal level between males and females? Additionally we test the hypothesis: are less experienced subadult bats selecting ordinal food taxa differentially from adults? We present a list of identified food species in fecal pellets, including both endemics of Hawai'i and alien species. Several known crop pests including Chinese rose beetles and macadamia nut borer moths as well as flying wood-termite elates are important in the Hawaiian hoary bat's diet and thus the species offers services in decreasing the populations of pest species. Moths fecund with eggs and presumably highly nutritious also are important in the diet.

Bats, Mines, and Citizen Science in the Colorado Rockies

Lea Bonewell, Mark Hayes, and Kirk Navo. United States Geological Survey, Fort Collins, CO, University of Northern Colorado, Greeley, CO, Colorado Division of Wildlife, Monte Vista, CO

Several educational theorists have argued that informal education and citizen science are important aspects of conservation and ecological education. In 1991, an innovative program called the Bats/Inactive Mines Project (BIMP) was initiated in Colorado, U.S.A., to involve volunteers in conducting bat surveys at abandoned mines. Thirteen of Colorado's 19 bat species have been documented using abandoned mines as roosting habitat. However, the approximately 23,000 abandoned mines in the state represent significant safety hazards to humans. The involvement of volunteers helped the state's wildlife management agency conserve habitat for bats in abandoned mines throughout the Colorado Rockies, while closing unsafe mine sites to access by people. We considered the value of BIMP including informal education and citizen scientists in its conservation project and believe that the program is a successful model of citizen science. BIMP volunteers developed conservation biology knowledge and skills such as bat natural history, field orientation, and safe survey techniques. Experienced volunteers also demonstrated knowledge and skills in bat species identification, understanding bat diversity and distribution patterns, and many eventually lead volunteer survey crews. Participants in BIMP informally achieved many of the learning targets biological educators seek in ecological and conservation curricula, and developed habits of mind necessary for effective conservation projects. Several volunteers went on to become BIMP employees and attend graduate school studying bat biology. Since BIMP's inception, biologists trained 1,421 citizen scientists, generated over 57,000 volunteer hours, conducted approximately 3,000 volunteer bat surveys, and saved the state of Colorado over $580,000 in human resource costs. Conservation biologists and educators who provide informal education and citizen science opportunities will be doing a service to their communities by improving the biological knowledge, skills, and experience of their citizenry. Citizen scientists can help organizations leverage limited financial resources and achieve conservation goals not otherwise attainable without supportive volunteers.

Applying non-invasive genetic monitoring to bat populations

Emma S.M. Boston, Mathieu G. Lundy, Daniel J. Buckley, David Scott, Paulo A. Prodohl, Ian Montgomery, Ferdia Marnell, and Emma C. Teeling
University College Dublin, School of Biology & Environmental Science, Science Centre West, Belfield, Dublin 4, Ireland; Queen's University Belfast, School of Biological Sciences, Medical and Biological Centre, Belfas, Ireland; National Parks and Wildlife Service, Dublin 2, Ireland

In response to the ever increasing threats to natural ecosystems internationally, the Convention on Biological Diversity (www.cbd.int) have established guidelines to monitor biological diversity towards the goal conservation and sustainable use of biological resources. Monitoring biodiversity at the ecosystem and species level already exist, however, at the level of genetic biodiversity little has been done. Most studies do not take full advantage of the potential afforded by molecular genetic markers to systematically monitor changes in genetic composition and diversity through time. Here we discuss the development of a genetic monitoring scheme applying microsatellite DNA fingerprinting through non-invasive genetic mark-recapture techniques to monitor two of Ireland's most elusive bat species, the Whiskered bat (*Myotis mystacinus*) and Natterer's bat (*Myotis nattererii*). In

Ireland these species are found in low abundance in the environment, are acoustically cryptic, and with no known hibernacula, traditional bat monitoring methods are made extremely difficult. We present the comparative results of fecal vs tissue sampling, examine the utility of census population numbers from mark/recapture analyses, compared to effective population estimates as monitoring indices, as well as discussing the reliability of recording temporal patterns of genetic composition from fecal matter. These species will be used as a model to develop this methodology which could then be applied worldwide as a monitoring strategy for rare, endangered or indicator bat populations

Summer Bat Community Structure across Vegetation Types and Burn Units within the Ozark National Scenic Riverways

Janelle Bowcock, Joseph Lemen, Lynn Robbins, and Victoria Grant. Missouri State University, Springfield, MO; National Park Service, Ozark National Scenic Riverways, Van Buren, MO

A three-year project, beginning summer 2009, is underway within Ozark National Scenic Riverways (ONSR) to evaluate potential park habitat to determine the scope and dimensions of summer/fall Indiana bat (*Myotis sodalis*) use. One aspect of this is characterizing bat community structure across different vegetation types within the park. In addition, prescribed burns are performed each winter over 2500-3000 acres of woodland forest and glade communities. Recent information on fire effects vegetation changes, however, indicate that summer burns would be more effective in restoring open woodland habitat communities, which are important to foraging bats, including listed species. Determining summer habitat use and activity patterns is necessary to reduce potential negative impacts caused by moving prescribed burns to summer months. How community structure changes over time across different vegetation types, including within burn and non-burn units, will be compared. Mist-net surveys, along with acoustic detection, take place between April and October with sampling periods beginning at sunset and lasting a minimum of 5 hours. Nets are placed in potential fight corridors, in proximity to proposed burn areas as well as in proximity to known hibernacula, with at least 4 days between sampling at each site. In 2009, 17 sampling sites were established, which yielded a total of 94 net nights and 89 detector nights. There were 1100 total captures, representing 10 species, within 19 of the 49 classified vegetation types within the park boundaries. Species diversity, sex ratios, and 2010 sampling data will be included in future analysis. These data will be used in the revision of the park's fire management plan and other park actions relevant to bats, especially listed species. Understanding which vegetation types are important to bat species will help determine future management practices.

Nightly Emergence and Seasonal Activity Patterns of a Mixed-species Bat Colony in Relation to the Pecan Nut Casebearer Moth, *Acrobasis nuxvorella*

Elizabeth C. Braun de Torrez, Lauren D. Snyder, Kristen M. Lear, and Thomas H. Kunz. Boston University, Boston, MA; Ohio Wesleyan University, Delaware, OH

Insectivorous bats have been postulated to play vital roles in ecosystem function by suppressing herbivorous arthropods. Installation of bat houses has been a commonly used strategy to increase these services on agricultural lands. However, seasonal variation in bat abundance, foraging activity and behavior around bat houses can influence the degree to which bats suppress insect pests. Pecan orchards, which span 14 U.S. states, are economically important for both local farmers and national exports. The pecan nut casebearer moth (PNC), *Acrobasis nuxvorella,* is considered the most devastating insect pest of pecans. Anecdotal observations suggest that bats inhabit bat houses in pecan orchards in response to seasonal emergences of PNC. This study investigated this relationship using a mixed-species bat house in an organic pecan orchard in San Saba, Texas. We hypothesized that 1) colony size and nightly activity around the bat house is influenced by emergence patterns of PNC and selected environmental factors and 2) foraging activity increases with proximity to the bat house. Throughout the summers of 2008-2010, colony censuses were conducted weekly at the bat house using a thermal infrared camera and hourly 15-second thermal-imaging recordings were taken on eight nights. AnabatII/Zcaim detectors were used to compare bat passes and feeding buzzes at different distances from the bat house. Colony size was not significantly related to PNC abundance; however, it was consistently highest in May during the largest and most damaging PNC emergence. Activity around the bat house was negatively correlated with temperature, suggesting that bats stay closer to their roost in low temperatures, and was lowest during peak hours of PNC activity. Bat passes and feeding buzzes increased with proximity to the bat house. These results suggest that roosting patterns of bats do not correspond to PNC abundance, but do show temporal overlap with PNC in the orchards.

Response of Tree Roosting Bat Species to Riparian Habitat Development Along the Lower Colorado River in Arizona and California

Susan C. Broderick. U.S. Bureau of Reclamation, Denver, CO.

Acoustic monitoring of riparian habitat being developed as part of the Lower Colorado River Multi-Species Conservation Plan (LCR MSCP) has shown bat activity for two species of tree roosting bats, western red bat (*Lasiurus blossevillii)* and western yellow bat(*L. xanthinus)* has increased substantially since planting began. These 2 bat species are being managed for specifically, along with 24 other threatened or endangered species, or species at risk of becoming endangered. Planting cottonwood, willow and mesquite in 5 restoration sites along the LCR began in 2006 and is ongoing, with the ultimate goal of creating 7,260 acres of riparian habitat. These sites are growing rapidly, creating diverse, multi-species stands with complex canopy structures. At Palo Verde Ecological Reserve near Blythe, California, the number of bat minutes (a measure of bat activity) has increased from 3 in 2008 to 11 in 2009 to 163 minutes in 2010, while bat activity in the adjacent agriculture and saltcedar habitats ranges from 0 to 8 minutes during the same time periods. Western yellow bat activity increased from 0 in 2008 and 2009 to 88 minutes in 2010. At Cibola Valley Conservation Area downstream 20 miles in Arizona, red bat minutes increased from 0 in 2008 to 91 in 2009 in cottonwood-willow habitats. Acoustic monitoring was conducted at all restoration sites during October, February, April and July, 2008 through 2010, following a 1 year pilot program. From 9 to 15 Anabat bat detectors were deployed in each restoration site with 3 detectors per habitat (sapling cottonwood, intermediate cottonwood, mesquite, agriculture, saltcedar) depending on which habitats are present. Analyses of recently collected acoustic monitoring data and the relationships between bat activity and various habitat variables for all bat species are ongoing. Acoustic monitoring results are used in adaptively managing the habitats.

Inferences on the diet of *Myotis* bats as revealed by stable isotope analysis

Hugh G. Broders, R.N. Hearn and L. Lawrence. Department of Biology, Saint Mary's University, Halifax, NS, Canada

Although dozens and dozens of researchers have spent tens of years studying and writing hundreds of papers on the diet of insectivorous bats there is still much on the topic that is a mystery. This difficulty in accurately characterizing foraging dynamics is likely due to a number of factors including: 1) tremendous variation in population sizes of nocturnal insects across spatial and temporal scales and among weather regimes, 2) possible differences in "preference" or "selection" of prey types between genders and among individuals or species, and 3) impacts of inter- or intra-specific competition for prey. Regardless, most studies find that species include a large variety of prey types in their diet, suggesting most bats are dietary generalists. Stable isotopes are a relatively new area of research that permits researchers to make characterizations of diet based upon the relative abundance of element isotopes in the tissues of predators. Previously, in samples collected from southern New Brunswick, Canada we had identified the possibility of a methane-derived source of carbon in little brown bats and shown that northern long-eared bats are diet specialists. The objective of this study was to expand the spatial scale of sampling in the same species to determine how generalizable these inferences are by further quantifying stable isotope ratios of carbon and nitrogen in little brown and northern long-eared bat tissues. For northern long-eared bats our results support the previous contention that they are specialists. However, there was significant spatial variation in the profile of little brown bats that highlight the unique nature of the presumed methane-derived-carbon that was found in southern New Brunswick. Further, we detected a marine influence in their diet on Brier Island and agriculturally-derived nitrogen enrichment on Prince Edward Island. Finally, because of the spatial variation in isotope patterns of little brown bats it may be possible, with more sampling, to use stable isotopes to assign some migrating, swarming or wintering bats to summering areas.

Change in Summer Bat Activity in Southern New England Following White-nose Syndrome Outbreak

Robert Brooks. U.S. Forest Service, Northern Research Station, Amherst, MA

White-nose syndrome (WNS) was first reported from a bat hibernacula in central New York State in February 2006. Serendipitously, I completed a three-year acoustic survey of bat activity in a working-forest landscape of central Massachusetts in 2006. The survey of three replicate sites of the 10 most common habitats showed that the Quabbin Reservoir watershed supported a rich and abundant summer bat community. *Myotis* species were the more commonly recorded (three-year average, all habitats, 6.0 call sequences/hr [CSs/hr]) than large-bodied species (1.34 CSs/hr). Both types of bats were recorded more frequently in open and aquatic habitats. The diverse landscape of

aquatic, open, and forest habitats provided abundant foraging and roosting habitat for bats. By 2010, WNS had spread across the northeastern U.S. and adjacent Canada and is associated with the death of untold numbers of cave-hibernating bats. To assess the impact of this catastrophe on the summer community of bats on the Quabbin, I repeated the passive acoustic bat component of the earlier surveys in 2010, using the same locations I had surveyed between 2004 and 2006. In 2010, *Myotis* activity had declined dramatically from the pre-WNS surveys to an average 1.67 CSs/hr across all habitats. Large-bodied bat activity increased slightly in 2010 from the earlier surveys, to an average 1.98 CSs/hr. From these preliminary data, it appears that WNS-caused mortality at winter hibernacula has resulted in a major decline in summer activity of cave-hibernating *Myotis,* resulting in a substantial change in the relative composition of the bat community. The results of the resurvey provide additional documentation of the devastation of North American bats being caused by WNS.

Bats and Mine Closure: A Double-edged Sword

Patricia E. Brown, Patricia. Brown-Berry Biological Consulting, Bishop.

Much of the Western United States was settled as a result of mining. When the mines were abandoned, bats colonized these new "caves". Cities grew up around some mining districts. Even in remote areas, mines are visited by people exploring on off- highway vehicles. Abandoned mines can be hazardous, and accidents result. The recent influx of funds in the United States for mine closure has stimulated a rush to remediate mine hazards on federal lands. To attain the goal of the Economic Stimulus Package of putting more people to work, some people are involved who do not have experience in bat biology or bat-compatible closures. If done properly, bats in mines could be protected through the installation of bat gates and cupolas. However if bat habitat is not identified, mines could be closed through foam and backfill that would deprive bats of roosting habitat and potentially kill them, especially if exclusions are not done properly at the appropriate time of year. Most bat species use a variety of roosts throughout the annual cycle as dictated by physiological and behavioral needs. The timing of surveys will influence the ability to detect bat use of a mine feature, which can affect the treatment that a mine may receive (hard or bat-compatible closure). There is no substitute for site-specific bat surveys using established protocols to detect bat use, nor is there a universal style of mine closure. Some bat colonies do not accept culverts or even gates. To understand the importance of a single mine feature, most of the mines in a geographic unit may need to be evaluated in order to determine those with the most significant bat use at different times of the year. The scope of the "landscape" will depend on the species of bat and their dispersal ability. The goal is to identify and protect the most important bat mines, and to avoid killing bats if a non-wildlife compatible method is selected.

Molecular analysis of guano from bats in bat houses on organic pecan orchards

Veronica Brown, Elizabeth Braun de Torrez, and Gary McCracken. The University of Tennessee, Knoxville, TN; Boston University, Boston, MA; The University of Tennessee, Knoxville, TN

Bats are generalist predators of night flying insects, including many crop pests. Pecan nut casebearer (*Acrobasis nuxvorella),* hickory shuckworm (*Cydia caryana*), and several stink bug species are some of the most damaging crop pests in pecan orchards. Attracting bats to agricultural areas using bats houses may reduce the numbers of these pests and, consequently, their economic impact. This study uses quantitative polymerase chain reaction (QPCR) of mitochondrial DNA found in the guano of bats living in bat houses on organic pecan orchards to document the consumption of pecan nut casebearer, hickory shuckworm, and corn earworm (*Helicoverpa zea*), which is one of the most destructive pests of many crops throughout the world. This study also uses direct sequencing of insect remains in bat fecal pellets to identify species of stink bugs consumed by bats in bat houses. Evidence that bats prey upon crop pests supports the hypothesis that bats are both economically and ecologically beneficial to pecan farmers and provides incentives for bat conservation.

Behavior of Bats with White-Nose Syndrome

Sarah A. Brownlee and D. M. Reeder. Bucknell University, Lewisburg, PA

In 2006 a fungus was found growing on the muzzles and forearms of hibernating bats in New York. This fungus was later found to be connected to the death of a million or more bats in the Northeastern United States. The relationship between the fungus, *Geomyces destructans,* and the disease, known as White-Nose Syndrome (WNS), is now at the forefront of bat research. Unfortunately, our knowledge of bat behavior during hibernation is sparse. Previous work has shown that WNS-affected bats arouse to euthermic temperatures during hibernation more

frequently than unaffected bats. However what they are doing during these arousals is unclear, and has been identified as a topic of high priority. To monitor hibernating bat behavior infrared motion-sensitive cameras were deployed in WNS-affected and unaffected hibernacula, and in captivity. The duration and frequency of behaviors was measured. Behaviors included general arousal behaviors, grooming, and locomotion. The duration of arousal bouts (time spent euthermic) was significantly shorter in WNS-affected bats, which spent significantly more time grooming (and less time engaged in all other behaviors) than unaffected bats. Future studies include monitoring the behavior of more affected and unaffected bats and experimentally testing the hypothesis that affected bats are disoriented, have lower flight maneuverability, and have altered echolocation calls compared to unaffected bats.

Shifts in Bat Activity in Response to Wildfire in the Southern Sierra Nevada

Michael R. Buchalski, Paul A. Heady III and Winifred F. Frick. Western Michigan University, Kalamazoo, MI; Central Coast Bat Research Group, Aptos, CA; Boston University, Boston, MA.

Little is known about the effects of forest fires on bat communities. Disturbance events such as fires can shift the composition of ecological communities. The frequency of wildfires is predicted to increase due to climate change, demonstrating the importance of understanding the impacts of fire on forest bat communities. Here, we assess changes in bat activity in response to a forest fire in the southern Sierra Nevada. We measured echolocation activity of bats across 14 sample locations to compare bat use of burned and unburned habitats associated with McNally forest fire in Sequoia National Forest, California during July and August 2003, one year post-burn. We used broadband ultrasonic detectors (Anabat II) paired with storage devices (Anabat ZCAIMs) to record all night activity for a minimum of five nights at each site in riparian and upland habitats. Call data were assigned to species or acoustic groups based on terminal frequency to avoid species misidentification. Categories included *Antrozous pallidus, Myotis thysanodes*, *M. evotis*, 50 kHz *Myotis*, 40 kHz *Myotis*, and 25 kHz. A zero-inflated Poisson generalized linear model was implemented in R to assess the influences of fire and habitat type on bat activity. Differences in bat activity by habitat type were consistent with known foraging ecology of the species. All *Myotis* species showed increased echolocation activity within burned habitats ($P < 0.02$). In contrast, species within the 25 kHz group (including, *Eptesicus fuscus*, *Lasiurus cinereus*, and *Tadarida brasiliensis*) had higher levels of activity in unburned habitats ($P < 0.001$). There was no difference in use of burned and unburned areas by *A. pallidus* ($P = 0.90$). Our study demonstrates that bat species may respond differently to the structural changes in habitat due to forest fire and that severe forest fires have the potential to shift the composition of forest bat communities.

Home range and habitat associations of a maternity colony of *Myotis mystacinus* (whiskered bat) in a heavily altered landscape in Ireland

Daniel Buckley, Mathieu Lundy, Emma Boston, David Scott, W. Ian Montgomery, Paulo Prodöhl, Ferdia Marnell and Emma C. Teeling. Centre for Irish Bat Research, University College Dublin, Dublin 4, Ireland; Centre for Irish Bat Research, Queens University Belfast, United Kingdom; National Parks and Wildlife Service, Dublin, Ireland

Since the expansion of agriculture in Europe, forest habitats have been significantly reduced and altered leading to the marginalisation of woodland specialist plants and animals. Nowhere is this more evident than in Ireland, where native woodland cover now stands at less than one percent. Forest animals, such as bats, have been driven to utilise woodland ecotone habitats. The whiskered bat *Myotis mystacinus* is a woodland specialist species found throughout Europe. In Ireland it is widespread but localised and in low densities. To elucidate what habitats this species used in a heavily altered lowland agricultural environment, a maternity colony of *M. mystacinus* in Co. Cork, southern Ireland was chosen for a radio telemetry study. Eighteen bats were tagged and followed for a five night period from May to July in 2009. Location points were estimated by triangulation. Bats were found to forage within a very small home range (70-180 hectares) but used a network of roosts, both man-made and artificial. Riparian habitats were found to be heavily utilised. The implications for agricultural landscape design and management through the identification of key habitat components that could be a conservation priority for this species is discussed.

Fruit bats are the major pollinators of the economic food plants, durian and *Parkia*, in southern Thailand

Sara Bumrungsri. Department of Biology, Faculty of Science, Prince of Songkla, Hat Yai, Songkhla, Thailand

Although the floral traits of durian and *Parkia* conform to the bat-pollination syndrome, many visitors other than bats have been observed at their flowers and some chiropterophilous plants are also pollinated by other animals.

The present study aimed to determine the breeding system of the economically important trees, durian and two species of *Parkia,* and to identify their pollinators. The floral biology and pollination ecology of durian, *Durio zibethinus,* were determined in eight semi-wild trees, while 28 trees of *P. speciosa* and four *P. timoriana* were examined. They are mostly or completely self incompatible. Flowers open fully during late afternoon or evening, and anthers dehisce around 2000 h when the stigmata are already receptive(*Durio*) or receptive at same time (*Parkia*). In a series of pollination experiments, the highest pollination success occurred either after hand-crossed (*Durio*) or open pollination (*Parkia*). Insect pollination resulted in fruit set in only 12% of *P. speciosa* inflorescences. Fruit bats, mainly *Eonycteris spelaea*, visit flowering plants continuously from dusk till after midnight. Nocturnal and diurnal insects (moths and giant honey bees, stingless bees) also frequently visit flowers. Bats visited durian flowers at the rate of 26.1 (SD=20.7) visits per inflorescence per night. The pollination services of fruit bats to these plants were estimated to be 137 million US dollars in southern Thailand. Although these economically important plants depend on fruit bats as their pollinators, *E. spelaea* appear to be declining throughout its distribution, often as a result of persecution by farmers who believe the bats damage flowers. Therefore protection of fruit bat populations and their roosts is vital for the continued production of these fruit crops.

@BatRoost: A Prototype Device to Monitor Bat Activity Through Twitter

Stephen C. Burnett. Clayton State University, Morrow GA

Non-invasive monitoring of bat populations is often expensive and time-consuming, but it has obvious potential benefits for our understanding of bat populations and behavior. New developments in web-based applications and microprocessors have made it possible to develop monitoring devices that can provide new capabilities with minimal expense or difficulty. With a minimum of hardware and software experience, it is possible to assemble custom-built devices that can be used to monitor bat activity while simultaneously measuring a number of environmental variables. The data recorded by such devices can be stored for retrieval at a later time, sent directly to a computer or other recording device, or sent through the Internet using services such as Twitter. I will provide details on the assembly of a prototype system, with a discussion of cost, flexibility, and potential uses of this device for bat population studies, including benefits and limitations to using such a system. While this type of device will not replace systems that are more expensive and precise, these devices can be included in the set of overall techniques used by bat researchers, allowing the collection of data from a wider variety of sources.

Citizen-based Acoustic Monitoring as Part of an Undergraduate Science Curriculum

Deanna Byrnes. Carthage College, Kenosha, WI

Research experiences at primarily undergraduate institutions (PUI) are valuable for providing students with practice in all aspects of the scientific process, and in their ability to generate excitement and a feeling of responsibility that cannot be matched by classroom experiences alone. Faculty at PUI's are challenged to develop excellent teaching practices that reach all students, maintain an active program of scholarship, and contribute to their communities in meaningful ways. As White-nose Syndrome spreads westward, agencies face difficulties in developing management and conservation plans given the paucity of population-level information for most of our bats. In an effort to learn more about Wisconsin's bat populations, our state's Department of Natural Resources has organized an extensive network of volunteers as part of the Wisconsin Bat Monitoring Program (http://wiatri.net/inventory/bats/) to gather occurrence and relative activity data from across the state. Here I describe how this citizen-based monitoring program has provided myself and undergraduate students at Carthage College a unique and rewarding research experience, and how incorporating research service-learning (RSL) into the undergraduate curriculum can develop ecological understanding in a broad range of students and help procure valuable information when help is most needed.

Ontogeny of Echolocation and Flight Performance in *Artibeus jamaicensis*

Richard Carter, Rick Adams, and Jason Shaw. University of Northern Colorado, Greeley, CO

The ontogeny of echolocation is fairly well studied in oral emitters, however, little is known about nasal emitters. We investigated the ontogeny of echolocation in *Artibeus jamaicensis* as it pertains to flight development. We hypothesized that calls will change in structure as flight performance progresses and predict that the calls will develop from lower frequency directives into higher frequency orientation calls as young bats learn to fly. Young were captive raised and calls were recorded as individuals were released from a 1 m high perch onto a foam pad

beginning on day 1 postpartum. Calls were recorded on Pettersson D240X detectors and analyzed with Sonobat V2.9.2. Each bat's flight stage was classified as either flop (n=7), flutter (n=15), flap (n=7), or flight (n=3). We measured call duration, high frequency, low frequency, bandwidth, and frequency of maximum power. An ANOVA and a Tukey's HSD were run on all variables to test for significance differences among flight stages. F values and means are reported below for each variable. Flight stage means together in parenthesis are not significantly different from each other, values with * are significantly different from each other. Call duration (P>F 0.0060) (ms): flop=3.24* SD=0.41, flutter=2.70 SD=0.23, flap=1.53 SD=0.40, flew=0.83* SD=0.58. High frequency (P>F <.0001) (KHz): flop=31.0* SD=6.3, flutter=47.9* SD=4.7, (flap 65.7 SD=6.2, flew=76.5 SD=7.4)*. Low frequency (P>F <.0001) (KHz): flop=20.9* SD=4.8, flutter=33.3* SD=3.4, (flap=49.4 SD=4.7, flew=54.9 SD=5.5)*. Bandwidth (P>F 0.0015) (KHz): flop=9.8* SD=1.8, flutter=14.7 SD=1.3, flap=16.4 SD=1.8, flew=21.7* SD=2.1. Frequency of maximum power (P>F 0.0003) (KHz): (flop=26.4 SD=5.9, flutter=40.6 SD=4.3)*, (flap=57.2 SD=5.8, flew=66.2 SD=6.9)*. These data suggest not only a shift to a higher frequency range but also an increase in bandwidth and frequency of maximum amplitude. These increases occurred at different stages of flight development providing a possible evolutionary trajectory of flight and echolocation in nasal emitting phyllostomids.

Bats: Conservation and Ecotourism, the experience at Tirimbina Rainforest Center

Chavarría Carlos and Rodríguez-Herrera Bernal. Tirimbina Biological Reserve, Sarapiquí, Costa Rica, info@tirimbina.org

Located in Costa Rica, Tirimbina Biological Reserve, is a nonprofit organization. We have been working for 10 years with the communities trough an Environmental Education Program, trying to create conscience among students and their families about the importance of protecting the forest on the area. The program works with around 1500 kids per year from 10 different communities. It´s a free program for the students, it includes transportation, meals, and materials. To maintain the education program for a long-term, Tirimbina has developed different ecotourism programs. One of them it´s called "Bat Program", and take advantage of a long term monitoring program on bats. The program is designed to provide information to our visitors about natural history of bats, through a multimedia presentation, but also with some "field work": tourists visit the mist-nets that are used by the assistants of the monitoring programs, and explain them how to work with the nets, and the benefit of the scientific research. Different issues are covered on the activity, from myths to environmental benefits provided by bats, to humans and ecology in general. The average tourist has few or wrong information about this group, this program contributes "cleaning" the bad reputation, which in general bats have. We generated a list of 62 bats, including rare species such as *Vampyrum spectrum*, *Centurio senex* and *Eumops hansae*. Not only the education and scientific aspect are important, financially on the period from September 2005 to August 2009, the program generates net earnings of $79.912.64, from 7733 people who took the activity. These visitors are from many different countries, including Costa Rica, USA, Canada, France, and Germany. Also a percentage of this has been donated to the Costa Rican Bats Conservation Association, to help on education programs in other regions in Costa Rica. This is an example of a model linking ecotourism for the benefit of research, education and finally conservation.

Molecular Dietary Analysis of *Myotis lucifugus*, in Southwestern Ontario: Spatial and Temporal Heterogeneity in Dietary Preferences Indicate Habitat Type and Quality

Elizabeth L. Clare, Brittany Barber, Bernard Sweeney, Erin E. Fraser, Amanda Adams, Paul D.N. Hebert, and M. Brock Fenton. University of Guelph, Guelph, Ontario Canada; University of Western Ontario, London, Ontario, Canada; Stroud Water Research Center, Avondale, PA.

We employ the molecular methods of Clare et al. (2009) to profile the diet of *Myotis lucufugus* at three maternity colonies and a swarming site from May- October 2008 and describe spatial and temporal changes in diet over the active season. Because our data provides species level identification of prey, we can isolate environmental indicator species in the diet and make predictions about the location and type of their foraging habitat and the health of these aquatic systems.We identified 63 prey species from the Arachnida (2 species) and Insecta. Most identifications were made to species level while 15 are to genus. The majority of identifications (~50%) were the mass-emerging *Chironomus sp.* and *Caenis sp.* Bats roosting in two rural settings had significantly lower dietary richness than a roost located in the forest. We detected temporal fluctuations in diet between early, middle and late summer though this was only significant in the forest roost. The species detected suggested that bats in one rural roost foraged over local rivers while those in the other rural and forest roosts both feed over pond, lake or lentic wetland habitat rather than flowing water. These predictions have been confirmed for the forest roost which forages

over a small lake. All water sources are of fair to good quality, though no species detected is intolerant of pollution thus the habitat cannot be classified as pristine. Our study outlines a model system to study the abiotic and biotic interactions between habitat factors such as water quality through this simple food chain to the top predator and reviews "best practices" for molecular dietary analysis.

The Colorado Bat Matrix: A Tool for Identifying and Evaluating Potential Threats to Colorado's Bat Populations

Colorado Bat Working Group. http://www.cnhp.colostate.edu/RASwebpage/cbwg_website/cbwg_index.htm

The goal of the Colorado Bat Working Group (CBWG), an affiliate of the Western Bat Working Group, is for various stakeholders to work cooperatively to conserve bat species and bat habitat throughout Colorado. The CBWG has completed a Colorado Bat Conservation Plan (2004) and a website that serves as a clearinghouse for information about bats in Colorado. While revising the Bat Plan, we identified the need for a stand-alone, readily-accessible, reference document that identified and ranked potential threats (e.g., timber harvest, urbanization, energy development) for Colorado bat species. The Colorado Bat Matrix is the result of collaboration between CBWG members from universities, the private sector, and state and federal agencies, and is housed on the CBWG website for ease of access and revision. The primary audience for the Matrix is land managers who can use the rankings as a starting point for identifying threats to bat species. Researchers may also find the Matrix useful to identify gaps in knowledge for future study. We ranked the scope, severity and immediacy of potential threats as high, moderate, low or insignificant for 18 species of bats found in Colorado. These rankings were condensed into a value ranging from "A," substantial, imminent threat, to "H," unthreatened. To illustrate the Matrix results, we use Townsend's big-eared bat (*Corynorhinus townsendii*), a sensitive species for the USDA Forest Service and Bureau of Land Management in Colorado and a species of special concern for the Colorado Division of Wildlife. In Colorado, the greatest potential threats to this species are abandoned mine lands closure programs and renewed uranium mining, whereas grazing and fire management are unlikely to significantly affect Townsend's big-eared bat populations. The Colorado Bat Matrix may serve as a model for other states or regions looking to create a tool to rapidly identify threats to bat populations.

Bat Diversity and Richness in the Monongahela National Forest

Jason D. Collins and Catherine Johnson. Eastern Michigan University, Ypsilanti, MI; US Forest Service, Elkins, WV and Sanders Environmental, Inc., Bellefonte, PA

Populations of eastern bat species have experienced significant declines in many areas, resulting in a reduction in species richness and diversity. This decline can be attributed to many factors, but some of the more influential are loss of summer habitat, wind power, and recently white-nose syndrome. The Monongahela National Forest consists of over 371,000 ha of land in the West Virginia highlands and is considered by the Nature Conservancy to be in an area of global ecological importance. Due to the concentration of suitable summer habitat and proximity to hibernacula, the Monongahela National Forest is a significant refuge for bats. However, a reduction in size of the populations of cave-dwelling bats after 2008 is expected as a result of white-nose syndrome, which was first reported in the state during winter 2008–2009. Data were collected by biologists from Sanders Environmental, Inc., at monitoring sites in the Monongahela National Forest, following mist-netting guidelines established by the U.S. Fish and Wildlife Service and the Monongahela National Forest. Over 280 sites were monitored during 2001, 2003-2010, with greater than 8,000 individual captures (2010 captures omitted). This data can be used to establish baseline information on capture success, species diversity and richness in the study area prior to the documentation of WNS in the region. Number of captures each year will be analyzed to determine whether capture success has changed since the arrival of white-nose syndrome, and whether there have been any changes in species richness and diversity. Eleven species were captured, including the endangered *Myotis sodalis* and *Corynorhinus townsendii virginianus.* Preliminary analyses suggest that fewer cave-hibernating species have been caught in summer since 2008.

How Do Tiger Moths Jam Bat Sonar?

Aaron J. Corcoran, J. R. Barber, and W. E. Conner. Wake Forest University, Winston-Salem, NC. Colorado State University, Fort Collins, CO

Many tiger moths defend against attacking bats by producing ultrasonic clicks. Recent work has confirmed the decades-old hypothesis that at least some tiger moth species use the sonic defense to jam bat sonar. The acoustic mechanism for how tiger moths accomplish this feat is unresolved. Three primary hypotheses have been suggested: (1) bats misinterpret the clicks as echoes from objects that do not exist, causing the bats to sharply veer away from the "phantom objects"; (2) the clicks mask the moth's echoes, making the moth temporarily invisible to the bat; and (3) the clicks interfere with the bat's neural mechanism for determining the distance to the moth (i.e. ranging interference), causing the bat to narrowly miss the target. For seven consecutive nights we observed bats attacking tethered tiger moths (*Bertholdia trigona*) in an anechoic flight room using high-speed infrared videography and ultrasonic acoustic monitoring. We reconstructed the 3D flight trajectories of the bats and moths and analyzed the pattern of bat echolocation emissions to determine whether bats appeared to be avoiding phantom objects (as predicted by the phantom echo hypothesis), losing the targets altogether (masking hypothesis), or narrowly missing their aerial prey (ranging interference hypothesis). On the first two nights of the experiment bats frequently veered sharply away from the moths and aborted attack echolocation almost immediately after the moths clicked (7 of 13 trials; 56%). However, on nights three through seven, the bats rarely veered away from moths (6 of 36 trials; 17%); they instead frequently continued their attacks on the clicking moths, but narrowly missed their prey (15 of 28 trials; 54%; 17.8 ±7.2 cm minimum bat-moth distance). These results suggest an initial startle response lasting two nights, followed by sonar jamming by means of ranging interference. 3-D simulations also support the ranging interference hypothesis for sonar jamming.

Habitat Use by Bats in Forested, Edge, and Clear-cut Ponderosa Pine Forest in Boulder County, Colorado

Katelin Craven and Rick Adams. University of Northern Colorado, Greeley, CO

Current silviculture methods incorporate various selective harvesting techniques. We investigated how often bats were present in forest, edges, and clear-cut selections of ponderosa pine forest in Boulder County, CO. We simultaneously placed Pettersson D240x ultrasonic detectors with Samson Zoom digital recorders on tripods one meter above ground, tilted 30^0 to slope in each habitat usually throughout the night. Recorded calls were analyzed to species using Sonobat 3.0 software. We also netted in forested and clear-cut areas and identified individuals to species, sex, age, and reproductive status. Over 45 detector nights, we found that bat activity was highest in clear-cut areas (180 calls), activity in forested areas was second (64 calls), and edge totaled 50 calls. Clear-cut areas had the highest species richness with nine species, forested habitat had eight, and edge had five. Forested areas were used predominately by clutter specialists *Myotis thysanodes* and *M. evotis. Myotis ciliolabrum* and *Lasiurus cinereus* used all habitats, whereas *M. lucifugus*, *Lasionycteris noctivagans*, and *Eptesicus fuscus* dominated calls gathered from clear-cut habitat. There was also an apparent relationship between moon-phase and foraging habitats wherein species activity was highest in forested areas on nights having higher illumination, and this was true even for open-aerial fliers such as *L. cinereus* and *E. fuscus*. Because habitat usage was diverse and may vary depending upon nightly conditions, such as moon phase, forest management and treatment plans are more likely to satisfy the requirements of more species if harvesting creates a mosaic of patches with different habitat types.

Evidence of Mating Readiness in Certain Bats Killed by Wind Turbines

Paul M. Cryan, Joel W. Jameson, Erin F. Baerwald, Craig K.R Willis, Robert M.R. Barclay, Elise A. Snider, and Elizabeth G. Crichton. USGS Fort Collins Science Center, Fort Collins, CO; University of Winnipeg, Winnipeg, Ontario, Canada; University of Calgary, Calgary, Alberta, Canada; U.S. Forest Service, Steamboat Springs, CO; University of Queensland, Gatton, Queensland, Australia

Bats consistently die at wind turbines during late-summer and autumn. Migratory, tree-roosting species show increased susceptibility compared to other bats, yet the exact causes remain unknown. A hypothesized cause with strong conservation implications is that migratory tree bats die at turbines while seeking mates around tall tree-like structures. In this pilot study we histologically examined reproductive tracts of hoary bats (*Lasiurus cinereus*) and silver-haired bats (*Lasionycteris noctivagans*), found dead beneath wind turbines, for evidence of mating or mating readiness. We sampled 61 *L. cinereus* and 31 *L. noctivagans* killed by turbines in New York, USA, and Alberta and Manitoba, Canada between early July and late September. By August most adult male *L. cinereus* had

sperm in the caudae epididymides (CE), indicating readiness to mate. About half of juvenile male hoary bats had sperm in their CE by August, revealing reproductive activity just months after birth. Sperm were seen in the uterus of the only adult female hoary bat collected in September, but we found no sperm in the other 17 females sampled in previous months. Ovaries of most adult and juvenile female *L. cinereus* had growing follicles, but they did not appear to be in estrus. Evidence of sperm in *L. noctivagans* was more limited, yet sperm were found in the CE of some adult and juvenile males. No female *L. noctivagans* contained sperm, but most adults and juveniles had growing follicles. These results indicate that adult and juvenile males of each species were ready to mate when they were killed by wind turbines, although evidence of copulation with females was limited. Results were insufficient to disprove the mating hypothesis – more thorough analysis of bats killed by turbines from late August through October and from a broader geographic area will be the next important step in assessing its merit.

Differences in Structure of the Bat Community in Managed and Unmanaged Southeastern Pine-hardwood Forests

Anica Debelica, Michael Weber, and Kenneth Wilkins. Department of Biology and Graduate School, Baylor University, Waco, TX

The Piney Woods extend along the coastal plain from eastern Texas to Florida and northward into Maryland. This ecoregion is considered highly endangered due to fire suppression and extensive timber production. Sam Houston National Forest comprises nearly 66,000 ha of southeastern Texas "pineywoods". The western side of the forest has been managed for red-cockaded woodpeckers through managed burns since the 1960s, so it more closely resembles the historic condition (pine species dominate; little to no understory, thus is uncluttered). The eastern side of the forest has been mostly "unmanaged," most areas not burned for >10 years. Hence, this area represents habitat degradation due to fire suppression (pine species not dominant; forest highly cluttered). However, due to differences in amount of understory vegetation between managed and non-managed areas, we expect to see differences in bat community structure. Managed areas should be dominated by species that are better adapted to forage in more open areas, while unmanaged habitat should be dominated by species more specialized for clutter avoidance. We sampled two sites, Kelly Pond (KP, managed) and Henry Lake Creek (HLC, unmanaged) using triple-high nets. Captured bats were identified to species, sexed, measured, and examined for reproductive state. During out pilot study at the KP in 2009, we captured >120 individuals of 8 species: red, hoary, Seminole, big brown, evening, eastern pipistrelle, southeastern myotis, and Mexican free-tailed bats. Thus far during summer 2010 we have captured 102 bats at the HLC site, and 37 at the KP site. We have observed differences in bat communities between these sites: KP is dominated by Seminole and evening bats, while the HLC site is dominated by Seminole bats and big brown bats. By the end of the netting season, we expect to see further differences between these bat communities concerning the less abundant, bat species.

Harp Trap Bias: Differences in Relative Species Abundance Using Group and Individual Captures

Yvonne Dzal and Liam P. McGuire. The University of British Columbia, Vancouver, BC; The University of Western Ontario, London, ON.

Mist nets and harp traps are common methods used for capturing bats. Although many studies have examined the use of mist nets and associated bias resulting from net placement, frequency of netting, species effects, and frequency of net checks; similar bias effects have never been assessed for harp traps. The purpose of our study was to examine sampling bias when using harp traps to determine population composition. We hypothesized that the proportions of species from traps left unattended would be biased as conspecifics are attracted to distress calls produced by the bats left in the traps. We predicted that estimates of species proportions would be biased in favour of the most common species, because this species is the most likely to be captured first and consequently, attract conspecifics. We used two different strategies to monitor the harp trap: group captures or individual captures. For group captures, the trap was left unattended for 30 minute intervals while for individual captures we immediately removed bats once they were captured in the harp trap. We found that the proportion of each species observed was affected depending on the method used to monitor the trap. We suggest that although impractical, individual captures are more likely to be representative of the true species composition at a given site. We therefore caution the use of group captures when using harp traps for determining relative abundance of species.

A Map of the Big Brown Bat Wing: "Typical" Damage and Scarring in an Urban Maternity Population Prior to White-Nose Syndrome.

Laura E. Ellison, Thomas J. O'Shea, and Paul M. Cryan. U. S. Geological Survey, Fort Collins Science Center, Fort Collins, CO

Wing damage is a clinical sign of white-nose syndrome in hibernating bats, yet few if any studies have characterized typical damage and scarring in bat wings prior to WNS. We examined wing damage in big brown bats (*Eptesicus fuscus*) sampled from maternity colonies in buildings of Fort Collins, Colorado, from 2001-2005. This effort was part of a research project investigating rabies transmission in urban bat colonies. We individually marked bats using passive integrated transponders (PIT tags) and monitored their presence at 5 major maternity roosts. We regularly captured marked individuals from these roosts to gather body measurements and ectoparasite counts, sample blood, and examine wing damage. For each bat, we noted the locations of scars, fresh holes, and other wing anomalies on diagrams of each wing. We then tallied the total number of scars and fresh holes for each bat. We examined the effects of roost, sex, age, reproductive condition, number of ectoparasites, and year of capture on the number of scars and fresh holes using a generalized linear model. We also examined a subsample of bats recaptured within and among summers to look at changes in wing scarring (i.e., disappearance of scars, length of healing time). Average number of scars and fresh holes varied by roost, sex, and age. Wing damage did not vary by reproductive condition, ectoparasite load, or year. Adult females averaged 21.3 ($\pm$5.5 SE) scars, juvenile females 17.1 ($\pm$6.2), male adults 18.8 ($\pm$7.1), and juvenile males 16.6 ($\pm$8.0). These results provide a baseline of information on the typical damage in wings of presumably healthy female *E. fuscus* and serve as a caution that not all wing damage is the result of WNS.

Long-Term Monitoring of Central California Bats: What We Know from 10 Years of Acoustic Monitoring and 20 Years of Roost Counts

Gary Fellers. USGS, Western Ecological Research Center, Point Reyes National Seashore, Point Reyes Station, CA

Automated Anabat bat detectors running 24/7 have been used in four National Park areas in the San Francisco Bay Area. The first detector was installed at Point Reyes National Seashore in 1999 and has been in operation ever since. An additional 12 detectors were subsequently deployed for periods of 4-8 years. These detectors provide information on the make up of local bat communities, as well as information on nightly, seasonal, and yearly patterns in bat activity. Some monitoring stations are in relatively close proximity, but have notable difference in patterns of activity, and species occurrence. Some bats are not readily detected with bat detectors, largely due to their quiet or infrequent vocalizations. Townsend's big-eared bat (*Corynorhinus townsendii*) is a rare bat that has very quiet vocalizations and is not readily detected. A maternity roost in an abandoned house at Point Reyes National Seashore has been monitored with exit counts since the roost was discovered in 1987. Counts begin in March or April and occur monthly through Sept or Oct. More than 150 exit counts have been conducted. The spring counts document the number of females in the roost, and summer counts include females and their volant young. Hence, it has been possible to track the increase in the size of the maternity colony, as well as the annual variation in reproductive success.

The Evolution of Echolocation in Bats

Brock Fenton. University of Western Ontario, London, Ontario, Canada

Although it is evident from the morphology of the shoulder girdle that well-preserved fossil bats from the Eocene were capable of powered flight, the situation for echolocation is not as clear. Contat between the stylohyal and tympanic bones, sometimes involving fusion, clearly separates extant laryngeally echolocating bats from those that do not echolocate or echolocate with tongue clicks (Pteropodidae). One key to the evolution of echolocation is avoiding self-deafening. Another is registering the outgoing pulse in the brain for future comparison with returning echoes. I will consider the selective advantages associated with largyngeal echolocation and argue that this mode of orientation was ancestral in bats. Most echolocators, including most bats, separate pulse and echo in time (low duty cycle echolocators) and cannot broadcast and receive at the same time. This is true of most echolocators including most echolocating bats. Some bats, however, species in the families Rhinolophidae and Hipposideridae, and the mormoopid *Pteronotus parnellii*, separate pulse and echo in frequency. These high duty cycle echolocators can broadcast and receive at the same time. I will consider the scenario in which high duty cycle echolocation might

have evolved, considering what is known now about the echolocation behaviour of extant high duty cycle bats (species of Rhinolophidae, Hipposideridae and the mormoopid *Pteronotus parnellii*).

Hibernating Bat Counts in New Mexico Caves

Jennifer Foote. Volunteer for Bureau of Land Management, Roswell NM

Information on size and stability of the bat population is important in cave and wildlife management, especially now with the threat of White Nose Syndrome (WNS) looming over the West. Information to be presented in this poster will include historical data, techniques used to inventory the bat hibernaculums, and methodology to organize the data into a useful form for use in future WNS research. Over more than 10 years, volunteer cavers have conducted hibernating bat counts in several caves designated as hibernacula within the Roswell NM BLM district. Historical data has been collected as far back as the late 70's. The most common bat species inventoried include *Myotis velifer*, *Myotis ciliolabrum*, and *Corynorhinus townsendii*. One cave hibernaculum has had variations between 300 and 14000 bats counted. A simple yet complete format for data collection needs to be distributed to western cavers to increase our body of knowledge about bats in caves in the West.

Measuring Habitat Improvement Along the Las Vegas Wash Using Bat Dietary Analysis

Marissa Foster and Jason Eckberg. Southern Nevada Water Authority, Las Vegas, NV

The purpose of this study was to better understand the environmental characteristics of riparian restoration areas along the Las Vegas Wash, Nevada and determine if these restoration efforts are successful. Three sites were examined including an invasive salt cedar stand which represents a pre-restoration state, an actively created riparian revegetation site and a back water area in a passively created wetland. Success was measured by combining bat capture and acoustic bat monitoring, bat dietary analysis, nocturnal invertebrate collection, and vegetation richness and cover monitoring. Bats were captured using triple high nets in flight corridors on a monthly basis for three consecutive nights each month from May through October. After capture, bats were placed in cloth bags for a minimum of one hour to collect fecal samples. Bats were then identified to species and sex, reproductive status and characteristic measurements were recorded. Fecal samples were collected from the cloth bags and analyzed for insect content at a later date. Insect parts in fecal pellets were identified by comparing them to insects collected using a UV light adjacent to bat capture sites. The UV light was positioned to reflect off of a white sheet, unique and otherwise unknown specimens were collected and identified later. Digital photographs were taken of the sheet which was divided into sixteen partitions, insects were later identified and quantified using prints of the photos compared to keys and those individuals previously collected. Finally, vegetation was monitored for species richness and cover of each site as a whole as well as how much each individual species contributed to the cover of each site. Success in this study is defined as having higher species richness and abundance of native species in bats, invertebrates and plants in restored areas as compared to pre-restored areas.

Fur stable isotope ratios in residential and migratory North American bat populations

Erin E. Fraser, Liam P. McGuire, M. Brock Fenton, and Fred J. Longstaffe. The University of Western Ontario, London, Ontario

Stable hydrogen isotope analysis is frequently used to learn about the origins of migrating animals. There is a predictable latitudinal pattern of stable hydrogen isotope (δD) values in meteoric water that is reflected in local animal tissues. A general limitation of this method is that individuals within a residential population may display a wide range of δD values, and this is true in bats. We sampled resident and migratory bat populations to provide a better understanding of the causes and magnitude of this variation, which will allow for increased efficacy in the use of stable hydrogen isotope analysis to learn about bat migration. Stable carbon (^{13}C) and nitrogen (^{15}N) isotope analyses were used to investigate the role of diet in creating δD variation. Further, we investigated whether we could distinguish residential and migratory groups of bats using stable isotope results. We present fur δD, $\delta^{13}C$, and $\delta^{15}N$ values from seven residential and four migratory bat populations representing four North American species (*Myotis lucifugus, Lasiurus borealis, Lasiurus cinereus, Lasionycteris noctivagans*). We show that δD variation is species dependent and that δD and $\delta^{13}C$ correlate significantly in some but not all residential groups. The magnitude of δD variation in residential and migratory *Lasionycteris noctivagans* populations did not differ; however, there was a significant δD and $\delta^{13}C$ correlation for the residential population but not the migrants, suggesting that the two groups may be isotopically distinct.

The Air as Habitat: Influence of meteorology on group behavior dynamics of a nocturnal aerial predator (*Tadarida brasiliensis*)

Winifred F. Frick, Kenneth W. Howard, Philip B. Chilson, and Thomas H. Kunz. Boston University, Boston, MA; NOAA National Severe Storms Laboratory, Norman, OK, University of Oklahoma, Norman, OK; Boston University, Boston, MA

We examine spatio-temporal variation in foraging dynamics of Brazilian free-tailed bats (*Tadarida brasiliensis*) in south-central Texas, demonstrating the potential of radar aeroecology for advancing understanding of ecological interactions in the aerosphere. Brazilian free-tailed bats disperse nightly in dense columns from cave and bridge roosts and forage at high altitudes (300 – 2500 m AGL) over large spatial extents that are easily detectable with Doppler weather radar (WSR-88D) installations. Understanding variation in emergence behavior of Brazilian free-tailed bats provides a model system for testing hypotheses about the influence of abiotic factors on the dynamics of group behavior. Using high resolution Level II NEXRAD radar products, we test hypotheses about the influence of weather conditions such as surface temperature, precipitation and cloud cover on timing and relative density of bat emergences to determine how atmospheric cues determine group behavior and foraging dynamics of an aerial nocturnal predator. We visualize bat emergences in 3-dimensional space and investigate seasonal variation in emergence behavior. In addition, we highlight the utility of radar visualizations for generating new hypotheses about foraging behavior of aerial species by demonstrating how radar makes it possible to 'observe' behavior at temporal and spatial scales not previously possible.

A Wing and a Prayer: Little Brown Myotis (*Myotis lucifugus*) Recover from Wing Injuries Associated with White-Nose Syndrome

Nathan W. Fuller, Jonathan D. Reichard, Morgan L. Nabhan, Spenser R. Fellows, Lesley C. Pepin, and Thomas H. Kunz. Center for Ecology and Conservation Biology, Department of Biology, Boston University, Boston, MA

Since the appearance of white-nose syndrome (WNS) in North America, researchers have observed discolored, scarred, and necrotic wings on little brown myotis (*Myotis lucifugus*) at maternity colonies. Over the course of the spring and summer the apparent abundance of bats with severely damaged wings decreases, leading to the hypothesis that damaged wings reduces flight ability, thus making bats susceptible to increased predation, reduced foraging success. We tested the hypothesis that reduced observed frequency of severe wing damage results from healing. We trapped bats weekly at the time of nightly emergence, alternating between two maternity colonies in Massachusetts and New Hampshire. Bats were assessed for age, sex, reproductive condition, length of forearm, and wing damage index (WDI). Wings were transilluminated and photographed before bats were banded and released. For bats that were captured and recaptured at maternity roosts, wing damage was quantified as the proportion of the wing area affected at first capture and at subsequent recapture. The relative proportion of bats with severe and moderate wing damage decreased as the summer progressed. We recaptured 36 banded bats, of which 50% exhibited evidence of improved wing conditions, including at least two individuals whose wings improved from the most severe condition (WDI = 3) to a lesser one (WDI $\leq$ 2). The maximum observed rate of healing was 2.11% improvement per day by an adult female that healed 29.6% of the observable wing area over 14 days. Our results suggest that wings of little brown myotis can heal rapidly from injuries sustained during winter. Thus, decreased occurrence of severely damaged wings later in the summer does not necessarily signal increased mortality. Further studies are needed to investigate the foraging ability, long-term survival, and reproductive success of individual bats and population trends of little brown myotis at WNS-affected hibernacula and associated maternity colonies.

Affects of Call Structure on the Jamming Avoidance Response (JAR) in Brazilian Free-Tailed Bats, *Tadarida brasiliensis*

Erin H Gillam. North Dakota State University, Fargo, ND

Bats rely heavily on echolocation for orientation and prey detection. When flying in the presence of other bats, individuals have been shown to adjust their call structure to avoid frequency overlap with the calls of nearby conspecifics, known as a jamming avoidance response (JAR). Despite previous work, the dynamics of JAR is still not well characterized, and further research is necessary to understand how bats are able to detect and process weak echoes in the presence of jamming signals. The objective of this research was to examine how the characteristics of

a jamming signal (ie. echolocation calls) affects JAR in free-flying Brazilian free-tailed bats, Tadarida brasiliensis. Specifically, I broadcast five types of echolocations calls that exhibited the same minimum frequency, but differed in call shape and frequency modulation. I determined if bats differentially respond to each call type or give a generic response to all broadcast signals. This study provides additional insight into the signal processing capabilities of bats, and helps us better understand how bats are able to orient using sound in a noisy world.

Monitoring Summer Maternity Colonies of *Myotis lucifugus* in Massachusetts: Assessing Impacts of White-Nose Syndrome

Katherine M. Gillman, Allison J. Harwick, Aaron Gatnick, Thomas T.D. Little, Margrit Betke, Zheng Wu, Jonathan D. Reichard, D. Scott Reynolds, and Thomas H. Kunz. Boston University, Boston, MA, Emmanuel College, Boston, MA, St. Paul's School, Concord, NH

Little brown myotis (*Myotis lucifugus*) populations in the northeastern United States (US) have recently experienced major declines in some hibernacula. These declines parallel the arrival and spread of a psychrophilic fungus, *Geomyces destructans*, that causes a condition known as white-nose syndrome (WNS). For the past several years, we have monitored two established maternity colonies of little brown myotis in eastern Massachusetts. We present census results from these two colonies for comparison with colony sizes at hibernacula in the northeastern US before and after the appearance of WNS. Our census data before the occurrence of WNS were based mostly on visual counts. With the first evidence of WNS in Massachusetts, we installed infrared AXIS cameras (BatCams) that record nightly emergence activity, even when weather conditions preclude reliable live visual counts. Computer software was developed to automatically detect and count bats from the video recordings. Weekly flight counts were made directly from the video recordings, along with live counts in the field. Current analysis of video records from one site (Paxton Colony) showed that the adult colony size decreased by 70% from 2008 to 2009. Video recordings from the second site (Lincoln Colony), a slightly larger colony initially, also show a decline, but we do not have a reliable record of colony size at this site in the pre-WNS period. Live visual counts of emerging bats were comparable to counts made directly from the video recordings, but the automatic computer counts were at times 20% higher than results from the two visual counting methods. Despite predicted regional extinction of little brown myotis, our current results suggest that there may be refuges of unaffected bats or perhaps survivors of WNS that will persist and may increase if suitable roosting sites are made available for small residual colonies.

Cheek Swabs as an Alternative to Wing Punctures for DNA Sampling in the Field

Aaron F. Goldberg, A. Russell, Y. Leon, M. S. Núñez and L. M. Davalos. Stony Brook University, Stony Brook, NY; Grand Valley State University, Allendale, MI; UASD, Dominican Republic; UASD, Dominican Republic; Stony Brook University, Stony Brook, NY

Determining the best method to collect DNA in the field is critical to saving both time and money for the researchers. In non-lethal tissue collecting in bats, wing punctures have traditionally fulfilled this role. However, quantity of DNA extracted can be quite low requiring multiple extractions or several wing punctures per individual for enough DNA. Additionally, the long-term effects of punctures on bat health are poorly understood. Cheek swabs traditionally have been used in human DNA extraction can increase DNA yields and minimize physical damage to the bat. We compared DNA quantity and quality from cheek swabs and wing punctures from multiple individuals of several species collected in the summer of 2009 in the Dominican Republic and Puerto Rico. We found that cheek swabs produce significantly higher amounts of extracted DNA compared to wing punctures from the same individuals collected on the same date and preserved identically. Cheek swabs provide the best method for non-lethal DNA collection in the field and allow researchers to save both time and money in DNA studies while also minimizing potential adverse effects in the bats.

Hibernacula Microclimate and White-Nose Syndrome Susceptibility

Laura E. Grieneisen, Gregory G. Turner, and DeeAnn M. Reeder. Bucknell University, Lewisburg, PA; Pennsylvania Game Commission, Harrisburg, PA

Anecdotal evidence suggests that bats that hibernate in colder and drier caves and mines are less affected by the emerging infectious disease White-Nose Syndrome (WNS) and that WNS-affected bats shift roosts in early-mid winter to cave entrances. To test the notion that colder microclimates offer protection against WNS, affected Little Brown Myotis (*Myotis lucifugus*) were housed in captivity at different temperatures (4°C, 7°C, and 10°C).

Likely due to energy savings and slowed growth of the putative fungal pathogen, bats hibernating at lower temperatures lived longer. To determine why WNS-affected bats shift to cave entrances, the thermal preference of WNS-affected and unaffected captive and free-ranging bats was tested. We predicted that WNS-affected bats hibernating at the front of the hibernacula would prefer colder temperatures than WNS-affected bats hibernating in 'normal' roosts deeper in the cave, but all bats selected relatively warm roosting sites (8.06°C ± S.E. 0.46). This suggests that WNS-affected bats are moving to the entrances of hibernacula not to select colder roosts and thus conserve energy, but for some other reason. The results from this study will help predict which hibernacula are more likely to be infected and whether altering microclimate properties of mines may mitigate the disease.

Using discriminant function analysis and other quantitative techniques to classify bat echolocation calls

Jeffery Gruver, Shay Howlin, Chris Nations, and Trent McDonald. Western EcoSystems Technology, Inc., Cheyenne, WY.

Modern commercial-scale wind turbines are known to kill bats, and surveys to assess risk before construction are generally conducted. Pre-construction surveys at proposed wind energy facilities include the use of passive echolocation monitoring to estimate relative levels of bat activity, a proxy for potential risk. However, risk has not been shown to be equal among species, and the predictive value of this approach has not been conclusively demonstrated, and may be difficult to demonstrate given the typical broad-level classification (high- versus low-frequency). In addition, concern over risks to endangered species has spurred renewed interest in a generally applicable method of quantitatively determining presence based on echolocation call data. Therefore, a multivariate canonical discriminant function was developed based on 640 echolocation sequences from 11 species of bats, to classify unknown bat call sequences from passively collected Anabat data. Cross-validation for all 11 species indicated that the model had a correct classification rate of 90%, ranging from 67% to 99%. Bootstrap simulations indicated that for most species, correct classification rates did not improve as the number of pulses per call increased over 5. Application of the model to real-world data, including relative abundance of species thought to be at risk from wind turbine operation will be presented. In addition to discriminant function analysis, a neural network approach to species determination will be presented and compared to discriminant classification. Neural networks may provide a better method for discriminating bat echolocation calls, and may be more robust to variability in call quality. The application of both methods will be discussed in the context of analysis of potential and realized risk to bats from wind turbine operations.

A New Method for Reliable and Repeatable Searcher Efficiency for Post-construction Mortality Surveys at Wind Energy Locations

Benjamin Hale and Lynn Robbins. Missouri State University, Springfield, Missouri

Wind turbines are a fast growing form of sustainable energy. Unfortunately, bat mortality has been recorded at wind turbine locations due to blade impact and extreme pressure changes (barotrauma) caused by the spinning rotors. The U.S. Fish and Wildlife Service recommends that wind energy companies develop a Habitat Conservation Plan (HCP) to minimize the effects of turbine construction and operation on bats, specifically the endangered Indiana bat, *Myotis sodalis*. Following construction, surveys are necessary to assess the effectiveness of the habitat conservation plan. As part of this, searches are conducted to estimate fatalities in project areas. Currently, the most widely used method for mortality estimates are based on searching performed by humans, which has a searcher efficiency as low as 25% and is highly variable. These low and inconsistent success rates make estimating actual impacts statistically unreliable. Mechanical methods would eliminate human-based variance and provide a more cost and time efficient method of postconstruction mortality surveys. This project tests a modified agricultural machine for its ability to pick up, or "search" for bat carcasses in vegetation. Formalin-prepared bat carcasses were randomly placed in transects across varying vegetations (4.5, 6, and 8 inches) to determine optimal height. Results of 20 repeated transect-trials in a vegetation height of 4.5 inches resulted in an average efficiency of 81% with a low variance among trials (0.011). Without reliable searcher efficiency, effects of turbine construction cannot be accurately and efficiently assessed and therefore types and level of turbine mitigation cannot be accurately determined. These data indicate that carcass searching using a modified machine reduces variability due to human bias, yields higher searcher efficiency than other methods, and allows for a repeatable and more scientific approach to mortality surveys.

Monitoring Bat Activity along Two Landscape Features in Southern Ontario, Canada

Rachel M. Hamilton. University of Western Ontario, London, On, Canada

The purpose of this study is to explore the basic patterns of habitat usage at sites along the Niagara Escarpment and Lake Huron shoreline in Southern Ontario, Canada. Levels of bat activity will be monitored through deployment of bat detectors (Songmeters and Batcorders) during the fall migration and swarming season. Collection of echolocation calls will signify the level of bat activity and identification of bat species active in the area. Data collected may indicate important areas for residential and migratory bat species and their use of the landscape. It has been suggested that crevices on the escarpment could serve as hibernacula for some hibernating bats. In addition, this forested stretch may also attract migratory species, acting as a fly way, in conjunction with the shoreline of Lake Huron. By comparing bat activity along these two land features to known active sites, we can test the prediction that these areas provide refuge for various bat populations. Data on the levels of bat activity in relation to landscape features may also inform the placement of future wind turbines.

The Role of Ecomorphology in Determining Response of a Forest-Dwelling Bat Community to Management by Prescribed Burns.

Cory Hanks, Anica Debelica, and Kenneth Wilkins. Department of Biology and Graduate School, Baylor University, Waco, TX

Prescribed burn management can improve habitat conditions for certain forest-dwelling species (e.g., red-cockaded woodpecker). However, the effect of such management practices on the forest-dwelling bat community is not well understood. We conducted our study in eastern Texas in Sam Houston National Forest, a large tract of mixed pine-hardwood forest that characterizes much of the southeastern United States. This forest comprises two districts: the area west of Interstate 45 (I-45) that is heavily managed by prescribed burns, and an unmanaged (unburned) area east of I-45. We predicted bat communities of these areas would differ in relation to the amount of vegetative clutter present. The managed area would have predominantly open-adapted (clutter-intolerant) species characterized by larger body size, higher aspect ratio, higher wing loading, and relatively narrow range of echolocation call frequencies (e.g., Mexican free-tailed bat). We expected the bat community in unmanaged areas would contain more clutter-adapted bat species having smaller body size, lower aspect ratio, lower wing loading, and broader range of call frequencies (e.g., southeastern myotis). The study was conducted during summers in managed (Kelly Pond, 2009 and 2010) and unmanaged areas (Henry Lake Creek, 2010). We netted bats by using triple-high nets. Bats were identified to species, and their age, sex, and reproductive status recorded. We took digital pictures of the wings to determine wing parameters and recorded echolocation calls before releasing the bats. Preliminary findings are that Seminole bats dominate the community at both sites, with evening bats and Mexican free-tailed bats more abundant in managed areas and big brown and southeastern myotis more abundant in unmanaged areas. Field data collection continues through summer, with analyses of wing morphology and echolocation data to follow.

The Morphology of Muscles, Connective Tissues, and Vasculature along the Length of the Tongue in a Nectar-Feeding Bat, *Glossophaga soricina*

Caroline J. Harper, E.L. Brainerd, and S.M. Swartz. Brown University, Providence, RI

During feeding, *Glossophaga soricina* extend their tongues into a flower and use the brush-like papillae at the tongue tip to collect nectar. At least two distinct mechanisms might produce tongue elongation in nectar-feeding bats. First, in a muscular hydrostat model, orthogonally arranged muscle fibers decrease the diameter of the tongue, which in turn causes the tongue to increase in length. Second, the vascular pump model suggests that muscle contraction and blood flow within the lingual vessels will act together to elongate the tongue. This study investigates the morphology of the muscles, connective tissues, and vasculature along the length of the tongue to determine if either or both models describe the mechanism of tongue elongation in nectar-feeding bats. The tongues from two *G. soricina* were serially sectioned in multiple orthogonal body planes and stained with hematoxylin and eosin. Micrographs show three distinct, orthogonally arranged muscle fiber populations within the tongue: the vertical, longitudinal, and horizontal muscle bundles. Contraction of these muscle fibers may decrease the tongue's diameter, causing a corresponding increase in tongue length. At the tip of the tongue, the relatively large lingual veins diverge into smaller branches, located within the center of each papilla. This architecture suggests that the horizontal and vertical muscle bundles are used to elongate the tongue, but that blood flow may inflate the brush-like papillae at the

tongue tip. The morphology supports the muscular hydrostat model for elongation and the vascular pump model as the mechanism to inflate the papillae and increase the surface area of the tongue during feeding.

Experimental Infection of Jamaican Fruit Bats with Tacaribe Virus

Ann Hawkinson, Richard Bowen, David Gardiner, Rick Adams, Charles Calisher, and Tony Schountz. University of Northern Colorado, Greeley, CO; Colorado State University, Fort Collins, CO

Tacaribe virus (TCRV) was first isolated from diseased and dying Jamaican fruit bats (*Artibeus jamaicensis)* in the early 1960s during a rabies virus surveillance program in Trinidad and Tobago. However, experimental infections were not performed to verify the etiology of the disease. We infected Jamaican fruit bats with TCRV to examine pathology, virus tropism, shedding, and transmission. Low dose inoculations led to persistent infection of most bats, while high dose inoculations resulted in death or required euthanasia of several bats. Prominent symptoms included lethargy, irritability and tremors, with deaths occurring as early as 10 days post-infection. Histopathology indicated multi-organ involvement, including pathology of the liver, lungs, and hearts, and in the brains of all bats that exhibited tremors. No transmission was observed, although virus was detected in and recovered from most tissues examined. Several bats inoculated with a low dose of virus were viral RNA-positive in oral and rectal swabs after 45 days, suggesting persistent infection. These findings imply that TCRV is a natural pathogen of *Artibeus* bats but it is unknown how it may affect natural populations.

Potential impacts of a changing climate on fringed myotis populations in the Southern Rocky Mountains

Mark Hayes and Rick Adams, University of Northern Colorado, Greeley, CO

The Southern Rocky Mountains are experiencing rapid climate changes, resulting in environmental modification with potentially negative impacts on some mammal populations. Recent research suggests that reproductive success of some Colorado bat species may be reduced during warmer, drier years. Fringed myotis (*Myotis thysanodes*) is a species of conservation concern in western North America. We used 15 years of capture data, logistic regression, Akaike's Information Criterion (AIC), and multi-model inference to investigate relationships between reproductive condition in adult female fringed myotis and climate and surface water conditions during the spring and summer of the year captured. We created a balanced set of 15 models, each representing a competing hypothesis using four predictor variables: average maximum temperature; total precipitation; average streamflow; and peak streamflow. From 1995-2009, 155 adult female fringed myotis were captured in Colorado's Front Range, of which 137 were reproductively active (88.4%). The model with most support incorporated average stream flow, peak stream flow, and precipitation ($w_i = 0.40$). Average stream flow received the highest cumulative AIC_c weight ($w_+ = 0.90$), followed by peak stream flow ($w_+ = 0.88$), average maximum temperature ($w_+ = 0.73$), and total precipitation ($w_+ = 0.71$). The 95% confidence interval for the unconditional parameter estimates for average stream flow and peak stream flow did not overlap 0. In our study, we found that fringed myotis females were less likely to be reproductively active during warmer, drier years. We discuss prospects and challenges of this research, including use in population modeling, and potential biases introduced by mist-netting locations and bat behavior at water resources. We conclude by showing how these results can be coupled with down-scaled streamflow and weather variability models to provide insight into the potential impacts of a changing climate on fringed myotis, and other species of conservation concern, in the Colorado Rockies.

Patterns of species richness and activity of bats among land-use types in Southern Chile

Paul A. Heady III, Christine N. Meynard, Mauricio Soto-Gamboa, and Winifred F. Frick. Central Coast Bat Research Group, Aptos, CA; Institut des Sciences de l'Evolution, Montpellier, France; Instituto de Ecologia y Evolucion, Valdivia, Chile; University of California, Santa Cruz, CA

Very little is known about bat ecology in Chile despite the fact that Chile contains important global conservation priority areas and high endemism for other taxa. Landscape studies in other regions of the world demonstrate that bat activity may differ according to the habitat type and food availability and that bat species can be susceptible to landscape perturbations, such as forest fragmentation and degradation. In this study, we focus on characterizing bat diversity and occupancy patterns within three dominant habitats (native forest, plantation, grassland) in three distinct regions of the Valdivian watershed in Southern Chile, including the Andean mountains, central valley and coastal mountain range. We recorded bat echolocation activity with Anabat II monitoring stations to determine species presence and relative foraging activity in different habitat types. We conducted acoustic

monitoring for seven consecutive nights at nine sites in each landscape during January and February of 2009. We compared recorded calls to a call library that we developed for the local fauna from hand-released bats captured during the study. We identified five bat species occurring in the Valdivian region during our study: *Myotis chiloensis*, *Lasiurus varius*, *Histiotus montanus*, *Lasiurus cinereus,* and *Tadarida brasiliensis*. Overall, *M. chiloensis* was the most common species in all three sites, and *Lasiurus cinereus* was the least frequently detected species. Our effort initiated a program of bat research in southern Chile in collaboration with local Chilean scientists and our results have broad implications regarding the impact of human land use on bat diversity patterns.

Fifty-Year Trends in the Literature on Bat Research

Roy Horst. Department of Biology, State University of New York, Potsdam, NY

It would be interesting to determine how the research interests of the bat community have changed over the past half century. It would be a formidable task to survey all the major literature citation sources such as *Current Contents,* but fortunately *Bat Research News* has included a section on recent literature since its inception in1960, which has served as a useful resource on published works concerned with research on bat biology. Initially this listing was somewhat limited but became more inclusive and far-reaching as more individuals became involved in its compilation and to date has included 10,147 titles (Figure 1.) From its inception the listed titles were arranged into subject areas, such as echolocation, distribution, physiology, etc. Arranging these publications over time, it is possible to determine trends in the number of titles in each subject published by our colleagues worldwide, even though these lists of recent publications were essentially limited to articles in English. Titles were grouped into five-year sets. The number of citations for each subject was converted to that percentage of the total citations each subject represented. Interest in some subjects changed significantly over time. Titles in ecology were relatively low at only 5.7% of the total but over the next five decades showed a steady increase to 22.4% of all citations, while those concerning evolution and genetics, for example, remained fairly constant. Citations concerning pathology (virology and disease) showed a marked recent resurgence as more presentations appeared concerning new rabies vectors and other diseases, especially the recent appearance of white-nose syndrome. The relative interests in some areas over the decades appear to be fairly constant but interest in other research areas fluctuate rather significantly. When presented in graphic form, as in Figures 2 – 4 these changes in relative interest seem obvious.

Formation flight and group behavior in bats using 3D thermal imaging

Nickolay I. Hristov, Louise C. Allen, Tyson L. Hedrick , Brad Chadwell , Thomas H. Kunz, Kenneth S. Breuer, and Sharon M. Swartz. CDI/WSSU, Winston-Salem, NC; Salem College, Winston-Salem, NC; University of North Carolina, Chapel Hill, NC; Boston University, Boston, MA; Brown University, Providence, RI

The collective behavior of large groups of organisms continues to fascinate and inspire scientific inquiry. Recent work in insects, fish, birds and terrestrial mammals has shown that a variety of sensory modalities and mechanisms can be responsible for the structure and maintenance of animal groups. Although bats represent an attractive model for the study of group behavior, currently, little is known about the structure and control mechanisms of their flight assemblages. We present the first such data using the Brazilian free-tailed bat (*Tadarida brasiliensis*) as a model. The emergence of a large colony of free-tailed bats was recorded using an array of time-synchronized and space-calibrated thermal cameras and the bats' three-dimensional positions and trajectories were reconstructed as a function of emergence rate and light conditions. Our results indicate a significant effect of these two variables on the structure and pattern of movement of individuals in the flight column. In addition, we describe non-uniform distribution of individuals in the group that make specific predictions about the sensory modality that bats use. Such information is important for further understanding the mechanisms that govern group behavior in this species, other colonial bats and group-living organisms in general.

Impacts of Land-use Intensification on Rainforest Bat Assemblages in Sumatra, Indonesia

Joe C.-C. Huang, Elly L. Rustiati, Ipoel Bahrie, Koko Yustian, Krisantus U. E. Kusuma, Miswandi B. Katinu, Jani Master, Hesti Prastianingrum, Meyner Nusalawo, and Tigga Kingston. Texas Tech University, Lubbock, TX; University of Lampung, Indonesia; Wildlife Conservtion Society-Indonesia program, Indonesia

Tropical rainforests, where bat species richness is generally greatest, are likely to experience severe losses of bat diversity as a result of rapid deforestation. Of the threats to tropical forests, conversion to agricultural plantations is the most prevalent after logging. Agricultural land uses can result in significant losses and/or a

modification of tropical biodiversity. In Indonesia the situation is critical as the region houses 225 species but relative rates of forest loss (up to 2.0% annually) are the highest among all tropical regions. However, the consequences of agricultural intensification on forest bat diversity in this region are virtually unknown. Here we study bat diversity along a gradient of agriculture intensification to understand how bat assemblages and functional groups respond to different land management strategies. We use harp traps and mist nets to conduct bat surveys in three habitat types in and around Bukit Barisan Selatan National Park southwest Sumatra, Indonesia: monocultural coffee farms; polyciltural coffee farms (cultivation type comprises a variety of crops, such as coffee, cocoa, banana, rubber tree) ; and primary rainforests. The values of agroforests to conservation of bat diversity are also discussed. Future work will focus on how land uses shape ecological functions of insectivorous bat ensembles.

Differences in the Foraging Capabilities Between *Pteronotus davyi* and *P. personatus*; its Relationship with their Echolocation Systems

Carlos E. Ibarra-Alvarado and Antonio Guillén-Servent. Instituto de Ecología, UNAM, México, D.F.; Instituto de Ecología A.C., Xalapa, Ver. MÉXICO

The foraging behavior of a species is closely related with his capabilities in detect the potential preys presents in the environment. In the particular case of insectivorous bats, these capabilities are mostly circumscribed to the echolocation system which enables to distinguish preys from the background clutter. Like the echolocation system, these capabilities are different for each species and besides vary according to the structural complexity of the space in which the bats fly. This study compares the capabilities of prey detection between two very closed related insectivorous bats, *Pteronotus davyi* and *Pteronotus personatus* (Mormoopidae), which have echolocation systems subtly different. The behavior of 20 individuals of each species were tested in a flight cage, presenting different scenarios to see if the horizontal or vertical distance from the prey to the background objects affects the detection capabilities of bats. The two scenarios were 1) A prey (*Tenebrio molitor* larvae) situated at different horizontal distances from a synthetical grass carpet (suited vertically), and 2) A prey situated at different vertical distances (heights) from the surface of a still pond. We found that a greater distance from the prey to the background translates in both species like a less time to find the prey (measured as the number of passes before capture) and a greater capture success. Nevertheless the key difference is that *P. personatus* is capable of capture preys at very short distances and *P. davyi* doesn't exhibit this capability. Besides, *P. personatus* showed a considerably better performance in the experiment with the pond, which is related with the foraging preference of this species that, almost always, hunts preys over water bodies. The results reinforces the previous knowledge that *P. personatus* has a more plastic echolocation repertoire than *P. davyi*, and uses it differentially according the spatial conditions in which fly.

Accounting for seasonal effects with additive mixed models for counts of bat activity

Tom Ingersoll, William Rainey, Elizabeth Pierson, and Perry de Valpine. The National Institute for Mathematical and Biological Synthesis, University of Tennessee, Knoxville, TN

We investigated the practicality of modeling the response of activity to the effects of season and a categorical covariate within an environment of random site effects and autocorrelated temporal errors. Specifically, we modeled spatially replicated time series of acoustic counts of bats in response to date, and two habitat categories, meadows and forest edges. Data for our analysis were digitally recorded counts of bat passes contracted by the National Park Service. These data were collected with twelve fixed-position bat detectors, one in each habitat type, paired at six locations, over a continuous period of 236 nights at Yosemite National Park, California, USA. Ten species and acoustic clades of bats had been identified and counted in the recordings, across a broad range of abundances and detection probabilities. These data presented substantial modeling challenges of non-linear response to date, interactions between date and habitat, non-normality of errors, serial temporal correlation of errors, and random site effects associated with repeated measures. Additive and generalized additive mixed models implemented in the mathematical language R were found to adequately represent seasonal activity patterns in most species, and were favored over linear models, and linear mixed models by AIC model selection. While bats may represent an extreme case of seasonal effects, correlated errors, and overdispersed counts, these modeling approaches may be applicable to activity-dependent counts of other animal taxa.

A Test of the 'Reproductive Landmarks Hypothesis' as an Explanation for Mortality of Bats at Wind Turbines

Joel Jameson and Craig Willis. Department of Biology and Centre for Forest Interdisciplinary Research, University of Winnipeg, Winnipeg, Manitoba, Canada

Despite the benefits of wind power, thousands of bats die every year at wind energy facilities due to collision with the rotors and barotraumas. It is still unclear why so many bats enter the rotor-swept air space of the turbines. In North America, the migratory tree bats account for most of the fatalities at turbines and available evidence suggests that these species are attracted to turbines. One possible explanation, which has been termed the "Reproductive Landmarks Hypothesis" proposes that migratory tree bats are attracted to tall structures such as wind turbines during their fall mating/migration period because they perceive them as landmarks at which to find mates, much like some hibernating bat species use hibernacula as mating landmarks. Our objective was to test two questions arising from the Reproductive Landmarks Hypothesis: 1) Do migratory tree roosting bats exhibit an attraction to tall structures such as wind turbines; and 2) Is there evidence that this attraction is associated with mating activity? We compared bat activity at open fields, woodlots, wind turbines, and other tall structures (telecommunication towers) by recording echolocation calls. We found strong evidence for an attraction to tall structures and the pattern of activity at tall structures varied with season. Determining whether bats are attracted to turbines is important because an attraction raises questions about the value of preconstruction monitoring. In addition, understanding why bats are attracted to turbines could be important for developing effective mitigation strategies.

Sounds Like Fun to Me: A Comparison of Six Ultrasonic Microphones

Meredith Jantzen and Amy Cameron. The University of Western Ontario, London, ON, Ministry of Natural Resources, Pembroke, ON

Comparisons of bat activity in various habitat types using echolocation detectors are increasingly common, but no recent study has quantified the range or detection abilities of different brands of acoustic hardware. The purpose of this study was to compare five types of microphones in order to better inform future purchases of bat detectors. This study compared six different ultrasonic microphones: Songmeter SM2Bat, (Wildlife Acoustics), AnaBat SD2, (Titley Scientific), BAT AR125 125Khz ultrasonic receiver, (Binary Acoustic Technology,), Batcorder 2.0 (ecoObs), Bat Echo-Tracker (EchoTrack, Inc.), and Avisoft CM16/CMPA microphone, (Avisoft Bioacoustics). Range was determined at 0, 90, and 270 degrees by triggering a DogDazer at 10m intervals from 10-60m away from the microphone. Maximum intensity of each call was recorded in a series of three trials. Detection abilities were also compared at two natural settings along the Ottawa River. For two nights, detectors were set to record from 22:00-0:00h. Calls recorded in wav. files were analyzed using auto-detection settings in callViewer18. Analook was used to analyze AnaBat files. Call numbers varied substantially between recorders. These results suggest that recorder performance differs between brands, and care should be taken when comparing activity levels reported by different types of recorders.

Social Roosting Behavior in Colonies of *Corynorhinus rafinesquii* in Bottomland Hardwood and Upland Karst Regions of Kentucky

Joseph Johnson, Michael Lacki, and Garret Langlois. University of Kentucky, Lexington, KY

Understanding social interactions among bats during day-roosting has implications for reproductive success and discovery of alternative roosts and foraging areas. Evidence suggests several forest-dwelling bat species form colonies composed of individuals faithful to a number of roosts on the landscape, and that roosting associations among members of the colony is preferential, but not exclusive. Thus, determining if species, and populations of species in differing ecological settings, conform to this fission-fusion model of roosting behavior is important to conservation and management efforts. We captured and radiotagged pairs of adult Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) from May through September 2009 and 2010 to test the fission-fusion model in populations of Rafinesque's big-eared bat. Work occurred concurrently at two study locations in Kentucky – a bottomland hardwood landscape and an upland karst landscape – where types of day-roosts and day-roost availability differed. As of mid-August 2010, we radiotagged 30 pairs of big-eared bats in the bottomland hardwood study site and 40 pairs in the upland karst study site. Data presented will include analysis of pair association using the pairwise sharing index and individual sharing index. Data will be analyzed by sex and reproductive condition of

individuals in the pair. These data will be used to evaluate the strength of day-roosting associations in Rafinesque's big-eared bat, and determine if differences exist between populations inhabiting different eco-regions.

Hoary bat (*Lasiurus cinereus*) and Brazilian free-tailed bat (*Tadarida brasiliensis*) mortality and movements at the Montezuma Hills wind energy region in Central California

David S. Johnston, J. A. Howell, N. Thorngate, S. B. Terrill, J. Castle, and T. Mabee. H. T. Harvey & Associates, Los Gatos, CA; ABR Incorporated, Fairbanks, AK

Few studies on wind turbine bat mortality have been conducted in California and none have included the needed daily carcass searches to accurately study the environmental conditions and the timing of bats' movements. We investigated the relationship between wind speed, distance and direction to tree groves, temperature, barometric pressure, bat mortality, and the direction of bats and birds above and below the turbine height of 125 m agl. This study comprised carcass searches at 48 turbines, radar sampling at 2 points, night vision observations at 2 points, and acoustic surveys at 8 stations for birds and 8 stations for bats using full-spectrum recordings. Survey techniques were conducted for 4, 10-day periods between August 15 and October 15, 2009. During the first of two seasons, we found that the lack of high winds (coefficient = - 0.48 df = 18, p = 0.03) and presence of a high barometric pressure (coefficient = 0.512, df = 26, p = 0.005) were important predictors of bat mortality for *Lasiurus cinereus*. The hoary bat mortalities were unevenly distributed temporally (Pearson chi-squared in R, (X-squared = 80.6452, df = 2, p-value < 2.2e-16) suggesting this species moved in pulses, but *Tadarida brasiliensis* mortalities were distributed evenly suggesting movement was not clumped. Furthermore, a relationship exists between turbine mortality locations and the distance and direction to the nearest clump of Fremont cottonwood (*Populus fremontii*) (Rayleigh Test for Uniformity, p=0.007) and for eucalyptus (*Eucalyptus globulus* and *E. camaldulensis*) trees (p=0.013.) The mean flight direction of birds and bats at High Winds was 103° whereas at Shiloh it was 83°. There was no significant direction of bats and birds below 125 agl suggesting strikes possibly occur when bats are searching for a roost.

Optimization of Hibernation in *Myotis lucifugus* - the Thrifty Female Hypothesis

Kristin A. Jonasson and C. K. R. Willis. University of Winnipeg, Winnipeg, MB

Cold, prolonged torpor bouts have often been considered the ideal pattern of hibernation because they maximize energy conservation. However, deep torpor appears to be accompanied by physiological and ecological costs, which means that patterns of torpor during hibernation are influenced by an optimization between the energetic benefits and physiological/ecological costs of torpor. The relative importance of spring energy reserves should affect this optimization. Females, which rely on fat reserves at emergence to fuel spring reproduction should be thrifty with their energy compared to males during hibernation by relying more heavily on deep, prolonged torpor bouts and/or short arousals. We used temperature telemetry and measurements of body condition index (BCI, mass/forearm) to test this hypothesis in *Myotis lucifugus* from hibernacula in Manitoba, Canada. Adult females exhibited a smaller decline in BCI throughout hibernation (24.8%) than adult males (30.7%), juvenile females (28.7%) or juvenile males (33.0%). Our results support the thrifty female hypothesis and have implications for understanding energy balance in hibernating mammals and suggest that female *Myotis lucifugus* may be more tolerant of disruption of energy balance during hibernation, including that associated with White-nose Syndrome.

Modeling current and future potential for peripheral populations of southeastern bats to mitigate effects of White Nose Syndrome in core populations

Matina C. Kalcounis-Rueppell, M. J. Vonhof, and L. J. Rissler. University of North Carolina at Greensboro, Greensboro, NC; University of Western Michigan, Kalamazoo, MI; University of Alabama, Tuscaloosa, AL

Bat species impacted by White Nose Syndrome (WNS) are characterized by winter hibernation in caves. Peripheral populations of WNS-affected bats at the southern edge of their species range in the southeastern United States may not hibernate. If core and peripheral populations of bats differ in behavior or physiology, peripheral populations may mitigate regional species extinction from WNS in core populations. Understanding how species' behavior and physiology vary across space in relation to the environment is essential to understanding the potential mitigating effects of peripheral populations in the face of WNS. We determined with ecological niche modeling (ENM), current and future probabilities that peripheral populations will mitigate core extinctions in WNS-affected

bat species by 1) using ENM to predict the location and distributional limits of peripheral and core populations; 2) determining the behavioral and physiological differences between peripheral and core populations; and 3) using ENM to identify regions where bat populations should have low susceptibility to WNS and high viability. We focused on *Myotis lucifugus*, *M. septentrionalis*, and *Perimyotis subflavus*. Preliminary models show that ENM based on current climate data predict known peripheral populations of bats at the southern extent of the species range. For example, peripheral populations of *M. septentrionalis* in coastal North Carolina are predicted based on core localities alone. In addition, ENM models based on future climate trends increase the likelihood for peripheral populations of the two *Myotis* species to be established in the Gulf Coastal Plain at localities further south than current distributional limits. ENM models show high variability in peripheral population locations along the southern extent of species distributions. Our ENM results underscore the potential for peripheral populations of bats in the southeastern United States to mitigate effects of WNS on core populations.

Behavioural Syndromes and their Social Implications in Adult Female Big Brown Bats, *Eptesicus fus*cus

R. Julia Kilgour and R. Mark Brigham. The University of Regina, Regina, SK

Behavioural syndromes are consistent and correlated behaviours found between and within individuals, and have become the focus of much research in the last decade. They have been studied in a wide range of taxa, both vertebrate and invertebrate, and have important implications on how animals interact with their surrounding environment and as well as with conspecifics. This study examines behavioural syndromes in adult, female big brown bats and explores their social implications. We created behavioural profiles for 28 individuals brought temporarily into captivity over the typical reproductive season of this species. The behavioural profiles consisted of 11 behavioural variables, including aggression, activity, competition, learning ability, and stress response. Several of the behavioural variables were compared between solitary and social contexts. Additionally, we examined the potential influence of several non-behavioural variables, including body size and colony of origin. The variables were reduced using principal component analysis and factors compared using correlation analyses. We used cluster analysis to determine how bats could be grouped according to similarity in behavioural profiles and found that profiles changed consistently over the reproductive period: pregnant females behaved differently than post-lactating females. The results to this experiment indicate that the behaviour of bats is constrained by behavioural syndromes and that these syndromes may change over the course of the reproductive period. Alterations in the behavioural patterns of adult females may also be a reflection of social changes that take place in this species during the summer, and these implications are discussed.

Landscape and temporal variability of insectivorous bat assemblages in a Malaysian rainforest: just what is a bat assemblage?

Tigga Kingston, K. Rakhmad S., Juliana S., Zubaid Akbar, Rosli H., T. H. Kunz, and S. Gopal. Texas Tech University, Lubbock, TX; Universiti Kebangsaan Malaysia, Malaysia; University of Malaya, Malaysia; Boston University, Boston, MA

Tropical bat assemblages are among the most species-rich and trophically diverse vertebrate assemblages in the world. They are both a source of inspiration for community ecologists, and, given the rapid loss of tropical habitats, a cause for concern for conservation biologists. Confounding both research foci are practical issues concerning the delineation of assemblages in both time and space. Few studies have addressed the spatio-temporal variability of bat assemblages, particularly that within contiguous undisturbed habitats. In this study, we used a standardized harp-trapping protocol to sample insectivorous bat assemblages at five study sites within the contiguous, undisturbed lowland rainforest of Krau Wildlife Reserve, Malaysia. The study sites were a minimum of 6 km apart, and comprised trail networks of 14 km (one study site with an irregular grid) and 22 km (four 1 km^2 study sites). Over a period of seven years, each assemblage was sampled four times. After standardization for weather, total trap effort exceed 6600 harp-trap nights and generated over 16,000 captures of adults of 31 species from six families. Estimated species richness varied slightly across space and time, but spatio-temporal variability in the composition of the assemblages was pronounced, underpinned by complex and asynchronous interactions at the species level. These findings have important consequences for our understanding of the processes determining assemblage structure, the design of diversity surveys, and the conservation of species-rich assemblages in the face of habitat disturbance and fragmentation.

Thermoregulation and Roost Selection During Early Development in the Solitary, Tree-roosting Hoary Bat (*Lasiurus cinereus*)

Brandon Klüg and Robert Barclay. University of Calgary, Calgary, Alberta

Raising young in cold environments results in slowed growth rates. Previous studies have suggested that neonate bats are unable to maintain a high body temperature following parturition, so keeping young warm to promote rapid growth seems imperative. For temperate-zone bats, providing young with enough nutrients and warmth to facilitate rapid development while sustaining their own energy needs can be challenging. Many bat species form sheltered maternity colonies, which provide the benefit of ambient warmth. For the solitary, tree-roosting hoary bat (*Lasiurus cinereus*) this strategy is not available. However, we hypothesize that like other bat species reproductive *L. cinereus* refrain from using torpor during lactation regardless of environmental conditions. We also hypothesize that neonate hoary-bat pups are able to maintain a high body temperature immediately after birth and that roosts are selected that minimize convective heat loss and maximize radiant heat gain, thus lessening the thermoregulatory demand of the mother and allowing rapid growth of the pups in her absence. We captured and radiotagged 15 *L. cinereus* families and monitored thermoregulatory patterns of both mothers and pups. We also measured roost variables, including wind speed and sun exposure, to determine if roosts are selected for physical and microclimatic characteristics. Preliminary analyses suggest that reproductive *L. cinereus* females are using torpor differentially throughout the reproductive period and choosing roosts with less variable sun exposure and more shelter from wind than randomly chosen roosts. It also appears that *L.cinereus* pups are able to maintain a high body temperature in as little as 2 days after birth, but continue to use torpor in the mother's absence. Further data analyses and conclusions will be presented.

Ectoparasites of Nectar-feeding Bats *Erophylla sezekorni* and *Monophyllus redmani* on Puerto Rico

Allen Kurta, John O. Whitaker, Jr., Brian Schaetz, and Olivia Munzer. Eastern Michigan University, Ypsilanti, MI Department of Biology, Indiana State University, Terre Haute, IN Eastern Michigan University, Ypsilanti, MI Eastern Michigan University, Ypsilanti, MI

The buffy flower bat (*Erophylla sezekorni*) and Greater Antillean long-tongued bat (*Monophyllus redmani*) are phyllostomid species that are endemic to the West Indies, where they typically roost in the cooler portions of hot caves. Between February 2007 and February 2008, we examined about 180 adult individuals of each phyllostomid for ectoparasites at Culebrones Cave, near Arecibo, Puerto Rico. Both species harbored large numbers of spinturnicid mites—*Periglyhus cubanus* on *E. sezekorni* and *Periglyschrus vargasi* on *M. redmani*. However, despite living in the same cave and having similar foraging strategies, there were many differences in the ectoparasitic assemblages. For example, streblid flies (*Nycterophilia* and *Trichobius*) were abundant on *M. redmani*, but uncommon on *E. sezekorni*. Conversely, ticks were common on *E. sezekorni* but rarely found on *M. redmani*. Unlike mormoopid bats that live in the same cave, these phyllostomids rarely were parasitized by chiggers.

Deployment of Heat-Trapping Roost Modules: a Strategy to Help Mitigate the Decline of Little Brown Myotis Populations Caused by White-Nose Syndrome

Thomas H. Kunz and D. Scott Reynolds. Boston University, Boston, MA; St. Paul's School, Concord, NH

In the wake of the massive regional population collapse of little brown myotis from white-nose syndrome (WNS) in the eastern U.S, we describe a heat-trapping roost module that can be installed in the attics of buildings that are currently or were previously occupied by large maternity colonies. The premise of this proposal is that colonies of little brown myotis that have been significantly reduced in size from the affects of WNS are likely to be most successful if small colonies can roost in buildings where heat-trapping crevices facilitate euthermic body temperatures. Based on expectations that there will be some survivors following the recent declines in colonny size from WNS, every reasonable effort should be made to protect these survivors and to facilitate colony recovery. Roost modules, modeled after unintended but successful bat roosts in some buildings, are designed to accommodate small colony sizes by providing a roost environment that can trap metabolic heat, thereby reducing energy expenditure and thus promoting reproductive success of bats that now comprise these small colonies. We describe a roost module that is relatively inexpensive and easy to construct and install in existing or new buildings that provide roosting space to accommodate small and potentially growing colonies. As colony size increases, additional roost modules could be installed to accommodate colony expansion. Roost occupancy can be monitored by collecting guano from beneath a relatively small roosting space and using molecular markers derived from feces to periodically

and unobtrusively monitor colony size. If desired, roost occupancy and colony size and dynamics could also be monitored by strategically placing temperature probes in roost crevices and installing a passive integrated transponder (PIT) system or infrared video camera to automatically census bats as they emerge nightly from roost modules or from the buildings in which these systems have been installed.

Identifying the Confounding Factors in Resolving Phylogenetic Relationships in Vespertilionidae

Justin B. Lack and Ronald A. Van Den Bussche. Oklahoma State University, Stillwater, OK

Resolving phylogenetic relationships within Vespertilionidae has been difficult, with large datasets (>100 taxa, >7 kilobases) resolving portions of the phylogeny, but leaving intertribal relationships within the Vespertilioninae unresolved. As a result, the evolutionary history of the most speciose chiropteran family is largely unknown. The presence of short internodes followed by long terminal branches relative to other chiropteran phylogenies suggests evolutionary rates of DNA substitution and lineage diversification may be inhibiting phylogenetic resolution. To test this hypothesis, we obtained sequences of the mtDNA 12s rRNA, $tRNA^{VAL}$, and 16s rRNA as well as the nuclear exon RAG2, resulting in over 3 kilobases of digenomic DNA sequence data for representatives of all subfamilies and tribes within Vespertilionidae and Phyllostomidae, a family of bats that radiated at approximately the same time as Vespertilionidae. Analyses revealed substitution rates for Vespertilionidae were significantly higher than Phyllostomidae, with the majority of fast-evolving lineages found within Vespertilioninae. Cladogenesis analyses characterized the vespertilionid radiation as compressed toward the root, with a rapid initial diversification, while the phyllostomid diversification was much more gradual. We suggest ecological differences between tropical and temperate environments may have influenced diversification rates for Vespertilionidae and Phyllostomidae.

Variability in Call Structure in *Pteronotus quadridens* (Mormoopidae)

Winston C. Lancaster. California State University, Sacramento, CA

Intraspecific variation in the time and frequency structure of biosonar calls has been described in previous studies. Variation relates to proximity to targets as well as to proximity to environmental structure. Variations in timing and frequency related to proximity to targets have been described as phases of echolocation behavior (search, approach and terminal phases). Variations made in response to environmental structure can be seen within the search phase, and since these are considered to be the calls best suited to species identification, they must be treated with caution. *Pteronotus quadridens*, endemic to the Greater Antilles, uses distinctive search phase calls consisting of an initial frequency modulated (FM) segment of low slope starting at or above 80 kHz, that breaks sharply into a steeply sloping FM. The slope of the steep FM declines gradually. These calls typically range from 5 to 7 ms in duration and have a bandwidth of 18-20 kHz. Two or three harmonics are typically recorded and the second harmonic usually has the highest amplitude. Recent recordings made on Isla de Mona, 50km west of Puerto Rico show calls of a different structure that appear to be attributable to *P. quadridens*. These calls eliminate the initial low-slope FM and consist solely of a concave-up FM call with gradually diminishing slope. Variant calls have a similar duration and harmonic structure as typical calls but have a narrower bandwidth (8-12 kHz). The onset of the second harmonic of the variant calls is usually about 70 kHz in contrast to typical calls. The current data set is insufficient to attribute these differences to proximity to environmental structure, or even to be sure that they are limited to search phase. Variant calls are of interest in that they could easily be attributed to a different species. They also may have functional differences; understanding the functional differences could shed light on the function of the typical calls with the initial, low slope FM seen in other species of mormoopids. This work was supported by a Research and Creative Activities award from CSU, Sacramento.

Declines of Six Hibernating Bat Species from White-Nose Syndrome in the Northeastern United States

Kate E. Langwig, W. F. Frick, S.R. Darling, C. J. Herzog, A. C. Hicks R. B. Smith, R. I. von Linden, and T. H. Kunz. New York State Department of Environmental Conservation, Albany, NY; Vermont Fish and Wildlife Department, Rutland, VT, Boston University, Boston, MA

Variation in susceptibility to pathogen infection among species can provide valuable insight into the causes and consequences of emerging infectious diseases. White-nose syndrome (WNS) is thought to be associated with the newly described psychrophilic fungus *Geomyces destructans*, with documented infections in all six hibernating bat species in the northeastern United States. The greatest prevalence of WNS infection has been observed in this

region, with overall declines at hibernation sites ranging from 70 to 100%. Based on surveys conducted at hibernacula during pre- and post-WNS periods, the little brown myotis (*Myotis lucifugus*), northern long-eared myotis (*M. septentrionalis*), and tri-colored bats (*Perimyotis subflavus*) have shown the largest overall population declines. Substantial declines in northern long-eared myotis at hibernacula have caused serious concern among natural resource managers that this species may be in immediate danger of regional extinction. Despite its highly gregarious winter roosting habits, the Indiana myotis (*M. sodalis*) has experienced less severe overall decline as compared to little brown myotis, northern long-eared myotis, and tri-colored bats, however, this effect is largely site dependent. The relatively rare eastern small-footed myotis (*M. leibii*) may be less susceptible to WNS, with overall positive population growth (lambda >1). Big brown bats also appear to be less susceptible to WNS, although surveys of hibernacula alone do not adequately assess the viability of this species. Variation in disease susceptibility among the six species of bats affected by WNS in North America suggests that environmental, behavioral, and innate biological factors may contribute to differences in susceptibility to infection from *G. destructans*.

Preference in Bat House Design by the Evening Bat (*Nycticeius humeralis*)

Kristen M. Lear, Elizabeth C. Braun de Torrez, and Thomas H. Kunz. Ohio Wesleyan University, Delaware, OH; Boston University, Boston, MA.

Since the early 20th century, people have used bat houses to attract bats. Factors that increase bat house success include appropriate external color, large landing areas, and mounting on buildings in areas with low disturbance, and low canopy cover. However, little research has been conducted to determine the most effective design for attracting specific species of bats. We attempted to create roosting sites specifically for evening bats (*Nycticeius humeralis*). Preliminary findings from our research, as well as published information on evening bats, suggest that they may be especially beneficial in pest suppression because they forage within the canopy of pecan orchards, have small foraging ranges, prefer orchards with old pecan trees, and consume pecan nut casebearer (*Acrobasis nuxvorella*) moths, one of the most devastating nut-feeding insects that occur in pecans. In addition, evening bats are thought to be in decline due to loss of old growth forest habitat. We tested two commonly used bat house designs for their effectiveness in attracting and maintaining colonies of evening bats. We installed nine pairs of bat houses in three organic pecan orchards in central Texas. Each pair consisted of one two-chamber rocket box and one standard medium three-chamber house. We monitored each house for evening bat occupancy by documenting the presence of guano beneath the roost, visually monitoring the bats inside the house during the day, and recording echolocation calls during nightly emergences. Preliminary results suggest that evening bats prefer rocket boxes to standard bat houses. These findings will allow us to better attract this species to conventional pecan orchards and other areas where there are no large, old trees with suitable roosting cavities. These cavities are beneficial to farmers wishing to reduce pests in pecan orchards and to evening bats that require suitable roost sites to sustain viable populations.

Genetic Approaches to Assessing the Impact of Wind Turbines on Eastern Red Bats

Min T. Lee, Maarten J. Vonhof, and Amy L. Russell. Grand Valley State University, Allendale, MI; Western Michigan University, Kalamazoo, MI

While wind energy is rapidly becoming a viable source of alternative energy, it is becoming increasingly clear that the presence of wind turbines is a conservation threat for wildlife, particularly birds and bats. Large kills of bats have been reported at wind farms across North America, with tree-roosting migratory species such as hoary bats, eastern red bats, and silver-haired bats being those primarily affected. For these same species, however, basic elements of their life history are unknown. How large is each species' population size? Is the population growing or declining? Is the population structured into discrete subpopulations? If it is structured, do different subpopulations use spatially segregated migratory routes? These life history parameters form a body of knowledge that is critical to assessing the long-term effects of wind turbines on migratory tree bats. Here, we present novel data contributed to an ongoing population genetic study to understand the demographic trends of eastern red bat populations in response to conservation pressures from wind farms. Mitochondrial data collected earlier in this project support a picture of eastern red bats as a large, panmictic, and growing population; however, inference from these data are inherently limited to the females of the species and further are subject to the statistical vagaries of a single locus. We explore the utility of the autosomal *chymase* locus to evaluate the presence of sex-specific dispersal and to provide a multilocus estimate of effective population size and population growth rate. The data obtained from this project will

provide the genetic and demographic background necessary to understand the potential biological and ecological impacts of increased wind power development on eastern red bat populations.

Modeling Indiana Bat Maternity Roost and Capture Site Habitat

Joseph R. Lemen and L. W. Robbins. Missouri State University, Springfield, MO

The preservation of Indiana bat habitat has important implications to a variety of projects including wind farm locations, power transmission line corridors and forest management. Determining presence of Indiana bats, especially reproductive females, is a high priority for all projects requiring land use changes. Modeling potential habitat before this occurs can help expedite sampling effort, minimize impact on the species, and reduce cost. Twenty eight reproductive female Indiana bats were captured during the summers of 2007 through 2010 and were radio tracked to roost trees. Exit counts were performed to confirm maternity tree status, either >30 bats present or repeated use. Twelve primary maternity roosts and twenty one capture sites were documented. Spatial attributes including distance to water source, distance to forest edge, soil type and land classification type were compiled and extrapolated in ArcGIS 9.3.2. The capture sites and maternity roost sites were modeled separately. The results of the model are shapefiles representing probable habitat for capture sites and maternity roost locations. These polygons can be overlaid with aerial photos to focus sampling efforts within expansive project boundaries or loaded into a handheld GPS unit to confirm specific "in habitat location". Also, these areas designated as "probable habitat" could be a recommendation as a metric to be used in defining areas of land that must be evaluated prior to disturbance.

Roost Use and Selection by Rafinesque's Big-eared Bats (*Corynorhinus rafinesquii*) Varies with Habitat

Susan C. Loeb. USFS Southern Research Station, Clemson, SC

Rafinesque's big-eared bat (RBEB) is a relatively rare and sensitive species found throughout the southeastern US. In the Coastal Plain Region, RBEB roost primarily in bottomland hardwood forests and surrounding areas. Some general patterns of roost site use and selection have been found across studies of Rafinesque's big-eared bats (e.g., use of large hollow trees), but variation in roost characteristics has also been found. The objective of this study was to test the effects of roost availability on roost use and selection by Rafinesque's big-eared bats in two sites in the Savannah River floodplain: the Webb Wildlife Center (Webb), a relatively undisturbed site, and the Savannah River Site (SRS), a site with a long history of disturbance. Thirty eight transects (28 on SRS, 10 on Webb) 50 m wide and approximately 2 km long were established perpendicular to the floodplain. All trees with basal openings and cavity volumes $\geq$ 150 dm^3 were examined for the presence of RBEB. Trees were classified by tree type (Type 1--basal opening only or Type 2--basal and chimney opening), and dbh, tree height, tree species, cavity texture, and decomposition state were recorded. Potential roost trees at Webb were significantly larger, more likely to be Type 2, and more likely to be tupelo or bald cypress. RBEB at Webb used Type 2 trees significantly more than bats at SRS and roost trees had a significantly larger dbh than those at SRS. RBEB at SRS used a wider variety of tree species and selected larger dbh trees; no selection for large trees occurred at Webb. These results suggest that roost use and selection by RBEB is dependent on roost availability and that full understanding of the roosting requirements of RBEB in the Coastal Plain Region requires examination of a wide variety of site qualities and types.

Hips Don't Lie: The Phylogeny and Morphology of the Bat Pelvic Girdle

Aja C. Marcato, William A. Schutt Jr., and Nancy B. Simmons. C.W.Post Campus of Long Island University; American Museum of Natural History, New York, NY

Compared to the extensive information on the bat cranium, relatively few phylogenetic studies have examined the postcranial skeleton. In this study, we examined anatomical variation in the chiropteran pelvic girdle and associated vertebra (sacral and caudal), focusing on the potential phylogenetic relevance of the observed characters among all families. We examined pelvic and vertebral morphology in adult male and female specimens from all recognized bat families. Skeletons were examined using stereoscopic microscopes equipped with a digital camera or camera lucida. Data sources also included scientific illustrations and casts from fossil specimens. In addition to developing new characters (e.g., variation in the pubic spine, presence or absence of an iliac fossa, the shape of the obturator foramen), we also reexamined previously analyzed characters, such as the presence of fused or unfused vertebrae. Finally, Morphobank was employed to organize the data for comparative purposes and to facilitate phylogenetic analysis.

Large-Scale Movements of Individual Little Brown Bats Throughout Manitoba and Northwestern Ontario

Felix Martinez-Nuñez, K. J. O. Norquay, J. E. Dubois and C. K. R. Willis. University of Winnipeg, Winnipeg MB Canada; Manitoba Conservation, Winnipeg MB Canada

Understanding distribution and social networks of bats is crucial for understanding their ecology and important for developing effective conservation strategies, especially for species affected by white-nose syndrome (WNS) Recent research has shown that *Geomyces destructans*, the putative causal agent of WNS, can be transmitted through direct bat to bat contact and also via contact with affected hibernacula. It is now critical that we better understand the movements and social networks of individuals to understand how the disease is spreading throughout North America and, potentially to inform strategies for conservation. Our objectives were to identify seasonal movements of little brown bats throughout Manitoba, Canada and examine connectivity between bats from Manitoba and Northern Ontario, where WNS was confirmed in winter 2010. We analyzed a band-recapture dataset of 10,147 bats banded between 1988 to present in Manitoba and northwestern Ontario. We recaptured 1365 banded bats at summer roosts, in mating swarms and in hibernacula during spring. Consistent with past studies we found high fidelity to both, summer colonies and hibernacula, but some individuals switched sites between years. Seasonal movements from hibernacula and/or mating swarms to summer nursery colonies ranged widely from 10.1 to 647.1 km. We found females banded at a nursery roost in Ontario using hibernacula in central Manitoba. Our data provide a mechanism to explain apparent jumps in the distribution of *G. destructans* and highlight the current vulnerability of populations in western North America to WNS. We present a hypothesized framework to explain patterns of association and movement among little brown bats during winter and summer and will assess this hypothesis by examining genetic relatedness of individuals within and between different hibernation sites and summer roosts.

Phenotypic Plasticity of Migrating Hoary Bats, *Lasiurus cinereus*

Liam P. McGuire, M.B. Fenton, and C.G. Guglielmo. University of Western Ontario, London, ON, Canada

During periods of migration, some bats travel hundreds or perhaps thousands of kilometers between winter and summer grounds. We investigated the energetic consequences of migration for bats and resulting phenotypic plasticity. We hypothesized that migration is an energetically demanding activity and would result in numerous phenotypic changes to improve energy efficiency. We predicted that migrating bats would have larger digestive organs to facilitate rapid refueling, greater nutrient stores, and elevated oxidative capacity as a result of the increased energetic demands of migratory flight. We collected hoary bats during spring migration (n = 30) and non-migrating hoary bats during summer (n = 15). We measured the mass of the pectoralis and 6 organs. We also determined fat and lean mass by soxhlet extraction. Finally we measured aerobic enzyme capacity (carnitine palmitoyl transferase, citrate synthase, and 3-hydroxyacyl-CoA dehydrogenase). There was no difference in pectoralis mass or heart mass between migrating and non-migrating bats. Contrary to our predictions, migrating bats had smaller stomach (-15%), intestines (-43%), kidneys (-7%), and liver (-11%). Migrating bats had larger lungs (+23%). A significant sex*migration interaction indicated that spring migrating females carry more fat than males. Results of aerobic enzyme capacity are pending. The reduction of digestive tract organs suggests that bat migration has selected for lower mass to reduce energetic demands during flight, rather than increased digestive tract organs to facilitate rapid refueling. Increased lungs reflect an increased capacity of aerobic exercise. We suggest that differences in thermoregulatory strategies during spring migration may have resulted in the differences observed in body composition between sexes. During migration, bats may use torpor to minimize energetic costs during non-flight periods, thus reducing the need for refueling along their route.

Using a Predictive Indiana Bat Habitat Suitability Model to Inform a Tiered Curtailment Strategy for an Ohio Wind Power Project

Cara W. Meinke and K.S. Watrous. Stantec Consulting, Inc., Portland, OR

The rapid expansion of wind power development within the range of the federally endangered Indiana bat *Myotis sodalis* has highlighted the need for increased scientific understanding of potential impacts and solutions to avoid and minimize those impacts. We created a predictive habitat suitability model to inform a tiered curtailment strategy for a wind power project in Champaign County, Ohio. We used a partitioned Mahalanobis D^2 model based on 1,124 nighttime radio-locations and 43 roost locations from 19 Indiana bats radio-tagged in the vicinity of the project area during summer mist-netting in 2008 and 2009. We used a Geographic Information System (GIS) to measure spatial characteristics of forest patches, habitat heterogeneity, slope, elevation, and distance to stream,

wetland, and forested stream within 2-km buffers of each pixel in the project area. The distances (D^2) between the vector of environmental conditions measured at each pixel and the mean vector of environmental conditions at known Indiana bat roosting and telemetry locations were rescaled using a Chi-square distribution, converted to p-values, and divided into 4 quantiles, representing most to least suitable. Indiana bat foraging habitat suitability was strongly associated with the configuration and spatial relationships of forested patches; the 3 most important variables were the degree of fragmentation, the connectedness of forest patches, and the total core area of forested habitat. This differed from roosting habitat suitability, which was driven largely by distance to forested streams, distance to streams, and distance to the nearest forest edge. A tiered approach to operational curtailment was developed based on the predicted Indiana bat habitat suitability at each proposed turbine location. Curtailment regimes differed in terms of cut-in speeds, duration, and seasonality, with turbines located in the most suitable Indiana bat habitat having the highest cut-in speeds applied over the longest duration.

Does Personality Correlate with Energetics in little brown bats (*Myotis lucifugus*)?

Allyson K. Menzies, M. E. Timonin, and C. K. R. Willis. University of Winnipeg, Winnipeg MB Canada

Basal metabolic rate (BMR), the minimum amount of energy needed to maintain an animal at rest, is highly variable within and between species. Expression of torpor, an energy-saving state used by many endotherms (i.e. mammals and birds), is also highly variable. Understanding individual differences in these traits is central to understanding how individuals budget energy and allocate resources to ensure survival and reproductive success. One potential correlate of variation in energetic traits among individuals is animal personality. Defined as differences in patterns of behaviour that are repeatable over time and across situations, personality has been well-studied in a range of taxa (e.g., rodents, songbirds, fish) but so far there has been little work on personality in bats. We devised an ecologically relevant, novel-environment test to measure exploratory behaviour in little brown bats (*Myotis lucifugus*) and measured BMR and torpor expression in the same individuals using open-flow respirometry. Some behavioural traits were repeatable in bats and behaviours clustered into three main categories (i.e., activity, exploration, anxiety) as seen in past studies with rodents, songbirds and fish. We found limited evidence supporting the hypothesis that personality is correlated to individual differences in BMR but some aspects of personality were significantly related to torpor expression. This suggests that the tendency to express torpor may reflect an additional aspect of personality in bats and that some of the variation in torpor expression among individuals is mediated by similar physiological mechanisms as variation in behavioural aspects of personality (e.g., glucocorticoid hormones).

Bat use of artificial roosts in ponderosa pine forests.

Elisabeth D. Mering and Carol L. Chambers. Northern Arizona University, Flagstaff, AZ

Bats use large (>69 cm diameter) ponderosa pine snags for maternity roosts in northern Arizona. Fire suppression, grazing, and logging have drastically altered forest structure, increasing density of live trees but decreasing average diameter. Large snags are thus more uncommon and their recruitment uncertain. To increase roost availability, we supplemented forested areas with artificial roosts. We selected 26 sites and tested 2 types of roosts (resin, wood) in 2 configurations (grouped, single). We placed 52 roosts of each type on live ponderosa pine trees (>45 cm dbh). At each site, we installed 4 roosts with a group of 3 roosts (south-, east-, or west-facing; <20 m apart) and a single roost (south-facing) 250-350 m away. We checked roosts every 2 weeks from May to October in 2009 and 2010 (ongoing), and collected guano and captured bats if present. Bats used 35% of roosts (19 roosts in 2009, 31 in 2010). Resin roosts were selected more often (20%) than wood (14%). Bats used south- (10%) and east- (9%) roosts more than west-facing (5%). We had higher use at groups of roosts (16 groups) than at single roosts (11). To date, we have identified 4 species using artificial roosts (*Eptesicus fuscus*, *Myotis volans*, *M. occultus* and *M. evotis*). Based on this and a comparative study, colonization and use appears to increase with time with initial use by males and maternity colonies forming after several years. The selection of resin over wood roosts may be because resin roosts offer greater concealment and area. Forest managers who want to supplement natural with artificial roosts should consider south- or east-facing resin roosts placed in groups.

Stable Isotope Analysis of a Behaviorally Novel Colony of *Tadarida brasiliensis mexicana* in West Texas.
Jennifer J. Miller, Raymond S. Matlack, Richard E. Strauss, and Brenda E. Rodgers. Texas Tech University, Lubbock, TX; West Texas A&M University, Canyon, TX; Texas Tech University, Lubbock, TX; Texas Tech University, Lubbock, TX.

The objective of this research is to evaluate the status of a colony of *Tadarida brasiliensis mexicana* (the Brazilian Free-Tailed Bat also known as the Mexican Free-Tailed Bat) in west Texas. Populations of *Tadarida brasiliensis mexicana* are thought to be migratory in the central and southwest regions of the United States, but a roosting location in west Texas has been observed to have year-round emergences. This behavior is contradictory to the published literature. Stable isotope analysis is being used to determine whether this roost supports a stationary colony or whether it is being used by a number of transient populations throughout the year. If a stationary colony of *Tadarida brasiliensis mexicana* is roosting in west Texas, it may be the first documentation of such behavior.

Can Hibernating *Myotis lucifugus* Mount Cutaneous Immune Responses to *Geomyces destructans*? Histological Analysis of Responses to the Phytohemagglutin (PHA) Skin Test
Marianne Moore, Elizabeth Buckles, Jonathan Reichard, Timothy Murtha, Elizabeth Braun de Torrez, and Thomas Kunz. Boston University, Boston, MA; Cornell University, Ithaca, NY

We tested the hypothesis that hibernating little brown myotis (*Myotis lucifugus*) have morphologically detectable reductions in cutaneous cellular inflammatory responses during deep torpor, and are therefore incapable of mounting sufficient responses against *Geomyces destructans*, the fungus responsible for the characteristic skin infections associated with white-nose syndrome (WNS). We used subcutaneous injections of phytohemagglutinin (PHA) and collected tissue biopsies for histological examination across a time series in pregnant, post-lactating and hibernating *M. lucifugus.* Using a four point ordinal system, we individually scored the presence of six leucocyte types, edema, vascular reaction, and vasculitis in PHA and control injected tissues. We also summed the scores for individual categories to generate an overall response score. In tissues of post-lactating bats, we found significantly more neutrophils, eosinophils, edema, vascular reaction, and vasculitis in PHA injected tissues starting at 6 hours post-injection and a significant increase in cellular infiltration over time. Significant differences between treatments also appeared in pregnant bats but not until 12 hours post-injection. Although significant differences between treatments were observed in individual response categories in hibernating bats starting at 6 hours post-injection, responses in this group lacked a cellular component and no increase occurred over time. In bats challenged during the hibernation period, responses to PHA were positively correlated with body mass index (mass/length of forearm) and time spent in euthermia. Additionally, bats affected by WNS exhibited significantly greater responses to PHA and had significantly more leucocytes in their tissues regardless of treatment compared to bats collected from unaffected sites. Overall, results show that during the first 24 hours, neutrophils and eosinophils are the primary cellular component of response to PHA in *M. lucifugus*, that hibernating bats have reduced cutaneous immune responses compared with active season bats, and that WNS-affected *M. lucifugus* have elevated cutaneous immune responses compared with unaffected bats.

The Case for Using *in situ* Recordings to Study Echolocation of Bats in Flight: a Comparison of Bat-based Versus Traditional Ground-based Devices
Paul Moosman, Kevin Austin, and Howard Thomas. Virginia Military Institute, Lexington, VA; Fitchburg State College, Fitchburg, MA

Current hypotheses about how bats echolocate, such as determining speed, direction, size, shape and fine structure of targets, are largely based on acoustic principals. Most of these hypotheses have not been tested empirically because researchers have been limited to using ground-based microphones. We recorded echolocation by big brown bats (*Eptesicus fuscus*) during flight, simultaneously, using *in situ* (bat-based) and ground-based devices made with identical components. Bats were released along a zip-line and were presented with spherical metal targets to produce echoes. At least one bat was recorded as it attempted to forage. Recordings from both systems were compared to identify differences in bat calls and target echoes. Bat calls obtained *in situ* were significantly louder, and had shorter duration and higher maximum and minimum frequencies than ground-based recordings. This likely was due to relative proximity of microphones to the bat and bias this caused during post-hoc delineation of bat calls (*i.e.*, the start and end of calls were more difficult to identify in ground-based recordings). Using the *in situ* device, target echoes were visible in spectrograms and discernable using Principal Components

Analysis. These echoes were spectrally distinct from and arrived before environmental echoes. Echoes of targets were not discernable in ground-based recordings because they coincided with environmental echoes. Results suggest *in situ* devices can record high fidelity bat calls, but more importantly, allow assessment of echoic information received by bats in flight. *In situ* devices also can be used to study foraging in bats not attached to a zip-line.

Comparing Two Methods of Acoustic Surveying for Bats: Point Counts and Moving Routes

Juliet Nagel, J. Edward Gates, and Dan Feller. University of Maryland Center for Environmental Science, Appalachian Laboratory, Frostburg, MD; Maryland Department of Natural Resources, Natural Heritage Program, Frostburg, MD

The emergence and spread of white-nose syndrome is decimating many populations of eastern bats. In order to quantify and monitor its effects on breeding populations, many states are beginning annual summer acoustic surveys. Traditionally, acoustic recording has been done at stationary locations, or points along a route. Recently, some states are switching to a moving route, where one drives a set route at a slow speed with an ultrasonic microphone attached to the roof of the vehicle. In order to compare the two methods, we designed eight routes throughout western Maryland, each between 32 and 40 km (20 to 25 miles). From 1 June through 11 July 2010, one route was driven each night, simultaneously employing each method. Starting at 30 minutes after sunset, one vehicle drove the route at 20 mph, while another vehicle stopped approximately every kilometer (0.6 miles) and recorded for five minutes. When using a point count, activity is presented as passes per minute, while moving routes are typically given as passes per mile or kilometer. Using GPS coordinates with time stamps, the moving route was split into kilometer sections. The results for each section were converted to passes per minute and compared with the corresponding points. We compared the two methods to determine: (1) if either has a species bias (if any species is more likely to be detected when using one or the other method), (2) which method allows you to identify a higher percentage of the calls recorded, and (3) how point data and moving data can be compared. This can be important if moving route data need to be compared to historical point data.

Thermal Ecology of *Pteronotus* in a High-Temperature Sea Cave in Costa Rica

Christopher W. Nicolay and M. Leigh Nelson. University of North Carolina Asheville, Asheville, NC; New College, Sarasota, FL

Bats of the genus *Pteronotus* (Mormoopidae) commonly occupy hot, humid caves. Here we report on the microclimate of a high-temperature sea cave on the Osa Peninsula of Costa Rica inhabited by three species of *Pteronotus*: *P. gymnonotus* (most abundant), *P. parnellii*, and *P. personatus*. The cave floor fills with water during high tide, but is accessible by descending a 10m cliff during low tide. After about 7m, the main entry tunnel opens to a large bowl-shaped upper chamber. Diurnal temperatures on the ceiling of the upper chamber, which was entirely covered with roosting individuals, were recorded by infrared thermometer at 40-41°C during low tides. During low-tide at night (with bats absent), temperatures of 38-39°C were measured in the equivalent parts of the cave. A Hobo temperature sensor was left inside the cave to evaluate two hypotheses: (1) influx of water into the cave with high tide significantly lowers ambient temperatures, and (2) that temperatures are higher when bats are in the roost than when they are absent. The sensor was placed on the floor of the upper chamber and recorded air temperatures continuously for six days. Two-way ANOVA detected no significant effect of tide levels (low vs. high) on ambient temperature, but found that temperatures at the bottom of the cave were significantly *lower* when bats were present. The sensors were then placed on a pole to measure temperatures in the upper part of the cave for 3 days. Near the ceiling of the cave, temperatures were significantly *higher* with bats present, but again the effect of tide was not significant. One possible explanation is that heat is stored in the rock of the cave and reabsorbed by roosting bats, but this heat is lost by convection and radiation when the bats are not present.

Population genetic structure of the bat fly (*Trichobius major*) based on amplified fragment length polymorphism analysis

Randilea D. Nichols, Justin B. Lack, Gregory M. Wilson, and R. A. Van Den Bussche. Oklahoma State University, Stillwater, OK; [2]University of Central Oklahoma, Edmond, OK

The bat fly, *Trichobius major*, is a blood feeding, obligate ectoparasite of the Cave Myotis (*Myotis velifer*). Although *T. major* possesses a spiraling flight pattern conducive to locating a host this flight pattern is highly limiting in terms of dispersal. This limited self-dispersal ability has lead previous researchers to hypothesize that *T. major* disperses via the host. In a previous mtDNA phylogeographic study, the cytochrome oxidase I and NADH

dehydrogenase 4 genes revealed no sequence variation between individuals from caves over 740 km apart, providing no insight into the dispersal and population genetic structure of *T. major*. To further investigate population genetic structure and gene flow of *T. major*, we examined Amplified Fragment Length Polymorphisms (AFLP) from 173 individuals collected from caves in Kansas, Oklahoma, and Texas. Using 8 primer pairs, we identified 233 polymorphic loci. Heterozygosity and gene diversity were low, with most populations possessing no private bands, and with no populations possessing more than 2 private bands. A principle coordinate analysis revealed a clear geographic clustering of populations, and an analysis of molecular variance (AMOVA) was statistically significant, indicating the presence of significant population structure. In concordance with mtDNA results, our nuclear analysis suggests a recent and dramatic population bottleneck for *T. major*, significantly reducing the amount of standing genetic diversity, as well as weak population structure. Comparisons of these results to the population genetic structure of *M. velifer* is necessary to understand the role the host is playing in bat fly dispersal.

Survival estimates for pre-WNS little brown bats (*Myotis lucifugus*) from Manitoba and Northwestern Ontario

Kaleigh J.O. Norquay, J.E. Dubois and C.K.R. Willis. University of Winnipeg, Winnipeg, MB, Canada; Manitoba Conservation, Winnipeg MB, Canada

Basic information on the natural history of North American hibernating bats has become even more vital since the appearance and rapid spread of white nose syndrome (WNS). A range of factors are thought to influence survival in bats but few long-term studies exist. Knowledge of overwinter survival for populations before and after the arrival of WNS will be important for precisely quantifying between-population variation in mortality. It will also help identify populations with already low survival rates which, presumably, will be at greatest risk from WNS. We report on results of a mark-recapture analysis quantifying over-winter survival in little brown bats across Manitoba and south-western Ontario. We banded or pit-tagged 10147 bats captured at hibernacula, mating swarms and summer roosts between July 1989 and May 2010. So far, we have recaptured 1365 of these individuals allowing us to, examine factors influencing annual survival prior to the arrival of WNS in western Canada, including the influence of sex, hibernaculum microclimates, winter duration and other climatic variables. These data will improve our understanding of factors influencing survival in bats and will provide an important baseline for comparison to survival rates after the arrival of WNS.

The Effects of Prescribed Fire on Roosting Habitat of the Endangered Indiana Bat, *Myotis sodalis*

Joy M. O'Keefe and S. C. Loeb. USDA Forest Service, Southern Research Station, Clemson, SC

Little information exists about the effects of fire on Indiana bat (*Myotis sodalis*) roost habitat. Studies in the southern Appalachians, where fire is an important restoration tool for oak-pine forests, have shown that Indiana bats selectively roost under sloughing bark in tall, low decay conifers (typically yellow pines) on upper and middle slopes. We measured snag availability, characteristics (species, height, dbh, and decay measures), and the effects of prescribed fire on snags in the southern Appalachians. In winter 2009–2010, we located mature stands with a conifer component, searched stands for dense snag patches, and measured ≥40 snags and all live trees in 23 variable size plots on lower, middle, and upper slopes. Temperatures were measured in nine plots that received prescribed fire (hand or aerial ignition) in Spring 2010; these plots were reassessed post-burn. Snag characteristics were compared with known Indiana bat maternity roosts (n = 50, 1999–2010) from the same region. Of 1063 snags, 75.3% were yellow pine, 12.2% were white pine, 6.4% were hemlock, and 6.1% were hardwoods. Pine snags were shorter and more decayed than known roosts, while hemlock snags were taller and less decayed than known roosts ($P < 0.0001$). Known roosts and yellow pines had 25–28% bark remaining, while white pines and hemlocks had significantly more bark (58–96%). Fire temperature and effects on snags varied with weather, ignition method, and slope position; snags were mainly lost on upper slopes, with lesser effects on midslope and lower slope snags. Although yellow pine snags are abundant in pine-hardwood forests, most will soon be too decayed to be suitable for roosting and recruitment of yellow pine snags is low. Though prescribed fire could be a critical management tool for restoration of yellow pine forests, managers must consider the potentially negative short-term effects of fire on snag populations.

The Role of *Artibeus jamaicensis* and *Brachyphylla cavernarum* in the Dispersal of Seeds with Emphasis on the Endangered *Stahlia monosperma*, Leguminosae, in Puerto Rico

Wilkins Otero, Armando Rodriguez-Duran, Elson Viruet, and Eugenio Santiago-Valentin. Universidad Interamericana, Recinto de Bayamon, Bayamon, PR; Botanico, Universidad de Puerto Rico, Rio Piedras, PR

In this preliminary report we present data on the diet and activity of the phyllostomid bats *Artibeus jamaicensis* and *Brachyphylla cavernarum*, as well as on food choice experiments performed with the endangered tree *Stahlia monosperma*. Mist nets were set for two consecutive nights each month from December 2008 through July 2010 as part of an ongoing project. Mist nets remain open for a period of four hours from sunset. Bats are removed from the nets and placed in cloth bags to collect feces. In addition, we release bats in a flight cage, where they are presented with two food choices with the purpose of assessing their role in the dispersal of *S. monosperma*. The distribution of *S. monosperma*, an endangered tree for which no dispersal vector is known, is restricted to a few locations around the island of Puerto Rico and eastern Hispaniola. It has been speculated that bats or land crabs might be the dispersal vector, that the extinct echimid rodents could have been the dispersal vector, or that the tree is thalassochorous rather than zoochorous. *Artibeus jamaicensis* and *B. cavernarum*, commonly carry fruits about the size or larger than those of *S. monosperma*. Our preliminary results reveal that when presented only with *S. monosperma*, bats will feed on the fruits. When presented with a choice, B. cavernarum will on occasions select *S. monosperma*. However, both species of bats show a strong preference for the introduced Mango (*Mangifera indica*), and commonly feed on fruits from the family Piperaceae. The activity of *A. jamaicensis* appears to correlate with increased fruit set in the area, *B. cavernarum*, on the other hand, shows a more erratic activity. The fact that some bats will carry and feed on the fruits of S. monosperma has important implications for the conservation of this endangered species.

Fatty Acid Metabolism and Lipid Transport by *Geomyces destructans*

Evan Pannkuk, David Gilmore, Ellis Benjamin, Earl Benjamin, and Thomas Risch. Arkansas State University, Jonesboro, AR

White-nose Syndrome (WNS) is a fungal disease associated with *Geomyces destructans* and is decimating cave dwelling bats in North America. Bat species' are risking extinction and the rapid spread of the disease leaves little time to find a cure. One of the symptoms of WNS is an increase in the number of times bats exit and enter torpor, which leads to emaciation and death. Polyunsaturated fatty acids, specifically linoleic and α-linolenic acid, are important for inducing mammalian torpor. Bats heavily affected by WNS have been shown to exhibit different amounts of linoleic and α-linolenic acid in their white adipose tissue. In order for *G. destructans* to be pathogenic to bats it must survive on the pelage of the host. Dietary fatty acids can be excreted through sebaceous glands onto the bat integument and provide vital carbon sources for fungal metabolism. Our study shows that *G. destructans* is unable to metabolize linoleic acid as a sole carbon source but readily metabolizes α-linolenic acid. If bats differ in their relative ratios of fatty acids this may play an important role in species specificity to WNS and bat survival. We also show that fluorescent dyes with hydroxyl groups can go through a Fisher esterification with the carboxylic end of fatty acids. When fatty acids have been fluorescently tagged they can be used to image lipid transport in fungal cells. This research provides vital evidence on the metabolic fate of essential nutrients to the fungus. Finally, if *G. destructans* cannot utilize specific compounds this research could lead to topical prophylactics to slow down the spread of WNS.

A Review of Factors Affecting Cave Temperature and Implications for White-Nose Syndrome

Roger W. Perry. Southern Research Station, Forest Service, U.S. Department of Agriculture, Hot Springs, AR

Geomyces destructans, the fungus likely responsible for white-nose syndrome (WNS) in bats, is cold-loving and grows optimally between 5 and 10°C; its growth is marginal above 15°C and it generally does not grow above 20°C. Consequently, temperatures of hibernacula may potentially affect the southward spread of this disease. Here, I review factors that determine temperatures of caves and mines. In the absence of other factors such as air flow, temperature of caves and mines approximate the mean annual surface temperature (MAST) of the area. However, temperatures in many caves and mines deviate from MAST. These temperature deviations result from differences in aspect, elevation, geothermal processes, radioactive decay, water flow, and air flow. In most caves, air flow is primarily responsible for deviations in cave/mine temps from MAST. Air flow in caves and mines results

from direct flow, the venture effect, thermal convection, the chimney effect, and barometric pressure changes. In caves/mines with little air flow, cold air sinks and warm air domes can occur. Thus, large, complex caves/mines can have many different thermal environments, and potential southern limits to spread of WNS based on MAST are complicated by physical structure that makes individual caves/mines deviate from MAST during winter. Furthermore, many bat species may actively select the coldest caves in an area based on these thermo-structural conditions.

The Relationship between Clutter Orientation and Bat Activity in Forest Canopies and Edges

Thomas W. Pettit and Kenneth T. Wilkins. Department of Biology and Graduate School, Baylor University, Waco, TX.

Bat biologists have long recognized a strong inverse relationship between bat activity and vegetative clutter. However, few have investigated the relationship between clutter orientation and bat activity. We sampled bat echolocation activity in forest edges and canopies in aspen (*Populus tremuloides*) forests in north-central Utah during four summer field seasons (2006-2009). We compared bat activity levels to clutter orientation (as indicated by slope of edge structure, or the degree of physical edge contrast), along with several common measures of vegetative clutter, including diameter at breast height (DBH), stem density per unit area, canopy base height (CBH), etc. Forestry metrics were compared both to general bat activity and to species-level or echolocation-call-guild-level activity. Strong correlations were discovered between clutter orientation (slope of the edge) and general bat activity levels, exposing a positive relationship between clutter orientation and bat activity levels in aspen forest edges. Results highlight the importance of edge structure in our understanding of bat habitat use.

Between a Rock and a Hard Place: Impact of Anthropogenic Disturbance on Cave-roosting Bats

Kendra L. Phelps and T. Kingston. Texas Tech University, Lubbock, TX

In Southeast Asia, limestone outcrop (karst) formations represent critical areas for biodiversity, with high levels of species richness and endemism due to their isolated distribution and rugged terrain. Solution caves formed within karst formations are of inherent importance to cave-roosting bats, providing secure shelter from adverse weather and predators, and for roosting and rearing young. Tragically, cave-roosting bats are being threatened by anthropogenic activities at karst formations, most directly by the destruction of roosting sites by commercial quarrying operations. Forest conversion for urban and agricultural expansion has resulted in the loss of suitable foraging habitats. Thus, this study seeks to document assemblage characteristics of cave-roosting bats in peninsular Malaysia, a landscape experiencing rapid anthropogenic modification, in order to determine the significance of specific karst formations to bat conservation. With approximately 50 cave-roosting bat species, peninsular Malaysia is a biodiversity hotspot within Southeast Asia. Surveys conducted during June-August 2009 at a karst formation, Kota Gelanggi, in central peninsular Malaysia documented 20 species, 4 species of Old World fruit bats and 16 insectivorous species, at 6 caves within this single karst. A total of 18 species were captured utilizing standard trapping methods (i.e., harp traps, mist nets) and 7 species were identified using acoustic monitoring methods. Our samples represent approximately 20% of all bat species found in peninsular Malaysia; however, surveys at additional karst formations, particularly those experiencing a range of disturbance levels, is needed in order to make comparisons. Ultimately, data resulting from this study will provide fundamental information for monitoring cave-roosting bat assemblages in relation to surrounding anthropogenic activities, and enable us to devise effective conservation policies for karst protection.

Feeding Activity as a Measure of Habitat Quality for the Hawaiian Hoary Bat

Corinna A. Pinzari, Brad R. Yuen, P. Marcos Gorresen, and Frank J. Bonaccorso. Hawai‘i Cooperative Studies Unit, University of Hawai‘i at Hilo, Hawai’i National Park, HI; U.S. Geological Survey, Pacific Island Ecosystems Research Center, Hawai‘i National Park, HI.

The Hawaiian hoary bat (*Lasiurus cinereus semotus*), or ‘Ope‘ape‘a, is Hawai‘i’s only extant native land mammal. It is listed as endangered by the U.S. Fish and Wildlife Service and the state of Hawai‘i. As part of the recovery plan for the species, the U.S. Geological Survey is conducting a five-year echolocation monitoring study across Hawai‘i Island to assess its distribution and habitat requirements. An essential component of the study is assessing the quality of various habitats and their importance for the bat. We have examined echolocation data to generate maps of bat activity at study sites as one measure of habitat quality. However, echolocation data that

encompasses orientation calls, search phase calls, and flybys may not necessarily be good indicators of habitat quality. By focusing specifically on feeding buzz calls (short bursts of echolocation pulses with rapid repetition rates emitted prior to prey capture), we are better able to identify high quality foraging habitat. We examined the occurrence of feeding buzzes at four sites on windward Hawai‘i Island at different elevations in comparison to overall bat activity. The proportion of feeding buzzes to search phase calls varied widely by site and time of year and only a small percentage (<5%) of total bat calls were feeding buzzes. We demonstrate the utility of identifying feeding buzzes (in addition to other bat calls) to produce a more accurate representation of habitat quality for conservation and land management decisions.

Monastic *Myzopoda*: The Foraging and Roosting Ecology of a Sexually Segregated Malagasy Endemic Bat
Mahefatiana Ralisata. University of Antananarivo, Madagascar

The Myzopodidae is endemic to Madagascar and represented by two species, *Myzopoda aurita* in the east and *M.schliemanni* in the west. Because few have hitherto been caught, little is known about the ecology of either species although on the basis of a single observation, H. Hoogstraal reported *M.aurita* roosting in the partially unfurled central leaf of the Traveller's tree *Ravenala madagascariensis*. The discovery of a population of *M.aurita* at an agricultural extension station at Kianjavato, southeastern Madagascar allowed an ecological study to be planned. All 138 bats mist-netted on trails in secondary forest were males, 18 of which were radio-tracked. The areas individual bats used for foraging varied between 7 and 108 ha. Bats foraged close to their roosts for the first hour after emergence, then travelled up to 1.8km away. Compositional analysis revealed that they selected coffee plantations, degraded humid forest and wooded grassland more than any other habitats. All 133 roosts located consisted of the partially unfurled leaves of *R.madagascariensis* and housed between nine and 51 individuals. Bats changed roosts every 1–5 days. No ectoparasites was found on any bats. Their diet comprised mainly of Lepidoptera (79%) and Coleoptera (12%), with a significant variation of these orders between seasons. Because *R.madagascariensis* is characteristic of secondary forest, *M.aurita* is one of the few mammals endemic to Madagascar that is not threatened by deforestation, although it may be affected by loss of roosts for building materials. The searches for females continue.

Population genetic structure of the lesser long-nosed bat (*Leptonycteris yerbabuenae*) in Arizona and Mexico
Judith Ramirez and Melanie Culver. School of Natural Resources, The University of Arizona, Tucson.

The lesser long-nosed bat *(Leptonycteris yerbabuenae)* is a nectarivore and a migratory bat, were Females mate in southern Mexico, and migrate to maternity roosts in northern Mexico and southern Arizona to give birth. There are two possible migration corridors: bats that occupy southeastern Arizona roosts arrive in July through the inland panniculate agave corridor and bats that occupy the southwestern Arizona maternity roosts are more likely to arrive and depart through the coastal lowland Mexico corridor, rather than moving between corridors. However, it has been suggested that there may be a connection between the southwestern and the southeastern Arizona roosts, which could indicate that bats are moving between the two proposed migration corridors. Our objectives for this project are to develop novel microsatellite DNA markers for the lesser long-nosed bat, and use these markers to determine if significant gene flow occurs between southwestern and southeastern Arizona roosts as well as throughout the migratory corridor between Mexico and the United States. Currently, we have developed 12 polymorphic microsatellite DNA markers, sampled five different roosts in AZ, five different roosts in Sonora, Mexico, three different roosts in Baja California Sur, Mexico and one roost in Chamela, Jalisco, Mexico. We have captured and sampled 486 bats and extracted DNA successfully from all 486 bats. At present we have a few preliminary results. These show that the Arizona roosts belong to a single population, indicating that bats are moving between the two proposed corridors, that is bats in maternity roosts in western Arizona are likely to be the same bats that are found in eastern Arizona during the early fall.

Identification and Characterization of Swarming Sites Used by Little Brown and Northern Long-Eared Bats in Nova Scotia
Jennifer Randall and Hugh Broders. Dalhousie University, Halifax, Nova Scotia; Saint Mary's University, Halifax, Nova Scotia

With the imminent threat of white-nose syndrome (WNS), there is a pressing need for baseline population data in regions not yet affected by the pathogen, such as the province of Nova Scotia. There are records of hundreds

of abandoned mines and caves in Nova Scotia, many of which have the potential to be important overwintering resources for bats. However, few have ever been surveyed for bat activity. An inventory of swarming and hibernation sites will be important in understanding the spread of the fungus associated with WNS and in implementing any monitoring and management initiatives. During the autumn swarming period of 2010, surveys of abandoned mines and caves in Nova Scotia are being conducted to determine which are important swarming (and thus likely hibernation) sites for *Myotis lucifugus* (little brown bat) and *M. septentrionalis* (northern long-eared bat). In addition, local and landscape external characteristics, as well as any known internal characteristics (depth, etc), are being measured in order to explain differences between used and unused sites. These results will facilitate predictions about the likelihood of there being other sites of interest in the province. This poster will discuss preliminary results and implications of this research.

Patterns of Fat Accumulation and Depletion in Little Brown Myotis Affected by White-nose Syndrome

Jonathan Reichard, Marianne Moore, Catherine Kang, Lucille Nichols, Timothy Murtha, and Thomas Kunz. Center for Ecology and Conservation Biology, Boston University, Boston, MA

Loss of critical fat reserves during hibernation is a leading hypothesis for proximate cause of death for bats affected by white-nose syndrome (WNS). We used destructive body composition analysis to quantify changes in fat reserves in little brown myotis (*Myotis lucifugus*) during prehibernation and hibernation at affected and unaffected hibernacula to test the following hypotheses: 1) bats at affected sites do not deposit sufficient fat reserves in autumn; 2) bats at affected sites deplete fat reserves prior to entering hibernation; and 3) bats at affected sites deplete fat reserves prematurely during hibernation. A subset of bats was tested for aspects of immune response. Although bats at Aeolus Cave in Vermont (affected) deposited similar total body fat (TBF) in autumn 2008 compared to 1976, TBF in late autumn was lower in adult bats at affected sites than at unaffected sites. In early winter, mean percent body fat at unaffected sites (28.1% and 24.9% for adult females and males, respectively) was significantly greater than at affected sites (20.1% and 19.4% for adult females and males, respectively). At Aeolus Cave, mean percent body fat of adult bats declined from 17.1% in early winter to 8.9% and 5.5% in mid- and late-winter, respectively. For juvenile bats, mean percent body fat declined from 18.0% in early winter to 7.7% and 7.0% in mid- and late-winter, respectively. Bats swarming at WNS-affected sites appear to deposit sufficient fat reserves during autumn, but fat decreased more rapidly at these sites compared to unaffected sites. At affected sites, hibernating bats appear to reach critically low fat reserves by midway through the hibernation period. Body composition was significantly correlated with immune function to varying degrees depending on WNS-status and the type of response. Thus, fat reserves are likely to impact a bat's ability to maintain effective immune function.

The Behavioral Function of Social Calls in the Migratory Hoary Bat *Lasiurus cinereus*

Gabriel Reyes and Joseph Szewczak. Humboldt State University, Arcata, CA

The hoary bat *Lasiurus cinereus* is a migratory tree-roosting bat that has been experiencing high rates of mortality at wind energy development sites during the fall migration/mating season. Seasonally variable social and behavioral factors may contribute to the susceptibility of hoary bats to turbines, and understanding these factors may be vital for the development mitigation strategies. This study aims to 1) determine how hoary bats respond to conspecific social call broadcasting, and if these responses are seasonally variable, 2) assess the effectiveness of using acoustic lures to aid in the study of hoary bats, and 3) describe social call behavior in hoary bats. We are broadcasting social calls through an ultrasonic transducer (Binary Acoustic Technologies AT800) at sites located near known flyways and water sources, placed in locations to minimize incidental captures. Each trial runs for one hour and consists of half and hour of broadcasting and a half an hour of silence. We are capturing approaching bats using mist nets and filming trials with infrared cameras. Additionally we are using mist nets and bat detectors (Pettersson D240X) to assess bat activity in proximal flyways and record hoary bat social vocalizations. This is a summary of preliminary results from fieldwork conducted in the Sandia and Jemez Mountains of New Mexico during May and June 2010. During trials, 22 hoary bats were captured during call playback, and only 2 during control, suggesting that hoary bats are attracted to conspecific social call broadcast. In addition we present a quantitative descriptive analysis of hoary bat social calls. We are continuing fieldwork during the fall migration in both New Mexico and California. Examining seasonal variation in hoary bat social behavior may provide insight into both the underlying causes of mortality at wind energy sites, and the natural history of this elusive species.

Re-Evaluating the Role for Banding in the Population Biology of Bats

D. Scott Reynolds, Eric Britzke, and Susan C. Loeb. St. Paul's School, Concord, NH; US Army Engineer Research and Development Center, Vicksburg, MS; and Southern Research Station, Clemson, SC.

Understanding the demographics of long-lived and highly mobile species requires long-term research and coordination across wide geographic areas. For bats, one critical tool is this research has been the use of wing bands. Although most of the information we have on bat movements, longevity, and migratory activity comes from mark-recapture data collected from banding efforts, a concern about banding injuries has resulted in very limited banding over the last thirty years. In light of conservation issues that require knowledge of bat movement patterns and demographics (such as wind-related bat mortality and White-Nose Syndrome), it may be time to look back on the 1972 moratorium on banding and re-evaluate whether large-scale banding research could provide some of the valuable information we need to confront these novel threats to bat populations. A review of the historic banding injury data suggests that much of the population-level impact of banding was due to the methodology and not to direct injury. A comparison of several different bands used on little brown myotis (*Myotis lucifugus*) over the last twenty years suggest that new metal alloy lipped bands have substantially lower injury rates compared to older bands and recent studies have proven the value of banding for collecting data on population demographics and migration patterns that are critical for the surveillance of WNS and the ultimate population recovery. Although banding and other marking techniques are not risk-free, the data gathered using these techniques may be worth the risk if they contribute significantly to the conservation biology of species.

Riparian Trees Big and Small - Day Roost Selection by *Noctilio* in a Costa Rican Dry Forest Mosaic

Jody Rintoul, Kyla Kotchea and Doris Audet. University of Alberta, Augustana Campus, Camrose AB

In spite of greater bat species diversity in tropical forests, most work on forest and tree characteristics that are favorable to bats has been conducted in temperate forests. As part of a study of the bat fauna in the Taboga reserve and surrounding area, we located and characterized the roosts used by five radio-tagged *Noctilio* (3 *N. albiventris* and 2 *N. leporinus*) during an undergraduate field course in February 2009. We also surveyed the area for potential roosts based on those characteristics and evaluated long term roost use by the two species using data collected from a total of 12 bats (7 *N. albiventris* and 5 *N. leporinus*) radio-tagged between 2005 and 2009. As in previous years, all *Noctilio* roosts were located within 50 m of water and of the seven roost trees that were identified since 2005, four were occupied by bats tagged in 2009, indicating long-term roost occupancy. Four of the roosts were in *Terminalia oblonga* with relatively small trunk diameter (dbh $\leq$ 0.8 m compared to 1.2 – 2 m for the other roost tree species), growing near water and forming extensive cavities that extend to the smaller branches. Those cavities provided significant buffer from the high daytime temperatures ($t = 3.27$, $p = 0.01$; mean outside T^{o}_{max} = 37.6 $\pm$ 5.5 vs mean inside T^{o}_{max} = 33.2 $\pm$ 2.1 ^{o}C). The substantial use of *Terminalia* suggests that in spite of its moderate size, this tree may be an important resource for the *Noctilio* species which each represented about 5% of bat captures in the area. Our results also suggest that large size of trees based solely on their diameter is not a sufficient indicator of the conservation potential of tropical forest fragments for bats.

How do Bats Modulate Thrust and Lift Production During Flight?

Daniel K. Riskin, J. Iriarte-Díaz, K. M. Middleton, K. S. Breuer, and S. M. Swartz. City College of the City University of New York, New York, NY; The University of Chicago, Chicago, IL; California State University San Bernardino, San Bernardino, CA; Brown University, Providence RI

Most studies of bat flight kinematics focus on the changes in wing motion that occur along the gradient between slow and fast flight. In this study we investigated changes associated with horizontal and vertical accelerations, which relate to changes in thrust and lift production, respectively. We studied five flights each from 27 individual bats among six pteropodid species, ranging in mass from a 28 g *Cynopterus brachyotis* to a 1,152 g *Pteropus vampyrus*. In each flight, 17 anatomical points were tracked through a wingbeat cycle at 1000 frames per second in three dimensional space, for a total of 135 wingbeat cycles. Using multiple regressions, we isolated the influences of horizontal speed, horizontal acceleration, and vertical acceleration on wing kinematics for each species. We found that increases in thrust were associated with increased downstroke wing extension, increased wingbeat amplitude, increased angle of attack, and decreased stroke plane angle. Increases in lift production were associated with increased wing extension, increased angle of attack, increased wingbeat frequency, and increased

wing camber. Our results demonstrate that kinematic changes with horizontal and vertical acceleration are consistent among pteropodid bats across a 41-fold range in body masses, and thus provide robust insight into the manner by which bats modulate aerodynamic force production during flapping flight.

Passive Acoustic Monitoring to Determine Pre-WNS Community Structure

Lynn Robbins, Benjamin Hale and C. Ryan Allen. Missouri State University, Springfield, MO

Permanently mounted solar powered Anabat detectors are presently collecting data in Missouri near three gated caves with large summer and winter concentrations of species known to be susceptible to WNS including two species of endangered *Myotis*. Comparisons of nightly, weekly, monthly, and seasonal data on species composition, relative abundance, and overall activity will be presented in terms of describing and predicting changes that may occur in community structure. Results of species composition from one location in July 2010 showed variation when daily, weekly and monthly data were compared. These temporal differences resulted in 416 calls on July 4th, 2,988 calls during the week of July 4th - July 11th and 11,256 calls during the entire month of July. Species percentages from one day, one week and one month were as follows: *Eptesicus fuscus* (0.7, 0.3, 0.6), *Lasiurus borealis* (13.0, 7.7, 8.3), *Lasiurus cinereus* (0.5, 0.2, 0.3), *Myotis grisescens* (12.9, 11.7, 15.4), *Myotis lucifugus* (2.2, 4.0, 3.8), *Myotis septentrionalis* (1.0, 0.7, 0.8), *Myotis sodalis* (3.4, 4.9, 5.0), *Nycticieus humeralis* (2.2, 3.5, 3.3), *Perimyotis subflavus* (56.5, 62.1, 55.6). These results indicate that population distribution within an area change not only among sampling periods but within sampling periods. Although WNS was found in two species in Missouri in the spring of 2009, no mortality was observed. It is hoped that the data collection that began in April represents pre-WNS community structure.

Lessons from Mom: Maternal Investment of *Ectophylla alba* in Costa Rica.

Bernal Rodríguez-Herrera, Karina Montero and Rodrigo Medellin. Tirimbina Biological Reserve, Sarapiquí, Costa Rica; Escuela de Biología, Universidad de Costa Rica; Instituto de Ecología, Universidad Nacional Autónoma de México, México D. F.

We describe and quantify maternal investment of the tent-making bat, *Ectophylla alba*, to determine if maternal investment is the same throughout the development of the offspring. We worked in Tirimbina Biological Reserve, Sarapiquí, Costa Rica, and recorded with video and infrared lights the nocturnal behavioural of a group (2 males, 2 females and their offspring) during 2 different periods: the lactation period (9 nights) and the fledging period (8 nights) (204 hrs total). We analyzed the first 10 minutes of the behavior of each individual each night they spent at least 30 minutes in the tent. We defined three behavioural categories: self-grooming, female grooming towards the offspring, and lactation. We analyzed a total of 910 minutes (91 visits) in which one female made 45 visits and the other female made 46 visits. We found the females spent more time in the tent than the males during both periods. We found no difference in the presence of lactating behaviour (G=0.51, d.f=1, p=0.48) or grooming behaviour (G=0.94, d.f=1, p=0.57) between periods. We made two uncommon observations that demonstrate a learning process of feeding the offspring: one female nursed both pups simultaneously (from different mothers), and another instance in which the mothers bring their offspring *Ficus* fruits to eat a few days before fledging. Our results indicate that mothers invest a considerable amount of time in raising the pups, also they teaching their young to feed.

Dietary Analysis of the Antillean Ghost-Faced Bat (*Mormoops blainvillii*) and Sooty Mustached Bat (*Pteronotus quadridens*) using PCR and Various Preservation Techniques

Ashley K. Rolfe. Eastern Michigan University, Ypsilanti, MI

The Antillean ghost-faced bat (*Mormoops blainvillii*) and Sooty mustached bat (*Pteronotus quadridens*) are insectivorous members of the Mormoopidae that are endemic to the Greater Antilles. Newly developed molecular approaches, such as the use of polymerase chain reaction (PCR), provide the opportunity to analyze the diet of bats in more detail than conventional dietary analysis by targeting the DNA of trace materials found within feces. Bats were captured at the Mata de Plátano Field Station, located ca. 7 km SW of Arecibo, Puerto Rico. Feces collected in the field was preserved in one of three ways: air dried and stored in individual Ziploc bags, placed in individual vials with ca. 2 ml of 95% ethanol, or placed in individual vials with ca. 2 ml of lysis buffer. All samples were frozen at -20 C within 2 hours of collection regardless of preservation method. DNA was later isolated from ca. 900 insect fragments taken from the fecal pellets. The isolated DNA was used to amplify a 648-bp target region of the mitochondrial cytochrome oxidase *c* subunit 1 (COI) gene using robust forward and reverse primers and was

unidirectionally sequenced using the forward primer. COI sequences recovered from fragments of insects will be compared with the reference database from the Barcode of Life Data Systems (BoLD) to provide species-specific identification of the insects within the diet of the *M. blainvillii* and *P. quadridens*. The percent yield of identified prey species from each of the three preservation techniques will be compared using t-tests.

Effects of Take on the Indiana Bat (*Myotis sodalis*) Population at a Proposed Wind Energy Facility

Shannon E. Romeling, Ryan Allen and Lynn W. Robbins. Missouri State University, Springfield, MO.

Methods for determining allowable Indiana bat Take for an Incidental Take Permit (ITP) are still in their beginning phases. We developed a method of estimating the long term effects of Take on a closed population of Indiana bats using the little brown bat (*Myotis lucifugus*) as a surrogate and Lefkovitch Matrix Models to estimate growth rates. Jain (2005) demonstrated a 54.5% decrease in turbine related mortality of little brown bats versus relative acoustic activity. Using this number and estimated yearly Take per Megawatt from three geographically similar wind farms, potential Indiana bat mortality was calculated for a proposed wind farm site. In 2009, a mist netting and radio telemetry study at the proposed site determined the presence of a minimum number of female Indiana bats during maternity roost counts within or adjacent to the project area. Three sets of demographic information were used to produce a range of potential growth rates for this Indiana bat population. These three growth rates along with five potential Take numbers (range = 0-11.6 Indiana bats/500 MW/year) were used in effect analyses to produce 540 scenarios. The effect analysis equation estimated the population size over 30 years using the three growth rates and took into account dependent young, additive mortality and recruitment. Of the 432 scenarios involving Take, 75% resulted in reduction in size or extinction of the population within 30 years. Assuming this population is viable, the 108 scenarios involving zero Take showed this population has growth rate and recruitment values above the line $Y=-330.97X + 431.24$, $R^2=0.999$, resulting in growing or stable populations 68% of the time. The methods used to conduct effect analyses and the resulting information gained are repeatable and can be used in the ITP process to make the best possible decision for the future of an endangered species.

Is conservation genetics a waste of time? A power analysis of genetic population monitoring

Amy L. Russell and Maarten J. Vonhof. Grand Valley State University, Allendale, MI; Western Michigan University, Kalamazoo, MI

The monitoring of genetic diversity has become an important tool in conservation biology, with the loss of diversity at neutral loci being used as a proxy for the loss of individuals. Furthermore, corresponding decreases in genetic diversity at coding regions may lead directly to a loss of evolutionary responsiveness or cause detrimental effects from inbreeding in threatened species. While genetic data may provide a means of monitoring populations particularly when traditional mark-recapture methods are unsuitable, the utility of genetic tools under specific models of population decline have not been fully explored. Are we, under some circumstances, asking more of a genetic-based monitoring approach than it can deliver? I used coalescent-based simulation analyses to determine the efficacy of genetic data as a monitoring tools for short-term population declines. Specifically, I addressed several questions: (1) which type of molecular marker (DNA sequence data vs. microsatellite genotypes) responds more quickly to population declines?, (2) over what time spans do population declines become statistically detectable?, (3) how does population structure affect our power to detect population declines?, and (4) which analytical tools are most useful for detecting population declines? These questions are addressed using biologically realistic population parameters from two species recently of conservation concern in North America, eastern red bats (*Lasiurus borealis*) and little brown bats (*Myotis lucifugus*).

Is social structure amenable to fixation of chromosomal rearrangements? Perspectives from the Peter's tent-roosting bat, *Uroderma bilobatum*

Maria Sagot, Caleb Phillips, Richard D. Stevens and Robert J. Baker. Department of Biological Sciences, Louisiana State University, Baton Rouge, LA; Department of Biological Sciences, Texas Tech University, Lubbock TX

Closely related mammalian species often differ karyotypically due to fixation of chromosomal rearrangements. Heterozygotes for rearrangements tend to be the least fit; therefore, the mechanism for fixation is unclear. It has been proposed that small and inbred social groups are necessary to promote these high rates of chromosomal evolution found in mammals. However, this hypothesis lacks empirical evidence and the role of molecular factors and positive selection driving chromosomal evolution has been overlooked. In the tent-roosting

bat, *Uroderma bilobatum*, three chromosomal races have been described. In this species there is low genetic divergence between races and two hybridize, making this a suitable system to test proposed mechanisms leading to fixation of chromosomal races. If small isolated demes are required to fix chromosomal rearrangements, we expect to find social groups formed from single matrilineal lines. To test this hypothesis, we sequenced the cytochrome-b gene from 10 social groups of *U. bilobatum* captured from their roosts to determine the number of matrilineal genealogies present. We found that groups are composed by multiple matrilineal lines, implying that female assemblages are likely comprised of individuals that are not closely related and that female dispersal occurs among tents. Population sizes do not appear to be amenable to fixation of detrimental chromosomal rearrangements simply as a byproduct of demography and breeding structure. Our study will help to illuminate mechanisms that lead for fixation of different rearrangements and speciation in mammals.

Metabolic Rates of *Brachyphylla cavernarum* and *Stenoderma rufum* in Puerto Rico

Jean M. Sandoval and Armando Rodriguez-Duran. Universidad Interamericana, Department of Natural Sciences, Bayamon, PR.

We provide data on metabolic rate for two species of neotropical bats, *Brachyphylla cavernarum* and *Stenoderma rufum* (Phyllostomidae) endemic to the West Indies. Despite its abundance on the island of Puerto Rico, relatively little is known about the biology of *B. cavernarum*. *Brachyphylla cavernarum* is known to roost in the frigidarium and tepidarium of caves. *Stenoderma rufum,* an endemic to the Puerto Rican Bank, is one of the least abundant species within its range. It is known to roost, among others, in trumpet tree, bullet wood, and sierra palms, solitary or in small groups. We measured oxygen consumption of 38 *B. cavernarum* and two *S. rufum*. The estimated basal metabolic rate (BMR) averaged 1.53 $O_2g^{-1}hr^{-1}$ for *Stenoderma rufum*, which for a 20 g eutherian mammal is 85% of the predicted value. At 1.01 $O_2g^{-1}hr^{-1}$, the BMR of *Brachyphylla cavernarum* is 78% of the predicted value for a 45g eutherian mammal. Both species conform to the pattern of lower than expected metabolic rates for insular mammals.

Monitoring of Microclimate Within Three Abandoned Railway Tunnels Used by Bats in Western Maryland

Jennifer Saville, and J. Edward Gates, Biology Department, Frostburg State University, Frostburg, MD; University of Maryland Center for Environmental Sciences, Appalachian Laboratory, Frostburg, MD

Three abandoned Western Maryland Railway tunnels (Indigo, Stickpile, and Kessler)located in the Chesapeake and Ohio Canal National Historical Park are currently serving as hibernacula for several bat species. Indigo, the longest tunnel, receives high use by bats and is the largest hibernaculum in Maryland for the very rare and state-endangered *Myotis leibii* while the other 2 tunnels are much shorter and are used by fewer bats. To better understand how these tunnels function as hibernacula, environmental conditions (including ambient temperature, surface temperature, and relative humidity) were measured every 4 hours throughout the tunnels from summer 2008to summer 2010. Because surface temperature is thought to be an important, but difficult to measure, factor in roost selection, data loggers measuring both ambient and surface temperature were employed to determine whether ambient temperature can be used as a predictor of surface temperature. Preliminary results will be discussed.

Utility of passive acoustic monitoring to conduct surveillance for White-Nose Syndrome

Michael R. Schirmacher, Eric Britzke, Cal Butchkoski, Ed Arnett, and Mylea Bayless.
Bat Conservation International, US Army Engineer Research and Development Center, Pennsylvania Game Commission

Interior surveys of hibernacula are likely the most effective method of White-Nose Syndrome (WNS) surveillance; however, possibility of human transmission, increased disturbance to hibernating bats, and/or the large number of hibernating sites serves to easily overwhelm resource managers. As early reports documented abnormal activity levels at hibernacula entrances, we investigated the ability of Anabat II detectors to detect differences in bat activity levels at WNS symptomatic (infected) and asymptomatic (assumed WNS-free) hibernacula. We deployed Anabat systems from 21 December 2009 to 13 April 2010 to automatically record bat activity at 7 hibernacula (3 - second-year infected sites, 2 - first-year infected sites (one only PCR confirmed), and 2 - asymptomatic sites). Second-year WNS sites showed higher activity than both first-year and asymptomatic sites. Additionally, mean daytime activity was lower for asymptomatic sites than the other 2 groups. While more data is needed on the

relationship between the degree of WNS infection and activity rates, acoustic monitoring appears to offer a non-invasive, effective, and affordable approach for WNS surveillance.

A Transcriptome Approach for Studying Immune Responses in Jamaican Fruit Bats

Tony Schountz, Ann Hawkinson, and Rick Adams. University of Northern Colorado, Greeley, CO

Tacaribe virus (TCRV) was first isolated from *Artibeus* spp. bats with a fatal disease resembling rabies in Trinidad. The virus is a member of the family *Arenaviridae* and is closely related to the viruses that cause the South American hemorrhagic fevers, although it is not known to cause serious human disease. Arenaviruses with known hosts are rodent-borne with the exception of TCRV, which has only been repeatedly isolated from Jamaican fruit bats (*A. jamaicensis*) and great fruit-eating bats (*A. lituratus*). However, it is unknown if these species are natural reservoirs of TCRV or if the bat infections were incidental. We have experimentally demonstrated that TCRV can cause dose-dependent fatal disease or persistent infection in Jamaican fruit bats and we are now developing genomic reagents and cellular methodologies for studying the immune response to infection. We are currently sequencing and processing hundreds of thousands of cDNAs representing transcriptomes of activated T cells, B cells and mononuclear cells, poly-IC-induced primary kidney cells, and several other organs for use in constructing immunoarrays. We will use these arrays to identify pathways involved in pathogenic and non-pathogenic immune responses in bats infected with TCRV.

Philippine Cave Bats in Crisis? An Assessment of Cave Bats on Siquijor Island

Jodi L. Sedlock, and Rai K. S. Gomez, Lawrence University, Appleton, WI; Philippine Biodiversity Conservation Foundation, Bacolod City, Philippines

Currently 76 species of bats are recognized in the Philippines, and more are likely to be described. Approximately one third of these are particularly vulnerable because of their need for caves. Despite their formal protection through the government's Cave Act, many are heavily disturbed by swiftlet nest gathering, treasure hunting, guano collecting, and mineral mining. Over the past few years, we have begun to collate existing data on cave bats nationally and conduct field surveys in key karst areas to better assess the problem. Between 18 June and 5 July 2010, we conducted an assessment of 20 large caves on Siquijor Island, a small (343.5 km^2) karst-covered island in the central Philippines. Trapping and mist netting in forest resulted in the capture of 19 species, including 13 cave-dwelling bats. We used visual and acoustic methods to survey bats in caves. Thirteen caves had insect-bat populations; however, only four caves had relatively large (> 100 individuals) colonies. Only 5 of the 20 large caves had fruit bats (*Rousettus* sp. or *Eonycteris* spp.) present and of these, only two had large populations. Despite the low numbers of bats present, we observed large (i.e., > 50 m^2) areas of staining in 10 caves indicating formerly large populations. Interviews with locals revealed that bats were collected for food throughout the island. Low species richness, small cave bat populations, and the conspicuous absence of fruit bat colonies and other, less common, cave-associated insect bat species such as *Rhinolophus rufus* distinguish Siquijor from other less disturbed karst areas in the Philippines. The apparent decline of cave-dwelling bats in Siquijor and other areas may mean not only a decline in biodiversity, but in the ecosystem services they provide as pollinators, seed dispersers and consumers of crop pests.

The relationship between wing morphology and bite force in a species-rich bat assemblage from Malaysia

Juliana Senawi and Tigga Kingston. Universiti Kebangsaan Malaysia, Bangi, MALAYSIA.
Texas Tech University, Lubbock, TX.

Wing morphology has a clear relationship with ecological and behavioral traits of bat species. In insectivorous bat assemblages, species can be divided into ensembles based upon their wing morphology, which is believed to be molded by the degree of vegetative clutter they encounter when foraging. Differences within ensembles in these characters may further facilitate niche differentiation. Furthermore, differences in food processing capabilities, particularly bite force, may further mediate resource partitioning in species-rich assemblages. Bats that bite harder tend to eat larger and harder prey. However, little is known of the relationship between these partitioning dimensions in complex bat assemblages. Here we investigate the relationship between wing morphology (relative wing loading) and bite force among 27 insectivorous bat species of six families from Krau Wildlife Reserve, Malaysia.

Ontogeny and Phylogeny: Evolutionary Divergence of Closely Related Bat Species

Jason B. Shaw and Rick A. Adams. University of Northern Colorado, Greeley, Colorado 80639

Flight in vertebrates has lead to an evolutionary diversification of species, inhabiting many new and unused habitats. Differences in developmental patterns important to diversification are produced through heritable variation of the onset/offset and timing of juvenile growth. As the size and shape of an organism changes during ontogeny, morphological and behavioral components must adjust to accommodate proper function. The purpose of this study was to explore the ontogenetic pathways of two closely related Phyllostomids that differ in flight ability, body size, life history strategies, and developmental state at birth. We hypothesized that *Artibeus jamaicensis* (AJ) and *Carollia perspicillata* (CP) will show ontogenetic differences that account for the diversification of morphological, body size and behavioral patterns. Comparisons between the two species' flight development, growth rates and morphometrics were made from day1 of parturition to adult size (AJ n=45, CP n=25). Forearm length, mass, wing area, and wingspan were measured on a daily basis. Flight behavior was compared using the flop, flutter, flap, flight method, with juveniles being dropped from a 1 meter high roost from day 1 postpartum. Logistic growth equations were used to compare growth rates of all measured parameters and t-tests ($p<0.001$) showed significant differences between the two species of all measured variables. There were significant differences between the day of first flap (t-test, $p=0.01$) and flight (t-test, $p<0.0001$) with *C. perspicillata* achieving flight at 22 days and *A. jamaicensis* achieving flight 33 days postpartum. Our data suggest that growth trends are significantly different with the more altricial *A. jamaicensis* developing at a faster rate than the more precocial *C. perspicillata*. Data suggest that *C. perspicillata* is able to achieve flight at an earlier stage as they are born with more developed wings and have a shorter postnatal developmental time period. Ontogenetic comparisons are important in determining evolutionary diversification of closely related species.

Inferring Echolocation in Ancient Bats

Nancy B. Simmons, Kevin L. Seymour, Jörg Habersetzer, and Gregg F. Gunnell. American Museum of Natural History, New York, NY; Royal Ontario Museum, Toronto, ON, Canada; Forschungsinstitut Senckenberg, Frankfurt am Main, Germany; and Museum of Paleontology, University of Michigan, Ann Arbor, MI

Most living bats use laryngeal echolocation to form images of their surroundings and to detect flying prey. Echolocation is considered a key innovation largely responsible for the evolutionary success of bats. Paleontologists have long sought osteological correlates of echolocation that can be used to infer behavior of ancient fossil bats, particularly Eocene taxa representing basal branches of the bat family tree. Four osteological traits have been postulated as indicators of laryngeal echolocation in bats: (1) an enlarged orbicular apophysis on the malleus (one of the middle ear ossicles that transmit sound from the ear drum to the inner ear); (2) an enlarged cochlea (providing increased sensitivity to high frequency sounds in the inner ear); (3) an enlarged paddle-like or bifurcated cranial tip on the stylohyal; and (4) an articulation between the stylohyal and the tympanic (providing a direct chain of transmission between the larynx and the ear). We examine these traits in light of new evidence from bats and other mammals, including high-resolution CT scans of the holotype of the Eocene bat *Onychonycteris*. We conclude that and enlarged orbicular aphophysis cannot be considered an indicator of echolocation. The other traits remain good markers, but stylohyal modifications and an articulation between this element and the tympanic represent two parts of single complex. Analysis of basicranial morphology indicates that many Eocene bats were echolocators (e.g., *Icaronycteris*, *Archaeonyteris*, *Palaeochiropteryx*, *Hassianycteris*, *Tachypteron*, *Tanzanycteris*). Contra recent suggestions that *Onychonycteris* might have been capable of larygeal echolocation, we conclude that available evidence is best interpreted as indicating that it could not echolocate. Because postcranial morphology indicates that *Onychonycteris* could fly and phylogenetic analyses place it on the most basal branch within Chiroptera, the "flight first" hypothesis for the origin of flight and echolocation in bats remains the best-supported hypothesis for the origins of these key features.

Bat activity in the Vicinity of Proposed Wind Power Plants along the Mid-Atlantic Coast

Angela L. Sjollema, J. Edward Gates, and John Sherwell. Department of Biology, Frostburg State University, Frostburg, MD; Appalachian Laboratory, University of Maryland Center for Environmental Science, Frostburg, Maryland; Power Plant Research Program, Maryland Department of Natural Resources, Annapolis, MD.

Although wind power plants are considered a renewable source of energy, they have tremendous effects on wildlife in the eastern United States. Bat fatalities at some wind facilities in the Appalachian Mountains have been

estimated in the thousands. Other possible migration routes for bats include areas near and off the Atlantic Coast. A comprehensive study of offshore bat activity has not been conducted despite bat occurrences on boats at sea for decades. Recently, wind power plants have been proposed off the Atlantic Coast, rendering a comprehensive assessment of offshore bat migration dynamics necessary to prevent potential detrimental effects to their populations. Determining if there are predictors for high activity, such as favorable weather patterns, is also vital. Bat species richness and density will be studied using acoustic monitoring equipment near and offshore in the Mid-Atlantic region. Four sites have been set up onshore to record year-round nightly bat calls in New Jersey, Delaware, and Maryland beginning in spring of 2009 and ending fall 2010. Offshore acoustic monitoring is conducted from boats traveling close to shore during the migration seasons of 2009 and 2010. Early findings include a substantial number of *Lasiurus borealis*, *Eptesicus fuscus* and *Lasionycteris noctivagans* near the coast. One bat, a *L. noctivagans/E. fuscus,* was recorded 8.53 km from the New Jersey coast in the spring of 2009. Preliminary fall detections total 69 offshore calls from two boats traveling the New Jersey and Maryland coast. Bats were recorded up to 19.31 km from shore with an estimated average of 9.64 km. The most frequently recorded species was *L. borealis* suggesting that these bats use offshore pathways in fall. Other species detected included *L. cinereus*, *E. fuscus/L. noctivigans*, and *Myotis* species. Therefore, their occurrences at these distances suggest that planned offshore wind energy developments could affect migratory bats.

Multiple Harmonics in the Calls of Echolocating Bats

Mark Skowronski, Liam McGuire, Brock Fenton, and Paul Faure. Audigence Inc., Melbourne, FL; University of Western Ontario, London, ON; McMaster University, Hamilton, ON

Recorded echolocation calls of bats may contain a single (the fundamental frequency or a higher harmonic) or multiple harmonics. We hypothesize that the presence of multiple harmonics varies significantly by three factors: 1) species, 2) situation, and 3) recording quality. To test our hypothesis, we analyzed approximately 2300 calls recorded from 17 species + 1 subspecies in 6 families of bats using 1- and 4-microphone arrays. The percentage of all calls with multiple harmonics varied from 0% to 83% across species. Recordings from a 4-microphone array (1 m tetrahedron arrangement) revealed that the percentage of calls detected with multiple harmonics across microphone channels varied by up to 50%, indicating the effect of bat position relative to the microphone. By comparing frequency of maximum energy (FME) with maximum energy (maxE), we found that calls formed clusters, and that detection of multiple harmonics varied significantly among clusters. In one cluster multiple harmonics were detected in calls with sufficiently high maxE (threshold varied by species) due to less-intense harmonics falling below the noise floor of the recordings. Five species exhibited another cluster in which multiple harmonics were detected in low-intensity calls with FME in the fundamental. To test the effect of situation, we recorded the echolocation calls of big brown bats (*Eptesicus fuscus*) flying in 3 environments (anechoic flight room, roost emergence, and foraging area). Call energy shifted to lower harmonics as clutter decreased. Comparing flight room calls with foraging calls revealed that the second harmonic decreased by about 30 dB with respect to the fundamental. Our results show that 1) multi-harmonic usage varied significantly among species, and 2) relative harmonic intensity changed with situation and, along with bat-microphone spacing, affected which harmonics remained above the noise floor of recordings.

Bat Activity within Organic versus Conventional Apple Orchards in Southern Michigan

Brenna Smith and Allen Kurta. Department of Biology, Eastern Michigan University, Ypsilanti, MI

Conventional orchards use pesticides to decrease insect damage to fruit, whereas organic orchards do not. I hypothesized that use of pesticides in conventional apple orchards will result in less bat activity compared to organic orchards, by decreasing prey potentially available to bats. To test this hypothesis, I am quantifying composition and abundance of the insect community, composition and abundance of the bat community, diet of captured bats, and levels of ultrasonic activity within four organic and four conventional orchards in southern Michigan. An ultrasonic detector (Anabat) was raised to a height of 6 m in each orchard, programmed to record from sunset to sunrise, and moved to a new location every 7 days. Between 5 June 5 2009 and 2 August 2010, there were 292 nights of recording in organic orchards, yielding 12, 774 bat files, whereas 285 nights of recording in conventional orchards yielded 18,679 files. Most calls appear to be from *Eptesicus fuscus* (big brown bat), with far fewer calls from *Lasiurus borealis* (red bat) and *Lasiurus cinereus* (hoary bat). Mist-netting was performed on a total of 75 nights, and 136 bats were captured: 131 *Eptesicus fuscus* and 5 *Lasiurus borealis*. I collected feces from each individual for analysis of their diet, using standard fecal analysis and molecular techniques. For DNA analysis of insect fragments

within the feces, I am targeting a 648-bp region of the mitochondrial cytochrome *c* oxidase subunit I then amplifying this region using specific primers. The product will be sequenced and then compared to reference sequences present in the Barcode of Life Data System. Preliminary data suggests the level of bat activity was not significantly different between types of orchards.

Comparison of Activity Rates Collected by Different Bat Detectors under Controlled and Natural Conditions

Donald Solick, Jeff Gruver, and Chris Nations. Western EcoSystems Technology Inc., Cheyenne, Wyoming

Assessing potential risk to bats at proposed wind energy facilities relies primarily on estimates of overall bat activity collected by ultrasonic detectors. To date, the Anabat™ ultrasonic detector has been the industry standard for passive monitoring of bat activity. However, full-spectrum detectors such as the Pettersson D500x and Wildlife Acoustics SM2 are becoming more prevalent at wind-energy studies, largely due to their increased potential for species identification. Because Anabat and full-spectrum detectors use different types of microphones, utilize different sensitivity settings, and process the data differently, they are unlikely to produce comparable activity rate data and could potentially yield very different risk assessments. For example, while the Anabat has a single input control (sensitivity) that varies between 1 and 10, the D500x has 4 different controls that may affect sensitivity, each having between 5 and 46 settings. The goals of this study were to determine what combinations of settings on the D500x and SM2 produce similar activity rates to the Anabat SD1 under controlled conditions, and to test these settings under natural conditions. For the controlled experiment, all possible combinations of settings for each of the detectors were tested by repeatedly broadcasting a 45-second sequence of echolocation calls, and calculating the number of calls per unit time (i.e., activity rate) recorded by each detector. The quality of the recordings for species identification by the full-spectrum detectors was also assessed using the SonoBat 3 automatic species classification algorithm. For the natural experiment, the three detectors were programmed using the settings that produced comparable data in the controlled experiment, and were placed side-by-side in the field to collect bat activity. The results of this study will be useful to ensure consistency in measured levels of activity across studies.

Prey Abundance and Seasonal Movements of the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*)

Christopher M. Todd, Corinna Pinzari, Frank Bonaccorso, Brad Yuen, and Marcos Gorresen. Hawai`i Cooperative Studies Unit, University of Hawaii at Hilo, Kilauea Field Station, Hawai`i National Park, HI; Pacific Island Ecosystems Research Center, United States Geological Survey, Hawai`i National Park, HI

The Hawaiian Hoary bat (*Lasiurus cinereus semotus*) is the only terrestrial mammal native to the Hawaiian Islands and currently is listed as an endangered species due to apparent population declines, lack of knowledge concerning it distribution, and habitat loss. Echolocation surveys indicate that Hawaiian hoary bats display striking seasonal movements along the steep gradient of elevation across eastern Hawai`i Island. Changes in temperature and rainfall are a likely cause for these migrations. However, the extent to which peaks in food correspond with the bat's migration has received little study. Here we present data on insect phenology and abundance across an annual cycle at five sites along a gradient of elevation. We link these insect data to echolocation surveys to gain insights on how availability of prey corresponds with seasonal migratory movements. We hypothesize that insect abundance will show a positive correlation with bat vocalization activity. Data collected from early April 2009 to July 2010 at two low elevation sites show a trend among the increase of overall insect abundance and the increase in bat activity. Data collected at a mid elevation site shows that in early April 2009 there is a spike in insect activity, primarily Lepidoptera, while bat occurrence is still relatively low. The following survey in May of 2010 shows an increase in bat occurrence and an increase in overall insect abundance and supports a hypothesis previously predicted by T. Menard that bats migrate from high interior elevations to coastal lowlands to reproduce in summer months. Within each survey night there also appeared to be a positive relationship with insect abundance and bat occurrence.

Preliminary Studies of Nectarivorous Bat Foraging in Fragmented and Continuous Forest Landscapes in a Mexican Tropical Dry Forest

Pamela Thompson and Victoria Sork. Ecology and Evolutionary Biology, University of California, Los Angeles CA

Tropical forests are increasingly fragmented as land is converted into agriculture and urban areas. This fragmentation may impact animal pollinators, which perform an essential ecosystem service of pollinating wild plants that have important cultural, medicinal, or economic value. Due to the ability of bats to move long distances, it is assumed that they are less affected by forest fragmentation. This study seeks to understand the impact of forest

fragmentation on the pollinating bat community in a tropical dry forest in Jalisco, Mexico, in and around the Chamela-Cuixmala Biosphere Reserve. Our objectives are to test whether (a) diversity and abundance of nectarivorous bats, and (b) species diversity of pollen found on bats, differ between fragmented and continuous forest landscapes. To test abundance and diversity of bats, bats were captured using mist-nets near flowering resources of bat-pollinated *Crescentia alata* trees at 3 fragmented forest sites, and 3 continuous forest sites, for 2 nights at each site. The total number of nectarivorous bats captured was 260, among 3 species: *Leptonycteris yerbabuenae*, *Glossophaga soricina*, and *Choeroniscus godmani*. We caught significantly more individuals from *Glossophaga soricina* than the other species, but found no effect of landscape type on abundance To investigate pollen species diversity differences between landscape types, pollen was collected from bats in the field using fucshin-stained gelatin cubes, and later identified to morpho-species using light microscopy in the lab. There was a significantly greater number of pollen species in continuous landscapes than fragmented ones (t-test, p=0.035), suggesting that bats in continuous forests forage on a wider array of resources. In the future, we plan to extend our mist-netting efforts to more nights per site, and across a broader geographic range, as well as commence studies on pollen movement of *Crescentia alata* using neutral genetic markers.

Histological assessment of cellular immune response to the phytohemagglutinin skin test in Brazilian free-tailed bats (*Tadarida brasiliensis*)

Amy S. Turmelle, J. A. Ellison and M. T. Mendonça. Centers for Disease Control and Prevention, Atlanta, GA, Auburn University, Auburn, AL

Bats are known reservoirs for numerous emerging infectious diseases, occupy unique ecological niches, and occur globally except for Antarctica. Given their impact on human and agricultural health, it is critical to understand the mechanisms underlying immunocompetence in this reservoir host. To date, few studies have examined immune function in the Order Chiroptera, particularly among natural colonies of bats. The phytohemagglutinin (PHA) skin test has been widely used to measure delayed-type cellular immune response in a wide variety of vertebrates, and has been routinely employed in immunoecological studies. Although this test is frequently described as a measure of T cell proliferation, recent studies indicate it may represent a combination of immune responses. In mammals, the immune response is differentially, temporally and spatially regulated, therefore, we characterized the infiltrating leukocyte response to the PHA skin test in bats by examining a time-series of histological sections from PHA, and saline injection areas in 41 Brazilian free-tailed bats (*Tadarida brasiliensis*). Results suggest that bats exhibit diverse leukocyte traffic within 6 h, and up to 24 h following subcutaneous PHA injection. There was a significant presence of lymphocytes and neutrophils, as well as eosinophils, basophils, and macrophages observed in the PHA-injected tissues, compared with saline-injected control tissues. We observed a highly significant negative correlation between the number of lymphocytes and neutrophils in PHA-injected tissue, with peak lymphocyte response at 12 h, and peak neutrophil response at 24 h post-injection. These results indicate substantial variation in the immune response of individuals, and may aid our understanding of disease emergence in natural populations of bats.

Diets of the sympatric Pacific sheath-tailed bat (*Emballonura semicaudata rotensis*) and Mariana swiftlet (*Aerodramus bartschi*) on Aguiguan, Mariana Islands

Ernest Valdez, Gary Wiles, and Thomas O'Shea. United States Geological Survey, Fort Collins Science Center, University of New Mexico, Albuquerque, NM; Washington Department of Fish and Wildlife, Olympia, WA; United States Geological Survey, Fort Collins Science Center, Fort Collins, CO

We investigated the food habits of Pacific sheath-tailed bats (*Emballonura semicaudata rotensis*is) and Mariana swiftlets (*Aerodramus bartschi*), two rare taxa restricted to the southern Mariana Islands in western Micronesia. Diet was determined by examining guano collected from two roosting caves during a two-week period in June and July at the onset of the rainy season on the island of Aguiguan. Important orders of insects consumed (% volume) by bats roosting at one cave included hymenopterans (64%), coleopterans (10%), lepidopterans (8%), isopterans (8%), and psocopterans (5%), whereas those at a second cave included lepidopterans (45%), hymenopterans (41%), coleopterans (10%), and isopterans (5%). Swiftlets, which roosted in only one of the caves, fed mostly on hymenopterans (88%) and hemipterans (6%). Significant differences existed between the two taxa in several insect orders eaten, with *E. s. rotensis* consuming more lepidopterans and coleopterans and *A. bartschi* taking more hymenopterans and hemipterans. Within Hymenoptera, bats fed more on ichneumoideans, whereas swiftlets ate more formicid alates and chalicidoideans.

Molecular Phylogenetics of *Myotis* Indicate Familial-Level Divergence for the Genus *Cistugo*

Ronald A. Van Den Bussche, Justin B. Lack, Zachary P. Roehrs, Craig E. Stanley, Jr., and Manuel Ruedi. Department of Zoology, Oklahoma State University, Stillwater, OK Department of Mammalogy and Ornithology, Natural History Museum, Geneva, Switzerland

The genus *Myotis* has undergone significant taxonomic revision since the advent of DNA sequencing techniques. Prior morphological examination of *Myotis* indicated as many as 4 subgenera correlated with foraging strategies. Recent studies using mitochondrial DNA (mtDNA) sequence data questioned the validity of these subgenera and indicated that several taxa may require reevaluation as to their position within Vespertilionidae. Nevertheless, no study has used large-scale nuclear DNA sequencing to examine relationships within *Myotis*. We generated 4,656 base pairs (bp) of nuclear intron (PRKC1, STAT5A, and THY) and exon (APOB, DMP1, and RAG2) sequence data in addition to 2,866 bp of mtDNA sequence data to test previously hypothesized subgeneric groupings of *Myotis*. We included 21 species of *Myotis* from all morphological subgenera previously suggested, representatives of all subfamilies and tribes currently recognized in Vespertilionidae, and multiple representatives of all other families currently included in the superfamily Vespertilionoidea. We also included a representative of the rare African genus *Cistugo*, because significant doubt exists about its familial position. Our phylogenetic analyses did not support the morphologically defined *Myotis* subgenera and confirm that morphological similarities among *Myotis* are the result of convergent evolution. Divergence estimates derived from the total data set were concordant with previous studies, suggesting a middle Miocene trans-Beringian dispersal from Asia colonized North America, with subsequent South American colonization and diversification prior to the formation of the Isthmus of Panama 3–4 million years ago. *Myotis latirostris* fell outside of *Myotis*, and the high genetic distance separating it from other *Myotis* suggested that *M. latirostris* represented a distinct genus. The genus *Cistugo*, previously a subgenus within *Myotis*, fell basal to all vespertilionids, with a high genetic distance separating it from Vespertilionidae. We conclude that *Cistugo* should constitute a distinct family within Vespertilionoidea.

Monitoring of four bat species for the Lower Colorado River Multi-Species Conservation Plan

Beatriz Vizcarra, Vincent Frary, Linden Piest, and Theresa Olson. Carol Chambers School of Forestry, Northern Arizona University, Flagstaff, AZ; Arizona Game and Fish Department, Phoenix, AZ; Allen Calvert Lower Colorado Region Bureau of Reclamation Multi-Species Conservation Program, Boulder City, NV

This project was initiated to satisfy measures within the Lower Colorado River Multi-Species Conservation Program. To determine distribution and habitat use in riparian areas of the western red bat (Lasiurus blossevillii), yellow bat (Lasiurus xanthinus), pale Townsend's big-eared bat (Corynorhinus townsendii pallescens), and California leaf-nosed bat; acoustical bat detectors have been deployed since March of 2008, at 72 sampling locations that include 4 vegetation types. Detection rates for California leaf-nosed and western red bat were high in all habitat vegetation types, slightly lower for western yellow bat, and lowest for Townsend's big-eared bat. The four bat species appear to be present in the four vegetation types. Four permanent acoustic detector stations along the river are providing data useful for analyzing migration movements and correlating bat activity with environmental variables. Data collected thus far from permanent stations suggests that bat activity was low during the winter but increased dramatically in early February, remaining high through March. There was much night to night variability during this time, which may have corresponded to migration pulses or to the influence of temperamental weather patterns. Call minutes were highly correlated to nightly mean temperatures (r^2 = 0.107). Activity declined during April and remained steady in May, perhaps a result of less influence from migrants and more consistent weather. During the colder months, bats apparently had a greater preference for foraging during the warmer hours early in the night. Negative correlation between call minutes and humidity were found, and no relationship with moon phase or mean wind speed. Data from permanent stations has not yet been analyzed separately for each species and it is possible that individual species may have responded differently to the environmental variables measured. All conclusions are based on a small incomplete sample and are likely to change as we accrue more data.

How smart are flying foxes? Megachiropteran bats use human referential stimuli to locate hidden food

Allyson L. Walsh, Nathan J. Hall, Monique A.R. Udell, Nicole R. Dorey, and Clive D.L. Wynne. Lubee Bat Conservancy; University of Florida, Gainesville, FL

Spontaneous point following behavior is considered a sign of advanced social cognition typically reserved for humans. Recently the domestic dogs' (*Canis lupus familiaris)* success on point following tasks has led scientists to ask whether the domestication process itself might lead to human-like social cognition in other species. We investigated this hypothesis by testing the socio-cognitive skills of a suborder made up of highly social but non-domesticated species, megachiropteran bats (*Pteropus spp.*). Three subjects were highly successful in following a human point to a target location, providing the first empirical evidence of cross-species social referencing in bats. Furthermore we demonstrate that bats experiencing human contact from birth are more sensitive to human stimuli than wild born bats, and that this responsiveness generalizes to unfamiliar humans. This study provides additional evidence that referential point following behavior is not restricted to domesticated animals or primates. Our data provide evidence that other social species can develop behavioral responses to unfamiliar human stimuli possibly through early experience or enculturation. When considering the origins of human-like social cognition in distantly related species, more attention should be placed on the ecological relevance of social referencing and cooperation to the species in question. Megachiropteran bats may prove to be an excellent model for such behaviors.

Evaluating Changes in Bat Activity and Species Composition from White Nose Syndrome at Fixed Acoustic Monitoring Locations in Vermont

Kristen Watrous, Eric Britzke, Scott Darling, Ryan Smith, Sarah Boyden, and Susi von Oettingen. Stantec Consulting, South Burlington, VT; U.S. Army Engineer Research and Development Center, Vicksburg, MS; Vermont Department of Fish and Wildlife, Rutland, Vermont; Vermont Department of Fish and Wildlife, Rutland, Vermont; Stantec Consulting, Topsham, ME; U.S. Fish and Wildlife Service, Concord, NH.

White Nose Syndrome (WNS) was first documented in southeastern Vermont during the winter of 2007/2008, one year after first appearing in New York. Since then, WNS has spread throughout the region and has caused unprecedented mortality to cave-hibernating bats. It is vital to verify and model expected declines in northeastern bat populations due to the possible future extirpation of local or regional populations. Long-term acoustic monitoring surveys along a forested ridgeline in central Vermont provided an opportunity to assess the affect of population change on recorded bat activity. The first year of acoustic monitoring occurred in 2007, prior to WNS documentation in VT. The second year of monitoring, in 2008, occurred during year one of WNS in the state. The 2009 season marked the second full year of WNS in Vermont, and additional surveys focused on documenting the progression of WNS and the projected decline in bat activity. Five Anabat detectors were deployed in the same locations for all survey years. Recorded files containing pulses with minimum frequencies above 30 kHz were used in a discriminant function analysis to assign species identification. Acoustic rates for all files recorded, for high frequency echolocators, and for *Myotis* species identified were compared among years. Overall activity was lowest in 2009, and yearly variation in activity patterns was driven by high frequency echolocators. Monthly detection rates varied among identified species, but were often lowest in 2009. Activity rates did not drop as much as expected based on mortality at nearby hibernacula, raising questions about the relationship between the amount of bat activity and the number of individuals present. Comparisons of bat activity at a single site are governed by site-specific influences and may not be representative of the larger geographic area. Continued sampling in 2010 will help determine if this observed trend continues.

Evaluating the use of stable isotope analyses to infer sex-specific seasonal movements of silver-haired bats in northwestern California

Theodore J. Weller and C. A. Stricker. USDA Forest Service, Pacific Southwest Research Station, Arcata, CA; U.S. Geological Survey, Denver Federal Center, Denver, CO

Effective conservation of bat populations requires understanding of their full range of seasonal movements and behavior patterns. In the western U.S., silver-haired bats, *Lasionycteris noctivagans*, are thought to undertake long-distance seasonal movements between their summering and wintering habitat. However the summer destinations, and potentially the distances moved between summer and winter habitat, appear to differ between males and females. Previous research in redwood forests of northern California suggested that female silver haired bats were present during fall through spring while males were present year-round. We confirmed these patterns

using mist net capture surveys and evaluated the use of stable isotope analysis as a means of assessing sex-specific movements between summer and winter habitat. We analyzed hair samples from 16 female and 51 male silver-haired bats. To better understand expected levels of variation in a presumably resident population of bats, we analyzed hair samples from 22 female and 34 male *Myotis yumanensis*. The mean hydrogen isotope (δD) value for *L. noctivagans* females was -77.6 ‰ (range: -93.6 to -52.9‰) while the mean value for males was -75.2 (range -112.6 to -38.5). Mean δD values for *M. yumanensis* females were -67.2 (range -104.5 to -41.3) while mean values for males were -74.6 (range -110.7 to -52.8). Using results from *L. noctivagans* alone might have led us to conclude that the summer whereabouts of male and females are drawn from a similar range of geographic locations across western North America. However combined results from both species indicate that further work, possibly with additional isotopes (e.g., $\delta^{34}S$), is necessary to understand isotopic signatures in bat hair if this technique is to be used to understand their seasonal movements.

A Proportional Hazards Model to Identify Hibernaculum-Llvel Variables Associated with White-Nose Syndrome

Aryn P. Wilder, Winifred F. Frick, and Thomas H. Kunz. Boston University, Boston, MA; University of California, Santa Cruz, Santa Cruz, CA.

White-nose syndrome (WNS) has spread rapidly across 14 states and two provinces from the first documented case in Howe Cave near Albany, New York in 2006. Little is known about the factors that influence the spread of WNS among hibernacula, or about the characteristics that predispose particular populations to WNS. We used a Cox proportional hazards analysis to determine the characteristics of hibernacula in the northeastern United States associated with yearly risk of becoming infected with the putative fungal pathogen associated with WNS, *Geomyces destructans*. We tested the influence of distance from the first identified WNS site, distance to the nearest infected site, site elevation, size of the total bat population within the hibernaculum, bat species richness, diversity and evenness, and the proportion of each species within the hibernating population. The best model included distance to Howe Cave ($p < 0.0001$), the proportion of *Perimyotis subflavus* within the population ($p = 0.042$), and a *P. subflavus* × total population size interaction ($p = 0.031$). Time to infection was negatively associated with distance to Howe Cave ($e^{coeff} = 0.989$), with each additional kilometer decreasing the yearly risk of infection by a factor of 0.989. Time to infection was negatively associated with the percent of *P. subflavus* within the population ($e^{coeff} = 0.921$), with the association decreasing in magnitude for larger hibernating populations. Our results indicate that distance from the first infected site is a strong predictor of the timing of *G. destructans* infection, which is consistent with the scenario of a pathogen spreading from an original focus. Our results also suggest that species composition may influence risk of becoming infected. Our analysis demonstrates the importance of spatial location for determining risk of infection and suggests that multi-host dynamics may play a significant role in the rapid spread of this devastating disease.

Nuclear DNA Phylogeography Reveals Sex-Biased Dispersal in the Pallid Bat, *Antrozous pallidus*

Jeremy E. Wilkinson, Justin B. Lack, and Ronald A. Van Den Bussche. Oklahoma State University, Stillwater, OK

Male-biased dispersal with female philopatry is a common pattern for many mammalian taxa. Due to the maternal inheritance of mtDNA, biparentally inherited nuclear markers are necessary to obtain correct estimates of population structure and gene flow. The pallid bat (*Antrozous pallidus*) exhibits a relatively continuous distribution across arid western North America, and a previous mtDNA study suggested little gene flow among populations and identified 3 distinct phylogroups. We examined population structure of *A. pallidus* using amplified fragment length polymorphism (AFLP) in 187 individuals from 29 localities across the distribution of the species. Eight primer pairs identified 797 polymorphic loci. All analyses indicated that populations in California and British Columbia were distinct from each other and all other populations. *A. pallidus* from the Baja peninsula were also distinct, but cluster analysis indicated gene flow has been occurring with more eastern populations. The pallid bat appears to be characterized by male-mediated dispersal and gene flow, while females are largely philopatric. The overall pattern is indicative of isolation by distance and does not support the presence of distinct phylogroups, suggesting significant gene flow has been occurring since populations diverged during Pliocene desert formation and mountain building.

Hibernating Rodents at a Bat Meeting: "Animal Models" and the Potential for Natural Selection to Help Bats Rebound from White-Nose Syndrome

Craig K.R. Willis, Jeffrey E. Lane, Loeske E.B. Kruuk, and F. Stephen Dobson. University of Winnipeg, Winnipeg MB Canada; Institute of Evolutionary Biology, University of Edinburgh, Edinburgh UK; Centre National de la Recherche Scientifique, Montpellier, France.

White nose syndrome (WNS) is causing a tremendous bottleneck for North American bats that has little, if any, precedent among wildlife populations. Such rapid population declines have the potential to exert a rapid response to selection on any phenotype which confers resistance to, or tolerance of WNS, as long as that phenotype is heritable. Such phenotypes could include aspects of immune response but, given apparent links between hibernation energetics and mortality, traits affecting energy balance during hibernation could be especially important for survival. We present a quantitative genetic ("animal model") analysis, based on a multi-generational pedigree and phenotypic measurements of individuals, which addresses the heritability of hibernation behaviours in Columbian ground squirrels (*Urocitellus columbianus*). The analysis confirms that hibernation emergence date, body condition at emergence and oestrus date following emergence (all traits closely linked to hibernation energy balance for this species) are significantly heritable and potentially subject to strong directional selection. We also present data on repeatability of the tendency for individual little brown bats to express torpor, which provides an 'upper-limit' estimate of heritability for this energetic trait in bats. These results emphasize the urgent need to identify any traits that provide a survival advantage in the face of WNS and highlight the potential value of detailed pedigrees and animal models to quantify the heritability of potential "WNS survival phenotypes" in bats.

Babies and Rabies: Transference of Immunity from Mother to Infant

Heather A. York and Susan M. Moore. Doane College Department of Biology, Crete, NE; Kansas State University Rabies Laboratory, Manhattan, KS

It is well known that adaptive humoral immunity developed in response to infectious agents may be transferred in eutherian mammals from mother to offspring during gestation and nursing, providing newborn animals with important immunological defenses. Less studied, however, are the efficacy with which immunity acquired through vaccination is conveyed and the persistence of this specific immunity in the offspring. Such transference of immunity to the rabies (*Lyssavirus*) virus has not been described previously in humans. Despite the medical and economic importance of this zoonotic disease, particularly for mammal biologists and others for whom contact with hosts is likely, its lethality makes *in vivo* studies of the rabies virus difficult, especially in humans. Herein, we report a case of transference of rabies virus-neutralizing antibodies during pregnancy and lactation from a rabies-vaccinated adult female human to her unvaccinated infant. We also suggest the utility of additional studies of this unique and potentially important immunological process in consideration of the methods of maternal transfer of immunity in mammals.

Observations of Patterns and Behavior of a Migrating Hoary Bat

Julie A. Zeyzus, J. L. Larkin, and J. E. Duchamp. Indiana University of Pennsylvania, Indiana, PA

Tree bat fatalities at wind facilities in the eastern United States remain a concern among bat conservationists. Research into the migratory patterns and behavior of these species provides data to help develop methods to minimize bat mortalities and direct mitigation efforts. We conducted a project in southwestern Pennsylvania during fall migration in 2007 and 2008 to capture, radio-tag, and track migrating tree bat species. We intended to observe the bats' 1) movement, foraging, and roosting behavior; 2) landscape use; and 3) response to weather patterns that may initiate migration. In 2008, one adult male hoary bat (*Lasiurus cinereus*) was followed via telemetry equipped ground vehicles and airplane for four nights before the signal was lost permanently. The hoary bat's movement was predominately in the eastern to southeastern direction, but this individual also moved north/northeast twice over the four night period for distances of 13km to 16km. The bat also followed the contour of one forested ridge and bisected another ridge, traveled over open fields in valleys and stopped to forage on a lake, within a stream corridor, and a field. During its flights, the bat passed within 6km of an operating wind facility. We found no strong correlation to movement and weather patterns such as changes in temperature, pressure, and/or wind. The average temperature over a 24hr period throughout the four-night movement and on the night of capture ranged between 13ºC and 17ºC, pressure was between 1022 mb and 1027 mb, and wind was between 1.0 m/s and 2.6 m/s. However, the night the bat was lost, the average temperature increased to about 2ºC greater than the

previous 24hr periods and the wind levels prior to movement dropped to under 1.2 m/s from over 2.0 m/s the previous 24hrs.