

ABSTRACTS

Western Bat Working Group Meeting



Spotted bats at Mesa Verde National Park by Lucas Navo

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Local Hosts: Colorado Bat Working Group

Unraveling Zero Crossing and Full Spectrum - What does it all mean?

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

Tree-roosting Bats in the Western United States: What We Know and What's Next

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Although most species of western bats primarily use caves and rock crevices as diurnal roosts, 19 of the 36 species found in the western United States roost in trees at least some of the time. Characterizing diurnal roost use at the tree, stand, and landscape levels is important for mitigating the impacts of forest management activities on western bats. I surveyed peer-reviewed studies (1980-2017) of diurnal roosts to identify gaps in our knowledge and provide recommendations for future research. Some species and subgroups have been studied too little to convincingly describe roost use, and many studies of western tree-roosting bats suffer from small sample sizes, failure to separate ecologically distinct groups (e.g. males and females, adults and juveniles), and inconsistent study design. We provide a framework for prioritization of research need and recommend that design of bat-roost studies more narrowly target specific populations, use a common case-control framework, and include *a priori* mechanistic explanations of roost use.

Implications Associated with the Western Range Expansion of Eastern Bat Species in the United States

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The Great Plains once served as a buffer creating a division between many eastern and western woodland species. However, expansion of riparian corridors along these prairie waterways has enabled a broad assortment of eastern deciduous mammals to expand their distributional range westward. Following our capture of an evening bat (*Nycticeius humeralis*) in southwestern New Mexico, which indicated a significant range extension for the species, we compiled all recent capture records to determine where else this species has been documented outside of its historic range. Although such captures may be anomalies, there is evidence to support the possibility that this and another eastern species, the tri-colored bat (*Perimyotis subflavus*), may exist in previously undocumented areas. After finding multiple records of

these species in novel areas, these captures should encourage researchers to factor in the possible occurrence of eastern bat species in mist-netting and acoustic surveys to reduce the likelihood of mis-identification. The movement of these eastern species along riparian corridors could also become an avenue for the transmission of White-Nose Syndrome (*Pseudogymnoascus destructans*) into western cave systems which poses a threat to western bat communities.

Acoustic Assessment of Year-round Bat Activity and Distribution in Montana and Surrounding Areas

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Montana's bat species face an array of conservation issues including wind energy development and disease. A collaborative project between state and federal agencies was initiated in 2011 to collect baseline data prior to the arrival of White-nose Syndrome and help inform surveillance and future mitigation strategies. In the last 6 years, we deployed a network of Song Meter ultrasonic acoustic detector/recorder stations at 76 sites across the region for an average of 1.8 years per station. Each detector recorded nightly bat passes across all seasons. To date 9.5 million sound files have been recorded. Using automated scrubbing and identification software we identified call sequences and generated initial species identifications, then hand confirmed species presence by month at each site. Over 54,000 bat passes have been reviewed by hand and used to track activity of all species at each site. To date we have 2,770 new records of monthly species presence, regular winter activity of 3 resident species, and year-round presence of 1 species previously considered migratory. Through integrating National Oceanographic and Atmospheric Association weather station with our call data, we have found positive correlations in activity with temperature and barometric pressure, and negative correlations with wind speed. Our experiences with these data highlight the importance of: (1) maintaining common settings across recording devices and consistent processing standards; (2) maintaining publicly available call libraries that can be reanalyzed using the latest software and made available to software developers; and (3) making standards used for species determinations available for peer review.

Bat Use, Human Visitation, and Environmental Attributes of Cave Hibernacula in Montana

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Across the eastern United States, caves historically supported large aggregations of overwintering bats. In contrast, few large aggregations have been observed within caves in Montana. To collect comprehensive information on cave use by bats and inform White Nose Syndrome surveillance, we inventoried caves to estimate numbers of hibernating bats, assessed the microclimate within hibernacula, monitored activity of bats using acoustic detectors, and quantified visitation by people using trail cameras. In collaboration with recreational cavers, state, and federal biologists we conducted over 300 structured and incidental surveys at 99 caves. Only 6 caves had counts exceeding 100 individuals, and our largest hibernacula had approximately 1,700 bats. The mean annual temperature and humidity across 16 caves averaged 5.0°C and 100% RH. At the 6 largest hibernacula, we established year round baselines of bat acoustic activity and quantify visitation by people. We found that both the number of people entering caves and bat activity within caves peaked in summer. During the winter, visitation appears largely dependent on accessibility of the cave and all monitored caves had low levels of bat activity. Caves in Montana appear to support relatively few aggregations of overwintering bats. Although we have visited most known caves in the state, the number of hibernating individuals we observed is likely orders of magnitude less than the total number we presume overwinter in-state. Future projects should explore the use of cracks, crevices, talus, and badlands to identify other important hibernacula.

In-hand Measurements of Adult Bats of the Northern Great Plains and Rocky Mountains

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Researchers often rely on keys and other published records of pelage and morphological characteristics to identify bat species in the field. Morphological characteristics may vary both within and between species, which can lead to difficulties in the discrimination of species with similar or variable attributes. Some resources use measurements of museum specimens or relatively few live individuals and may not accurately represent in-hand measurements taken in a field setting. To provide a resource to aid in the identification of bats we created a supplement to the “*Key to Idaho, Montana, and South Dakota Bats*”. We aggregated and analyzed the capture records of 3,222 adult bats representing 14 species caught between 1994-2016 in Montana, northern Idaho, and northwestern South Dakota. Within this document, we present the distributions of morphological measurements by species and data on the seasonality of captures by age, sex, body condition, and reproductive status. This allows comparisons between these metrics and in-hand measurements while in the field, and provides a general understanding of the life history of species in our region. Through analyses of these data we concluded that: (1) measurements of smaller appendages such as the thumb or tragus show a high degree of variability relative to total length and may be unsuitable for species identification; (2) decreases in body condition in the late season indicate error in identifying older juveniles with current methods; (3) Parturition dates are similar across all species present in our area; and (4) measurements of rare species are needed.

WNS/Pd Surveillance Guidance for Western States

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The recent confirmation of white-nose syndrome (WNS) in Washington in Spring 2016 caught many by surprise given the apparent 2,100 km leap from the nearest known distribution of the causative fungus, *Pseudogymnoascus destructans* (*Pd*). It also highlighted the paucity in surveillance data from the western half of the US which may have helped explain how *Pd* had arrived there. The USGS National Wildlife Health Center oversees a nationwide, multi-year *Pd* surveillance project whose objectives are to assist wildlife and land managers with early detection of *Pd* expansion into new areas and the identification of new susceptible North American bat species. Data generated from this project as well as other studies investigating transmission dynamics, fungal ecology, and ecology of WNS informs surveillance efforts that can be applied and adapted for unique challenges presented by western bat species and the environment. Understanding the limitations of the various surveillance strategies and sampling methodologies, appropriate application, and recognition of potential selection biases are necessary to accurately interpret outcomes and achieve confidence in surveillance efforts. Surveillance recommendations for *Pd* in western states, based on current knowledge, will be discussed.

Establishing a pre-WNS baseline for bats on a remote island archipelago

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Gwaii Haanas National Park Reserve and Haida Heritage Site comprises the southern half of Moresby Island, one of two main islands comprising the island archipelago of Haida Gwaii. Four species of bats are present in our protected area, yet little is known of their distribution and abundance. As fears increase that WNS may spread across western North America, the need for baseline population studies is important to monitor spread and impact of WNS on native bat populations. Our remote off-shore location may provide a refuge for the disease as it spreads continent-wide. Our sampling design covers the entire extent of the protected area on a 12x12 km grid (24 cells). In 2016, we sampled 15 of 24 cells, with SM4BAT Songmeters deployed in each. Within these large cells, we stratified habitat using an array of forest attributes, on a smaller 2x2km grid. Sampling focused on areas of large, old growth spruce and hemlock forest, using the NABat protocol for acoustic sampling to guide microsite selection and recorder

programming. The nightly mean bat count across all site was 87 ± 5 detections sites (33 nights were outliers, removed due to false triggers on rainy nights. Of the 13 496 recordings identified to species using Kaleidoscope software, 24% were classified as little brown bats (*Myotis lucifugus*; MYLU), 31% California myotis (*M. californicus*, MYCA), 21% long-legged myotis (*M. volans*), 14% Keen's myotis/western long-eared bats; (*M. evotis/keenii*; MYEV), 4% Yuma myotis (*M. yumanensis*), 3% eastern red bat (*Lasiurus borealis*), 2% hoary bat (*L. cinereus*), and 2% silver-haired bats (*L. noctivagans*; LANO). Of these 8 species, only 4 are presently confirmed to inhabit the Haida Gwaii archipelago (MYLU, MYCA, MYEV, and LANO). This is the first time that we are aware of that bat abundance monitored on a grid has been conducted along the BC coast, so we have little to compare this information to. We intend to continue annual monitoring to examine interannual variation.

Wet Refuges for Bats: What Influences Bat Use of Waterbodies at the Landscape Scale?

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Climate change is expected to reduce habitat quality for bats in warming, drying regions like the Western US and recent bioclimatic modeling indicates many bat species will shift north in their distribution within this region. Conservation of appropriate refuges in landscapes affected by climate change may allow bats to persist. We investigated perennial water sources (streams and ponds) as potential refuges for foraging bats, contrasting them with paired, similarly structured dry habitats. We used meta-models to compare bat activity between wet and dry habitats across a gradient of aridity in blue oak woodlands in California. We predicted that importance of water bodies for bats would increase as the landscape grew drier. As predicted, bats used wet habitats (streams and ponds) 23 times more than dry habitats. As the landscape became dryer, bat activity in wet habitats reached 68 times that of dry habitats, while in the wettest parts of the blue oak distribution, activity was only 7 times that of dry habitats. Streams and ponds showed similar levels of bat activity. Our findings indicate that water bodies have disproportionate value for bats compared to surrounding dry habitats and that they are likely to be important refuges for bats in regions where climate change is predicted to decrease water availability.

Emerging Insights: Transition Season Behavior and Winter Roosts of Little Brown Bats in Southeast Alaska

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Little brown bats in eastern North America typically hibernate in caves and mines, often in large groups, whereas few large hibernacula have been identified in the West. Although >300 caves have been explored and mapped in Southeast Alaska, only a handful of bats have been observed roosting in caves in winter. We used acoustics and radio-telemetry to identify hibernation roosts of little brown bats near Juneau, Alaska and to study their roosting behavior during spring and autumn, when the bats were moving between their winter and summer roosts. During 2011-2014, we captured and radio-tagged 32 adult bats (28 females and 4 males) in spring and 75 adult bats (28 females and 47 males) in autumn and radio-tracked them daily from the air and on the ground. We tracked bats to 186 unique roosts during the transition seasons; most were in buildings (n=84) or snags (n=78), with smaller numbers in trees (n=11), rock crevices (n=2), a cliff (n=1), and a bathhouse (n=1). Most bats used only 1 type of roost, with females more often in buildings and males more often in snags or trees. We located 10 hibernation roosts on 2 ridge systems. Two roosts were under the roots of trees or stumps on level ground at elevations 86 m and 8 roosts were located on steep, forested rock scree hillsides at elevations from 128 to 452 m. Understanding the roosting behavior of little brown bats during the transition and hibernation seasons is

important for management of this species and will be critical to understanding the transmission dynamics of WNS in the West.

Bats in the Boondocks: Citizen Science Bat Monitoring in Southeast Alaska

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Southeast Alaska comprises a rugged mainland coast and an island archipelago, with most communities accessible only by boat or plane, making it logistically challenging and expensive for biologists to collect data at multiple locations. In 2014, the Alaska Department of Fish & Game's Threatened, Endangered and Diversity Program partnered with local libraries, science centers, and the US Forest Service to establish a citizen science acoustic driving transect program to monitor the region's bat populations. Partners helped recruit, train, and coordinate volunteers, as well as issue the survey equipment and download and submit the data. Surveys followed North American Bat Monitoring Program (NABat) protocols and were conducted up to 8 times per month during April – early October to provide information on bat distribution, relative abundance, seasonal activity, and habitat use. To date, 151 volunteers have conducted 145 surveys in 6 communities across the region. A total of 1740 bat calls were recorded; 58% of calls were identifiable to species (*Myotis lucifugus* (n=565), *M. californicus* (n = 204), *Lasiurus noctivagans* (n=199), *M. keenii* (n=35), and *Lasiurus cinereus* (n=1) and the remainder were ambiguous (n=736)). These surveys will provide an important baseline for assessing the population impacts of White-nose Syndrome should the disease reach Alaska.

Nocturnal Airplane and Ground Telemetry to Determine Foraging Range of California Leaf-nosed and Townsend's Big-eared Bats

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As part of the Lower Colorado River Multi Species Conservation Plan (LCR MSCP), California leaf-nosed and Townsend's big eared bats were captured at mine roosts in California near the now predominantly agricultural LCR floodplain. Holohil transmitters were attached, and the bats were tracked using aircraft and ground-based telemetry for four sessions of 2-3 weeks each in summer and winter of 2015 and 2016. Individual bats demonstrated fidelity to certain foraging areas and some travelled minimum distances of 70 km in a single night. The bats foraged in relatively undisturbed native desert vegetation as well as over agricultural areas, within which they often concentrated activity in remnant riparian vegetation, such as incised channels of the historic LCR floodplain. Bats captured in mist nets and tagged while foraging in California and Arizona in Bureau of Reclamation habitat creation areas of planted native cottonwood and willows were tracked to diurnal roosts in mines, shallow caves (inaccessible to ground trackers) and to the interior chambers of an interstate highway bridge over the LCR.

Are Bats Acoustically Challenged by Mine Closures Using Corrugated Culverts?

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Bat-compatible closures have been installed in thousands of caves and mines across North America to prevent human entry due to considerations for safety and resource protection. However, not all types of cave and mine closures are acceptable to all species of bats, and suitability may depend on colony size as well as closure size and design. Some bat colonies abandon a roost after installation of gates set in corrugated culverts.

Echolocating bats routinely fly through complicated natural scenes, such as vegetation, which present multiple sources of echoes. Obstacle-avoidance tests in the laboratory at Brown University have sought to mimic the spatial complexity of natural scenes while also offering better quantitative environmental control. Bats are able to negotiate even the most complex, cluttered experimental scenes while adapting their emissions to the requirements of prevailing echo sequences. Echoes reflected by hoops (similar to the raised ring pattern of culvert corrugations) have unique characteristics that interfere with perceiving that the path forward through the center of the ring is unobstructed. Flight tests were conducted with big brown bats in a 5.4 m long tunnel consisting of a long row of 36 hula-hoops 90 cm in diameter spaced at regular intervals of 15 cm. Naïve bats are confused by the hoops and exit rapidly with violent flight maneuvers, abruptly swerving to exit between adjacent hoops. Interpulse interval of echolocation signal patterns reveal that the bats consider the task to be very difficult with regard to perceptual ambiguity associated with scene density and spatial extent.

Monitoring Western Bats in the face of White-nose Syndrome

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The eastern U.S. has sizeable deposits of limestone with exponentially more caves than are found in western states. Eastern scientists have conducted winter census counts for decades and have documented sites with thousands of hibernating bats. In contrast, western bat hibernacula are poorly understood. This may be due to the remoteness of western landscapes where bats hibernate. As white-nose syndrome (WNS), caused by *Pseudogymnoascus destructans*, swept through the East, western biologists recognized that it was critical to locate and monitor bat hibernacula. The West has diverse winter roosts varying from sites with 1-10 individuals to some with >2,000 hibernating bats. In Arizona and New Mexico we take a conservative approach to roost monitoring because we believe that unnecessary disturbance to check for WNS is, in itself, detrimental to bats. We conduct biennial census counts at hibernacula with a small group of experienced personnel. The predominant species we observe are *Corynorhinus townsendii* and *Myotis velifer*. *Corynorhinus townsendii* tend to roost as singles or in small clusters but *M. velifer* hibernate in large clusters (300± individuals) in microclimate ideal for *P. destructans*. We monitor roost microclimate passively using programmable data loggers, which we download during pre- or post-hibernation when few bats are in residence. Since 2011 we have swabbed 14 bat species to determine their natural pre-WNS microbiota across six western sites. We swab bats during post-hibernation when few individuals remain in a roost. Our motto is “don’t monitor hibernating bats to death” merely to detect a fungal pathogen for which we currently have no treatment.

Western Bats as a Reservoir of Actinobacteria Species with Antifungal Activity

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White-nose syndrome (WNS) is an invasive bat disease caused by the fungus *Pseudogymnoascus destructans*. To date, this wildlife disease has killed more than six million bats across 29 U.S. States and five Canadian Provinces. Prior to the arrival of *P. destructans* to western states, we determined the naturally occurring microbiome on 14 bat species sampled across five distinct areas in New Mexico and Arizona. The results showed high numbers of Actinobacteria present on many bats. Because at least two-thirds of our natural antibiotics today are derived from Actinobacteria, often from the genus *Streptomyces*, we focused on the possible health benefits of Actinobacteria on bats. Actinobacteria are ubiquitous and abundant in cave systems and may contribute to the microbiome of cave-roosting bats. In this study, we isolated naturally occurring Actinobacteria from 101 WNS-free bats. We sequenced the 16S rRNA region and tested 632 isolates from 12 different bat species using a bi-layer plate method to evaluate antifungal

activity. Thirty-six Actinobacteria either inhibited or stopped the growth of *P. destructans* with 32 (88.9%) belonging to the genus *Streptomyces*. Twenty-five of the isolates with antifungal activity against *P. destructans* represent 15 novel *Streptomyces* spp. based on multi-locus sequence analysis. Our results suggest that bats in western North American caves may possess novel bacterial microbiota with the potential to inhibit *P. destructans*. USGS: This information is preliminary and is subject to revision.

Acoustic Monitoring for Bats in Alaska's National Parks

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Little is known about the bats of Alaska's National Parks, their abundance, distribution, and habitat. Bats are seen in the night skies above the parks and been found roosting in abandoned buildings and other structures, but we do not know whether they are year-round residents or if they migrate to the coasts and southward for the winter. Knowing their range is vital for determining if they may interact with White Nose Syndrome infected bats from farther south. We established 7 acoustic monitoring sites across 5 parks in 2015 and 17 sites across 6 parks in 2016 to identify areas for more intensive work, including possible mist netting. Detectors were placed as soon as the sites were accessible and were left out for the full summer season (generally through late September or early October). The number of call in 2015 were: Denali (2 sites) - 0; Katmai - 3,807; Kenai Fjords - 15; Lake Clark (2 sites) - 413; and Yukon-Charley - 0. In 2016: Bering Land Bridge (2 sites) - 0; Denali (2 sites) - 0; Katmai - 17,947; Kenai Fjords - 224; Klondike Gold Rush (9 sites) - 710; and Lake Clark (2 sites) - 5,198. With the exception Klondike Gold Rush sites, all of the calls were consistent with little brown bats. More analysis is needed to evaluate the other potential species calls in Klondike Gold Rush. Future plans also include adding more sites in additional park units and conducting road transects along the only three vehicle accessible park roads.

Crucial Hibernacula for Bats in Southern Idaho: Implications for Conservation and Management

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Bat populations are being impacted by human disturbance and modification of hibernacula. Identifying important hibernacula and counting hibernating bats are effective ways to conserve these mammals. We compiled periodic counts of hibernating bats during winter (November to March) in 68 caves from 1984 to 2015 to document the number of caves used by bats and to investigate if the number of bats hibernating varied by colony size. Researchers counted 37,616 bats representing 6 species. Townsend's big-eared bats (*Corynorhinus townsendii townsendii*) comprised 96.8% (36,395 individuals) of those bats and used 57 caves. Western small-footed myotis (*Myotis ciliolabrum*) comprised 3.1% (1,069) of those bats and used 22 caves. Thirty caves were substantial hibernacula (≥ 20 individuals) for Townsend's big-eared bats, and five caves were substantial hibernacula (≥ 5 individuals) for western small-footed myotis. Kid's Cave ($\bar{x} = 1,500$, $SD = 509.4$, range = 619 to 1,994 individuals) has the largest hibernating colony of *C. t. townsendii*. Fool's Wading Pool ($\bar{x} = 87$, $SD = 51.4$, range = 32 to 146 individuals) has the largest hibernating colony of *M. ciliolabrum*. Smaller hibernating colonies varied more in the number of bats counted than did larger colonies. We document one of the largest densities of caves used by hibernating bats in the western USA. As well as possibly the largest reported hibernacula for Townsend's big-eared bats and western small-footed myotis in their distributions. This information provides important context regarding hibernating bats prior to major threats (i.e., white-nose syndrome) occurring in southern Idaho.

Use of Miniature GPS Tags and Data Loggers to Track Microbats Long-term

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Tracking broad-scale movement of microbats is limited by transmitter technology and long-term attachment methods. This limitation inhibits understanding of bat dispersal and migration, particularly in the context of emerging conservation issues like wind turbine fatalities and disease, such as white-nose syndrome. We tested a novel method of attaching lightweight global positioning system (GPS) tags and geolocating data loggers to small bats. We sutured GPS tags and data loggers to the skin of anesthetized big brown bats (*Eptesicus fuscus*) in Colorado and hoary bats (*Lasiurus cinereus*) in California. Tags or data loggers were sutured to 17 bats. Three tagged bats were recaptured seven months after initial deployment, with tags still attached, and no apparent ill effects from the tag. No injuries were apparent upon recapture of six additional bats that carried tags up to 26 days. Results from GPS tags illustrated remarkable movement patterns of male hoary bats, including one that completed an over 1000km round trip journey. Data loggers allowed us to record sub-hourly patterns of activity and torpor use, in one case over a period of 224 days spanning an entire winter. In this bat, we documented 4 torpor bouts that lasted ≥ 17 days including one that lasted 39 days. Using miniature tags on small bats demonstrated that male hoary bats make multi-directional, long distance movements during the migratory season and may hibernate during winter at similar temperatures to those common during active times of the year.

Managing the Spread of *Pseudogymnoascus destructans* and Conserving Bats Threatened by White-nose Syndrome in North America

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White-nose syndrome (WNS) is an infectious disease, caused by the fungus *Pseudogymnoascus destructans* (*Pd*), which is responsible for decimating hibernating bat populations in eastern North America. WNS continues to spread and now has been confirmed in 7 North American bat species in 30 states and 5 Canadian provinces. The fungus infects torpid bats resulting in physiological and behavioral impacts, often leading to mortality. Corresponding population declines exceeding 90% have been documented at many hibernacula. *Pd* was likely recently introduced to North America and it has been documented on numerous bat species across Europe and Asia. Coordinated plans in both the U.S. and Canada provide the framework for a comprehensive North American response and working groups have been established to address the research and management needs for affected bats. The U.S. Fish and Wildlife Service is the lead federal agency coordinating the response to WNS in the U.S., and since 2008 has provided considerable technical and financial assistance to researchers, states, and federal agencies to address WNS. These coordinated efforts have served to advance our understanding of bat hibernation physiology, population dynamics, disease ecology, and general bat behavior, with the goal of developing effective disease treatment and management strategies. Recent documentation of WNS and *Pd* in Washington State marks the first detection in western North America. Combined with the relative lack of knowledge about western bat hibernation behavior as compared to eastern species, this detection highlights the need for increased coordination and collaboration in western bat research, management, and conservation.

Recognizing Bat Social Calls

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Acoustic identification of bats is generally based on echolocation calls, as these are the best understood

and the most often encountered. Yet social calls can be important, because they can either confuse or assist identification. Social calls are just sounds which are not normal echolocation calls. Many of these are broadband squawks, but the current subject is those with a simple frequency content. These fall broadly into two categories, according to whether or not they also have an echolocation function. Calls sharing an echolocation function may be like echolocation calls, but with additional features such as initial or terminal upsweeps, variations in slope or the addition of subharmonics. Others differ greatly in frequency or shape, and may resemble echolocation calls of unrelated species. Social calls without an echolocation function are usually very different from echolocation signals and often at much lower frequencies. Such calls emitted during flight must not interfere with echolocation and are typically brief. Calls from stationary bats can be very long. No single rule will allow recognition of social calls, but temporal patterns can be very helpful. While many are obvious, others require an intimate understanding of bat echolocation.

A West-wide Perspective on Subterranean Roost Conditions

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Having surveyed thousands of mines and caves across the western US (WA, OR, ID, MT, WY, CO, UT, NV, CA, AZ, NM) I will briefly cover the range of internal climatic conditions found in sites that were identified as bat roosts. Roosts varied from shafts to adits to caves with temperatures ranging from 20°F - 85°F and relative humidity levels from 10%-100%. Elevation of sites was from near sea level to 12,000'. Bats and bat sign have been positively identified in all of these conditions highlighting the immense roosting diversity represented across the west. The broad range of conditions presents challenges for creating a comprehensive WNS management strategy as bat behavior, roost conditions, and weather conditions defy current commonly encountered conditions in nearly all WNS positive states.

Ultraviolet illumination as a means of reducing bat activity

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Tree-roosting bats die often at the blades of wind turbines, but reasons for this higher susceptibility of 'tree bats' remain unknown. One possibility is that bats might not be able to discriminate wind turbines from trees. Attraction from afar may be a chronic problem of bat fatalities at wind turbines, because distant attraction could act against or beyond the influence of many curtailment and deterrence strategies. Despite low visual acuity, bats navigate by vision and can see the silhouettes of trees from great distances in darkness, a plausible distant-attraction cue. Furthermore, bats see light in the ultraviolet (UV) spectrum. We integrated these concepts and are pursuing the possibility that dim UV light that is not visible to humans or birds can be used to visually enhance turbines so that bats perceive them differently from long distances. Decreasing visual resemblance between turbines and trees at night might keep bats from approaching and perishing at turbine blades. This talk will detail our ongoing, multi-year effort to assess the practicality of using dim UV light to keep tree bats from turbines. Our promising results thus far have us moving forward with this research and we are now planning a full efficacy trial on operating wind turbines.

Molecular Analysis of the Diet of *Parastrellus hesperus*

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The documented diet of *Parastrellus hesperus* is largely based on a single conventional identification effort that identifies eight orders and twenty-three families of prey items including caddis flies, stoneflies, moths, small beetles and flies. Our objectives were to use a molecular approach to analyze the diet of

Parastrellus hesperus, the American parastrelle, and to determine if the diet varied across sex and age-classes. We collected guano pellets from a total 147 *P. hesperus* from May - July 2015 over nine nights in Big Bend National Park. We then sequenced a fragment of the cytochrome c oxidase gene from the fecal pellets of 79 individuals and inferred the identity of prey items from voucher sequences in DNA reference databases. Using conservative molecular identification criteria, we assigned molecular operational taxonomic units to eight orders, 28 families, 36 genera and 27 species of arthropods of which two orders and 20 families contain new prey items for *P. hesperus*. We observed no dietary differences between the age-classes or across female reproductive condition. However, we found significant variation in the diet between males and females.

Winter Activity of Bats outside Nine Desert Caves in Idaho

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Documenting activity patterns of hibernating bats in western North America is important for understanding the behavioral ecology of these mammals, especially before white-nose syndrome affects some of these species. Few published studies describe winter emergence activity at bat hibernacula entrances. We acoustically monitored 9 lava tube caves that are important hibernacula (up to 705 hibernating bats) in southeastern Idaho during winter (November to March) from 2011 to 2015. At those caves, Anabat detectors operated for a total of 1620 nights, resulting in the generation of 278,000 files. We used noise and species filters in AnaLookW to quantify exit flight activity and documented western small-footed myotis (*Myotis ciliolabrum*), Townsend's big-eared bat (*Corynorhinus townsendii*), big brown bat (*Eptesicus fuscus*), little brown myotis (*Myotis lucifugus*), and western long-eared myotis (*Myotis evotis*) flying outside of caves during winter. Big brown bat (*Eptesicus fuscus*), little brown myotis (*Myotis lucifugus*), and western long-eared myotis (*Myotis evotis*) have not been detected in study caves during internal hibernation counts spanning 30 years. Activity was highly sporadic and differed among species, with western small-footed myotis being most active during winter (call files = 2,538), followed by Townsend's big-eared bat (call files= 959). Our study documents activity patterns outside of caves for several species of bats during hibernation. These results suggest that acoustics may be a better method to detect the presence of some species hibernating in western caves and provide unique insight into the behavioral ecology of these species in western North America prior to white-nose syndrome's onset.

Winter Occupancy Trends of Hibernating Cave Myotis in the South Central Great Plains

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Monitoring hibernating bats to establish baseline population estimates became a high priority for many states with the arrival of White-nose Syndrome (WNS) to North America in 2006. The Texas Parks and Wildlife Department initiated annual winter surveys in the Texas panhandle in early 2012 to estimate wintering bat numbers and to conduct WNS surveillance. Oklahoma researchers began monitoring hibernacula in western Oklahoma, near the Texas panhandle, in 1988, with WNS surveillance beginning in 2009. Cave myotis (*Myotis velifer*) hibernate in high numbers in 12 gypsum caves in this region. This species forms large, dense clusters during hibernation and occupies a microclimate that is within the optimal range of growth of *Pseudogymnoascus destructans*, the causative agent of WNS. These attributes might make the species vulnerable to WNS, elevating its priority in monitoring and surveillance efforts. Combined, this is the largest known dataset to track winter occupancy trends for this species. Significant interannual variation was documented at both the individual hibernaculum and regional scale. Total counts ranged from 67,656 *M. velifer* detected in 2012 to 189,349 *M. velifer* in 2015. Such variation

suggests that there are additional, unknown hibernacula in the region and significant movement between hibernacula. Additional winter surveys have been conducted in southern Kansas and we hope to incorporate those data into this dataset for a more complete understanding of winter occupancy for this species in the region. With these, we will be able to assess the scope of impact from WNS on this species in the region.

Region-Wide Western Bat Working Group White-nose Syndrome Surveillance Activities

Katie Gillies

Bat Conservation International, Austin, Texas

The confirmation of White-nose Syndrome (WNS) in Washington state in 2016 initiated increased communication, coordination and surveillance activities in Western Bat Working Group (WBWG) states and provinces. WBWG members represent states and provinces from a vast landscape with varied capacities, resources, and needs. I developed a survey to assess what WNS surveillance activities each state conducted in winter 2016-2017. Eighteen states received the survey and 13 states responded. The survey results compile: 1) western participation in national, regional, and local WNS surveillance studies, 2) identify the kinds of samples collected in western states, 3) the estimated number of hibernation sites visited by western agencies, and 4) what kinds of sites are being surveyed for WNS in the western landscape. This survey provides a framework of the western region's WNS surveillance participation.

Tailoring the analysis of bat acoustic recordings to ecological research goals: effects of changing software parameters

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Acoustic monitoring of bat echolocation calls is a non-invasive technique that allows for estimates of bat activity to be surveyed at remote locations over long periods of time. Acoustic surveys have become central components of many bat research and monitoring programs, resulting in large repositories of bat acoustic data, such as the National Park Service Bat Acoustic Survey Database. Several software packages are available for bat call analysis, allowing for automated and efficient analysis of large acoustic datasets. Although this software is user-friendly, there is a range of parameter specifications at each of multiple steps, the effects of which have not yet been fully explored. This uncertainty makes it difficult to decide among settings and interpret results in the context of specific research questions. Here, we used two years of bat acoustic data from Agate Fossil Beds National Park to examine how altering the parameters within the bat call analysis software SonoBat changes estimates of bat activity, false positive and negative rates, and species richness. We found that changing acoustic analysis parameters had an effect on estimates of bat activity, notably an underestimate when using more stringent filter parameters. Our results indicate parameter selections are important when analyzing bat acoustic data and should be considered in light of project goals. Therefore, we produced a decision tree to guide selection of SonoBat parameters in order to best answer specific research questions. Finally, standardizing the analysis of bat acoustic data in large acoustic databases will allow for comparable data at large scales.

Estimating Bat Species Occupancy and Habitat Use in the Great Basin

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Species distribution and habitat use of chiropteran species in Western North America remain understudied and poorly understood. Passive acoustic monitoring of bat echolocation calls presents a more cost and effort efficient approach relative to live captures and direct counts. Monitoring was conducted over two summers across two elevation transects within and adjacent to Great Basin National Park, covering 32

sites. Individual sites were determined using spatially balanced randomization within a buffer distance to roads and trails. All acoustic calls were recorded with Pettersson D500x bat detectors, and processed with SonoBat species classification software. Occupancy probability, detectability, and predictive site- and observation-level covariates were assessed using R statistical package Unmarked. Future usage of these methods over larger networks of sites, such as that proposed by the North American Bat Monitoring Program would provide greater landscape and regional scale understanding of bat diversity and distribution in North America.

Winter Bat Activity in a Landscape without Traditional Hibernacula

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Prior to 2014, bat research at Devils Tower National Monument (DETO) focused on species inventories conducted in the summer. It had long been assumed that bats were summer residents only, due to the lack of caves, mines, or other “traditional” hibernacula. Passive acoustic monitoring and emergence surveys have now shown that bats are present at DETO in the winter months, particularly near the Tower feature. Winter activity is greatest during the swarming period, from September to mid-October, and emergence in late April. A variety of complex social calls have been detected during these periods. Bats have been recorded consistently throughout the winter, with approximately 200 bat passes per month recorded at two sites near the Tower feature in 2015. In the winter of 2016, which has been much colder than 2015, bat echolocations have continued to be recorded in the same monitoring locations. Species detected during the winter months include a variety of *Myotis* species, as well as *Eptesicus fuscus* and *Lasiurus noctivagans*. Additionally, summer radio telemetry work and rock climbing surveys have confirmed that bats are using cracks and crevices in the Tower formation and the sprawling talus field beneath it. Based on these findings and the winter acoustic data, it is likely that bats are hibernating in the Tower rock feature, the talus boulder field, or both, during the winter months. Additional work is planned in 2017 to investigate this hypothesis.

Recovering America's Wildlife Act of 2016 and What Passage of the Act May Mean to You and the Bats You Love

Lauri Hanauska-Brown

Montana Fish, Wildlife and Parks, Helena, MT

In 2015 the Association of Fish and Wildlife Agencies organized a panel of 26 national business and conservation leaders to examine the current system of conservation funding and recommend a new mechanism to conserve all fish and wildlife. Known as the Blue Ribbon Panel on Sustaining America's Diverse Fish and Wildlife Resources, the group recommended Congress dedicate up to \$1.3 billion annually in existing revenue from the development of energy and mineral resources to the Wildlife Conservation and Restoration Program. These funds would be awarded to state wildlife management agencies for wildlife related conservation, recreation and education projects that benefit all wildlife species and their habitats, including bats. Federal House Bill 5650 “Recovering America's Wildlife” act was introduced in the fall of 2016 but needs to be reintroduced in 2017. If passed and fully funded, the federal act would bring \$3 to \$64 million dollars annually to each state. Many of the Western states would receive more than \$20 million dollars each year but would need to secure nonfederal match at a rate of 25%. Proactive and partner based projects will be critical to ensure the best use of these funds but prior to that a broad based effort to pass the act is needed. Bat enthusiasts, recreational cavers, agricultural industry representatives, developers, researchers, and others will be needed to argue it is in everyone's best interest to keep species from becoming federally listed and to keep wildlife and habitat healthy.

A Risk Analysis Framework for Considering the Potential Spread of White-Nose Syndrome in Western North America

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Risk analysis has been extensively used to evaluate the potential spread and impacts of wildlife diseases and invasive species. Risk analysis for wildlife diseases and invasive species involves the following steps: problem description; hazard identification; risk assessment; risk management; risk communication; and implementation and review of the risk analysis process. The risk assessment step includes evaluation of the likelihood that a pathogen will be introduced into a given area of concern, the likelihood that a given species will be exposed to the pathogen, and the possible consequences of such exposure. Although species distribution models (SDMs) and maps have been extensively used in ecological and conservation research, they have not commonly been used as a tool in the risk assessment process. We discuss a risk analysis framework for considering the potential spread of white-nose syndrome (WNS) in western North America, focusing on SDMs as quantitative tools to support the risk assessment phase of risk analysis. We are using presence-only occurrence data to develop species distribution models (SDMs) for each of 7 bat species known to be affected by WNS in North America: big brown bat (*Eptesicus fuscus*); eastern small-footed bat (*Myotis leibii*); gray bat (*Myotis grisescens*); Indiana bat (*Myotis sodalis*); little brown bat (*Myotis lucifugus*); northern long-eared bat (*Myotis septentrionalis*); and tricolored bat (*Perimyotis subflavus*). We discuss how these models and maps can be combined to consider potential patterns of WNS spread in western North America and provide insights into opportunities for early detection, rapid response, and containment efforts.

The Application of Acoustic Detection Technology for Bat Conservation: The goals, challenges, and needs of land and natural resource management agencies (summary of discussion at 2017 Bat Echolocation Symposium)

Bronwyn Hogan

United State Fish and Wildlife Service, Sacramento, California

I will summarize the presentations and discussion from the agency session at the Bat Echolocation Symposium which will address the following:

Land and natural resource management agencies are tasked with making decisions regarding conservation and management of bats and their habitats. Those decisions have to be made using the best available data, which usually is far from ideal. We will present a case study or two discussing agencies' applications of acoustic monitoring. After an overview of agency needs and issues around acoustic surveying, we hope to have a facilitated discussion to exchange information and views. We would like to come out of the discussion with guidance for managers on how to evaluate and use acoustic data. Some of the categories of questions and issues that management agencies face when thinking about the use of acoustic data are:

1. What kind of management questions are acoustic data being used for?
2. What are the ongoing and upcoming efforts to improve understanding of the biological limitations of echolocation data?
3. Do we understand technical limitations of echolocation data?
4. How do we best account for those biological and technical limitations?
5. How do we as a community improve efficiency, accuracy, and standardization of large-scale data processing?

NABat and Stats: Exploring and Improving Statistical Guidance in “the Plan”

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The NABat plan outlined an ambitious omnibus program for monitoring bats across North America. As with any static document outlining a dynamic program, revisions and updates are required to remain relevant and useful. We present our recently published statistical work that informed the modified NABat survey design used by Bat Grid 2.0 (91 sample units with at most 4 revisits) in Oregon. Based on 2016 stationary acoustic data, single species occupancy model estimates appeared adequate for three of the four species investigated (*Lasiurus cinereus*, *Lasionycteris noctivagans*, *Myotis lucifugus*). However, for *Myotis volans* (MYVO) the estimated detection probability was low (~0.30) and would suggest increasing the number of revisits to 8 or more to properly draw statistical inferences. More revisits would substantially increase programmatic costs and optimize the design for only harder to detect species. An alternative approach is to “borrow information” among species using a multi-species hierarchical occupancy model. Compared to using single species models as suggested by the NABat plan, this approach improved MYVO inferences and produced similar estimates for the other species. Our preliminary results suggest Bat Grid 2.0 is poised to accomplish its objectives in Oregon and maintain its alignment with the NABat program. We also provide an update on other statistical research and development we are conducting to further improve guidance and “best-practices” for NABat.

Large-scale Winter Acoustic Monitoring in Colorado

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In response to the westward movement of White-nose Syndrome, Colorado Parks & Wildlife started collecting baseline information on the hibernating bat species in the state. One of the projects undertaken was a large-scale acoustic monitoring effort conducted at 30 known winter roosts to determine the current level of bat activity during winter months. Between 2011 and 2016, ultrasonic acoustic monitors were deployed at sites from January 1 until March 31 each year. Data was analyzed to determine the timing and level of bat activity throughout the monitoring period. Bat activity was found to be higher than expected during the winter months and ranged widely by site. Developing standardized protocols for deployment and call processing raised a number of issues including how to deploy and power acoustic monitors at remote backcountry locations for 3 winter months, how to process large volumes of multi-year acoustic data, how to deal with site-specific problems of noise, and the ability to use acoustic monitoring of known winter roosts as an early warning system for the arrival of White-nose Syndrome. Changes in site access, equipment, processing software, and staff presented challenges to monitoring at a large scale over an extended time period.

Identifying and Characterizing Roosts of *Lasiurus ega* and *Lasiurus intermedius*

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Previous research has demonstrated the southern yellow bat (*Lasiurus ega*) to roost in the dried fronds of native palms (*Sabal mexicana*) and non-native palms (*Washingtonia robusta*). Roost use by the northern yellow bat (*L. intermedius*) is similar, with the addition of Spanish moss (*Tillandsia* spp.). In urban areas of Texas’ Lower Rio Grande Valley, fronds of both palm species are routinely trimmed during landscaping thereby potentially eliminating critical roosting habitat. Our objective was to identify and

quantitatively characterize the diurnal roosts of *L. ega* and *L. intermedius* in the Lower Rio Grande Valley of Texas. Through radio-telemetry from May – November of 2015, we located 20 roosts in *S. mexicana* palms used by eight yellow bats. Comparison of characteristics between roosts and randomly selected palms showed that yellow bats selected sabal palms with significantly taller, thicker frond skirts, and narrower trunk diameters. From our study, we created a predictive model that will allow land managers and landscapers to assess the potential use of palms by yellow bats prior to frond trimming.

Searching for Natural Defenses (Actinobacteria) Against White-Nose Syndrome, Found on Bats at a Gateway to the West

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Since 2006, millions of eastern North American bats have died from white-nose syndrome (WNS), caused by the fungus *Pseudogymnoascus destructans*. This disease has spread westward across 29 states and 5 provinces in the United States and Canada, respectively. A recent study on the external microbiota of bats from the Southwest revealed the presence of many Actinobacteria, some of which produce antifungal properties against *P. destructans*. All of the sample sites in that study came from southern and western New Mexico, as well as from northern and southeastern Arizona. Despite this, we believe that one pathway for WNS to enter into the Southwest would be through northeastern New Mexico and southeastern Colorado, which we regard as the northeast corridor of New Mexico. In 2016, we sampled bats for external bacteria, targeting Actinobacteria, from Capulin Volcano National Monument (CAP), and Pecos National Historic Park (PEC), and Bent's Old Fort National Historic Site (BEOL) within this northeast corridor. Herein we document new records of occurrence of bats and bacteria found on 23 bats belonging to seven different bat species occurring on CAP, PEC, and BEOL. From our analyses of bacteria we found that our bat samples contained seven dominant bacterial phyla including Acidobacteria, Actinobacteria, Bacteroides, Cyanobacteria, Firmicutes, Proteobacteria, and Synergistetes. NMDS plots showed that microbiota within a location were similar. However, some bat species share common microbiota despite being from different locations. Upon closer examination of Actinobacteria, we documented 324 isolates with *Streptomyces* representing the dominant genus and comprising about one-third of these.

USGS: This information is preliminary and subject to revision.

Winter and summer torpor in a free-ranging subtropical desert bat, *Myotis vivesi*

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Use of torpor likely favors the survival of subtropical bats in harsh environments. The fishing myotis (*Myotis vivesi*) is a species endemic to desert islands in the Gulf of California, where summers are extremely hot and winters are cold and windy. We explored thermoregulating abilities of *M. vivesi* measuring skin temperature (T_{skin}) on free-ranging individuals in winter 2010 and 2011, and in summer 2010. We also measured ambient (T_a) and roost (T_{roost}) temperatures during the study, and we obtained data for wind speed at night time during winter periods. We found that all bats entered torpor in both winters and that at least three individuals hibernated for several days, which had not been reported previously for bats in subtropical deserts. In summer, three individuals entered short bouts of shallow torpor in early mornings. Roosts were slightly warmer than T_a in winter at nighttime, and in summer they never reached temperatures > 38.7°C, even at T_a ≈ 45°C. Roost occupancy in winter was higher during windy nights in 2010 but no pattern was found in 2011. Therefore, in winter fishing myotis were more

likely to remain in their night roosts and enter torpor when ambient conditions (e.g., strong winds) limit fishing on marine waters. In summer, roosts provide good insulation against high T_a , and bats might not need to resort to torpor to lower their metabolic rate except for a brief period during early mornings. When resources are limited the use of torpor may increase this insular species' chances of survival.

Crevice-roosting bats: hibernacula and winter flights

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In western Canada, there are many bat species for which no winter roosts have been located. BatCaver, a Wildlife Conservation Society Canada program to locate bat hibernacula in western Canada, has been successful in locating some cave and mine hibernacula for bats in British Columbia (BC), Alberta and Northwest Territories, but this accounts for a relatively small number of bats and only a handful of species. Many species of bats are thought to use crevice roosts in winter for hibernation, yet the extent of use of crevices by bats is largely understudied, and hibernacula are undescribed. Understanding what microclimates bats hibernate in when they are using crevice roosts is pivotal to determining the risk that white-nose syndrome poses to western species. Bats hibernating in crevices are likely to experience different conditions and consequently different winter behaviors than bats hibernating in caves or mines. Using radio-telemetry, we documented crevice hibernacula and winter ecology for big brown bats, silver-haired bats, and California myotis. Silver-haired bats showed the highest level of plasticity in types of winter roosts, using a combination of rock crevices, mines, and tree bark, in southeastern BC. California myotis used rock crevices and mines. Big brown bats used riparian rock crevices in a dry area of southern Alberta. Bats showed a high degree of fidelity to roosts within and between years. Bats were tracked with temperature-sensitive transmitters and arousal rates were measured. Bats aroused frequently, not always flying during their arousals. Higher arousal rates were generally observed in southern BC compared to the big browns in southern Alberta.

Long-eared Bat Taxonomy: Nuclear Genetic Evidence Eliminates the Species Status of Keen's Myotis

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Four species of long-eared myotis bats occur in British Columbia: Keen's Myotis (*Myotis keenii*), Northern Myotis (*M. septentrionalis*), Long-eared Myotis (*M. evotis*), and Fringed Myotis (*M. thysanodes*). *Myotis keenii* and *M. evotis* are especially difficult to tell apart in the hand in areas where the species are sympatric. Field differentiation is desired given the 'vulnerable/sensitive' conservation status listings of *M. keenii* across its range, versus the 'secure' listing of *M. evotis*. Small differences in skull morphology, coloration, and mitochondrial DNA have been used to try to distinguish the 2 species, but it has been unclear as to whether species distinction is biologically warranted. To examine this question, we genotyped 257 long-eared myotis samples at 14 microsatellite loci. Samples were obtained from across the range of *M. keenii* along the BC, Alaska and Washington coasts, and long-eared myotis were sampled as far east as Alberta. We identified 195 of these samples as potential *M. keenii* or *M. evotis* based on morphology. We also included 24 Little Brown myotis (*M. lucifugus*), as a closely related outgroup. We plotted all genotypes in Genetix (factorial correspondence analysis) to observe the nuclear population genetics relationships. Four distinct clusters, representing 4 species were delineated: *M. septentrionalis*, *M. thysanodes*, *M. lucifugus* and a mixed cluster of *M. keenii*/*M. evotis*. The highly mixed cluster of all potential *M. keenii* and *M. evotis* provides clear evidence that these individuals

represent a single species that interbreeds. A few cases of hybridization between *M. thysanodes* and *M. evotis/keenii* were also noted.

Winter bat activity in western Canada

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An increasing number of studies report winter flights by some species of bats. In western Canada, species that we most often recorded on bat detectors in winter were big brown, silver-haired, Townsend's big-eared, California myotis, and Western small-footed myotis. Weather conditions of flights varied, although warmer winter temperatures were associated with more bat activity. Through capture at some locations, we confirmed the presence of species difficult to tell acoustically; for example, we determined that big brown bats, not silver-haired bats were active in southern Alberta, and that both species were active in southern British Columbia. While California myotis and Yuma myotis are acoustically similar, especially when recorded near roosts, we were able to confirm some winter roosts of California myotis. We explore the possible reasons for winter flights of big brown bats, silver-haired bats, and California myotis, focusing largely on the latter species, for which freshly produced guano was collected in mid- to late winter. Using genetic analysis of prey items in the guano we found no evidence to support feeding mid-winter, but instead propose they may be defecating fall stomach contents gradually throughout the winter when body temperatures are high and digestion completes. Nightly (but not daily) visitation of some mines by California myotis during winter, as determined through stereo acoustic recordings and guano collection, suggests that crevice-roosting individuals of this species enter mines at night to fly under cover, lending further support to a fundamental need for flight during winter, and highlighting potential adaptations of this species to reduce predation risk during this risky behavior.

Conservation of Endangered Pollinators: Designing Community “Bat-friendly” Agave Management Programs in Northeast Mexico through Interdisciplinary Research

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In northeast Mexico, agaves (*Agave spp.*) are harvested from the wild and cultivated for market products and other cultural uses by rural communities. However, harvest of agaves may be contributing to declines of the endangered Mexican long-nosed bat (*Leptonycteris nivalis*), which feeds on the nectar of agaves. “Bat-friendly” agave management, such as allowing some agaves to flower or replanting wild agaves, can potentially be encouraged within local communities to help conserve the species. This research integrates ecological and social science methods to understand where and how “bat-friendly” management practices could be implemented in northeast Mexico. The specific objectives are to: 1) create statistical models of bat foraging rates at agaves that can be used to design high quality forage resource areas and 2) identify potential incentives for promoting adoption of “bat-friendly” practices in local communities. In a pilot study, I monitored bat feeding activity at flowering agaves with infrared cameras and conducted key informant interviews with community leaders and agave harvesters to understand current management practices. Preliminary results from the foraging study suggest that bats prefer habitat patches with higher densities of flowering agaves, supporting the clustering of flowering agaves in “bat-friendly” programs. Preliminary results from the community work show that each community has differing social, political, and economic contexts, highlighting the need for locally-tailored approaches to promoting “bat-friendly” practices. A full field season is planned for summer 2017 to follow up on these results. Ultimately, this research will help inform conservation efforts for the endangered Mexican long-nosed bat.

An Examination of Fungal Diversity of Resident and Migratory Bat Species in Colorado

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A number of studies have attempted to provide insight about the establishment of Pd by focusing on the fungal community composition present on bats over-wintering in geographic areas where WNS is known to occur. However, little is known about fungal community diversity in western bat species where WNS is absent. Our research is intended to 1) characterize the fungal community composition of Colorado bat species, and 2) monitor for the presence of Pd in these populations. Since 2013, we surveyed resident and migratory populations of bats from 6 study sites throughout Colorado and have collected fungal spores from 224 individuals from species including *Eptesicus fuscus*, *Lasiurus cinereus*, *Lasionycteris noctivagans*, *Myotis evotis*, *M. lucifugus*, *M. volans*, and *Tadarida brasiliensis*. We used DNA sequence barcoding analysis for taxonomic identification of cultured fungal spores and, based on 975 fungal isolates, have developed an initial characterization of the mycobiome of Colorado bats. Our results indicate that there are pronounced differences in fungal community composition across bat species, seasons and age classes. We isolated a number of fungal species that are capable of growing at low temperatures, indicating that Colorado bats harbor viable psychrophilic fungi and that these spores can be collected outside of the winter season. Comparing our results to similar studies conducted in regions of the US that are affected by WNS will improve our understanding of how Pd can become established in healthy bat populations. Furthermore, results of our study can be used to develop recommendations for future Pd monitoring efforts in Colorado.

Acoustic Bat Activity and Fatality Estimates from Post-Construction Monitoring at a Montana Wind Farm

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Montana's wind resource is among the top 5 in the nation, with predicted production rising to 5,261 megawatts (MW) by 2030. However, this method of green energy is not environmentally neutral as bat fatalities have been found at wind farms across the nation. Tree roosting bats such as the hoary bat (*Lasiurus cinereus*) and silver-haired bat (*Lasionycteris noctivagans*) have been shown to have high mortality at wind farms, and are on Montana's Species of Concern list. In June 2015, we began assessing wildlife impacts at a 40 MW wind farm located in central Montana. We deployed 2 acoustic bat detectors to examine year-round activity patterns. We analyzed call sequences to determine when bats were most active and species present at the site. To monitor bat fatalities, we conducted weekly carcass searches May-September, 2016. Bat fatality was estimated by adjusting raw carcass counts for searcher efficiency and carcass persistence bias using the Huso (2011) Fatality Estimator software. Bat activity peaked in August; we documented the presence of 6 species at a water source near the turbines, but only 4 in proximity of the turbines. In contrast, just two species were found during carcass searches, Hoary Bats and Silver-haired Bats. The mean fatality estimate for the site over the five-month monitoring period was 221 bats (95% CI: 120-397), or 8.83 bats/turbine and a mean rate of 5.53 bats/MW. Observed bat fatality rates are at the threshold identified in the Bird and Bat Conservation Strategy and mitigation options will be discussed.

North American Bat Monitoring Pilot Surveys in Arizona

Angie McIntire

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Monitoring bat populations is challenging. The North American Bat Monitoring Program (NA Bat) is a multi-agency, multi-national effort designed to address the need for standardized monitoring and management of bat species across multiple taxa in North America. The goal of the NA Bat Initiative is to facilitate continent-wide monitoring of bats at local to range-wide scales. The national program has been designed with the best knowledge available, but is dependent upon pilot studies and state and local

partner participation to refine the design. In 2014, Arizona obtained a multi-state State Wildlife Grant with partners CA, CO, ID, MT, TX, UT, WA and BCI, to build capacity for and begin conducting acoustic and roost monitoring, core components of the NA Bat Initiative. In 2015-2017, Arizona conducted acoustic and roost monitoring using NA Bat Protocols to build capacity for this monitoring program and begin to gather baseline data for bats in Arizona. Arizona surveyed more than 50 fixed point and mobile locations, using SM2, SM4 and Anabat SD2 detectors. Information gained in this project will contribute to refinement of national protocols, state data needs, and strengthen regional and local partnerships.

Baseline Data on Wintering Bats and Hibernacula in Texas

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White-nose syndrome (WNS), caused by a fungus (*Pseudogymnoascus destructans*), has led to substantial declines in population size of some bat species in eastern United States. Of the 33 species documented in Texas, three species have known susceptibility to the fungus. Based on current rates of expansion, the fungus and WNS could be documented in Texas within the next few years. To understand the potential threat of WNS to bats in Texas, we monitored for the fungus and signs of WNS, as well as collected data on bat species, abundance, distribution, and environmental characteristics at 19 sites from January-March 2016, and 102 sites for the 2016-2017 winter season as of January of 2017. We submitted 142 samples for testing of *P. destructans* using real-time PCR in the 2016 winter season. All swabs were negative for the fungus. Additionally, we submitted 93 samples for testing in January 2017. Throughout our surveys, we documented baseline data for winter roost sites of seven bat species (*Tadarida brasiliensis*, *Eptesicus fuscus*, *Perimyotis subflavus*, *Myotis velifer*, *M. austroriparius*, *Corynorhinus townsendii*, and *C. rafinesquii*). Two of these seven species (*E. fuscus* and *P. subflavus*) are susceptible to the disease and two (*M. austroriparius* and *C. rafinesquii*) are known carriers of the fungus. This baseline data will play a critical role in developing management plans prior to the arrival of WNS, and provide guidance on how to proceed should it arrive.

Do dams affect bat diets?

Anya N. Metcalfe

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Dams drastically alter water courses by converting river segments into reservoirs, impeding the downstream transport of sediment and woody debris, and shifting ratios of coarse and fine particulate organic matter. These changes, in turn, affect the composition, abundance, and distribution of aquatic insects. In this poster presentation I ask, are changes in aquatic insect populations cascading to insectivorous stream-foraging bats? Equipped with acoustic devices, citizen scientists recorded 103 nights of acoustic activity on 17 river expeditions on the Colorado, Green, Yampa, and San Juan Rivers. Acoustic data was collected simultaneously with data on emergent aquatic insects through an existing USGS monitoring program. I describe a watershed scale aquatic insect monitoring program and the potential for using these data to expand our understanding of aquatic-terrestrial linkages in dam-regulated rivers.

The Use of Abandoned Mines and Caves by Bats in Colorado, and Implications for Winter Surveillance

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The emerging threat of WNS to western states is an important conservation challenge for resource managers in the Western US. It is still widely believed that little is known about the roosting habits of our western species, and this contributes to development of surveillance and monitoring guidelines in the West. However, surveys in western states over the last 30 years provide important information necessary for effective planning. In Colorado, the Colorado Bats/Inactive Mines Project has been conducting surveys since 1991. Data collected during this project has provided insights into the use of abandoned mines by bats, and relevant information for the surveillance and monitoring for WNS.

During the period 1991–2010, over 7,000 surveys were conducted at abandoned mines, over a wide range in elevations across the state. More than 740 winter surveys were conducted, and multiple species have been documented using mines as roosts. Numbers of bats winter roosting in mines is considerably lower than WNS impacted hibernacula in eastern states. Microclimate data collected over the years indicates temperatures and relative humidity in Colorado mines are adequate for Pd, the causal agent of WNS. Winter cave surveys in Colorado have also not documented high numbers of hibernating bats.

Given the situation found in Colorado, a priority of surveillance and monitoring to winter roosts at mines and caves may not be a very effective or efficient approach. In addition, winter surveys conducted at mines/caves in Colorado may put the one species most commonly encountered, *C. townsendii*, at an unnecessary risk to potential disturbance and population impacts.

Swarming Surveys of Bats in Colorado: Standardized Sampling and Evaluation for the Transmission of White-nose Syndrome

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Information on roost usage by bat species, particularly those used as hibernacula and for swarming, is needed before making management decisions, particularly those related to White-nose Syndrome (WNS). Swarming in bats is thought to occur when individuals aggregate, typically at a cave, and interact through repeated circling, diving, chasing, and landing events. The behavior could serve multiple social purposes including mating and orientation of young bats for migration or with potential hibernacula. The objectives of these surveys were to determine to what extent swarming occurs at caves in Colorado with known bat use, to quantitatively evaluate swarming activity at sites where it does occur to establish relative indexes of swarming activity, and to simultaneously examine swarming levels between closely situated caves. We conducted swarming surveys on 12 nights at 15 caves during the autumns of 2011-2014. At the cave portal bat passes were tallied. Internal counts of chasing, landing, and copulation were collected. Most caves previously known to be used by bats exhibited at least some swarming and 4 copulation events were noted. High activity levels occurred at multiple caves in the same area simultaneously indicating that one group of bats isn't moving between sites and accounting for all of the activity. At the same time, marked individuals were sighted visiting more than one cave in the same night. Swarming may act as a vector in the transmission of *Pseudogymnoascus destructans* and spread of WNS as bats often land on walls and ceilings, and interact directly during such activities.

Unsuspected Retreats: Use of Rock Crevices and Talus as Autumn Transition Roosts and Potential Hibernacula

Daniel Neubaum

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Identification of autumn and winter bat roosts in Western North America (West) has become a priority as White-nose Syndrome (WNS) spreads. Management efforts in Eastern North America have focused on caves and mines that house large winter colonies. Surveys across the West indicate most bat species are not using caves and mines in large numbers leaving biologists and land managers struggling to make management decisions. Identifying appropriate sites in which to collect baseline population data prior to arrival of WNS, where to limit access to reduce accidental spread of WNS, and determining how well WNS will persist if introduced are difficult questions to address without known locations. Mounting evidence for use of rock crevices as summer, autumn and winter roosts, may explain why numbers of bats found in caves and mines across the West generally tend to be lower than expected. We tracked 38 little brown bats in autumn as maternity colonies dispersed and located 49 roosts in buildings, trees, and rock crevices, some of which were in talus fields. Marked bats moved small distances between capture sites in summer range to autumn roosts (Mean = 3km) with changes reflected in elevation rather than latitude. Roost switching was common, averaging 2 roosts per bat (range 1-7). Temperatures in rock crevice roosts maximized benefits of torpor with those in talus fields covered by snow for 2-6 months. Landscape analysis evaluate *a priori* models with distance from capture site, roost density, aspect, elevation, and shade variables compared to randomly available sites.

Using non-invasive methods (fecal DNA) to identify a maternity roost

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Traditional methods for monitoring wildlife can be stressful or even harmful because they involve direct capture and handling of wildlife. However, advancements in noninvasive genetic analysis (DNA collected from an animal without handling it e.g. from feces) are allowing biologists to gain a better understanding of animal presence and facilitates management practices with less impact. Townsend's big-eared bat (*Corynorhinus townsendii*) is a species of concern in many western states and a USDA Forest Service Sensitive Species. The cryptic nature of bats makes them hard to study and traditional methods of understanding demographics of *C. townsendii* are invasive; mist netting and direct collection off roost substrate is stressful for bats and are extremely harmful if carried out in a maternity or hibernation roost. Noninvasive DNA techniques can be a useful tool in this case because there is no direct human interaction with the bats and guano (feces) is abundant. Developing a methodology for quantifying sex ratio in *C. townsendii* roosts by examining mitochondrial DNA (mtDNA) from guano samples would provide a cost effective noninvasive means for investigating demography and identifying critical roost sites (e.g. maternity). We developed a method using a multiplexed quantitative polymerase chain reaction (qPCR) approach including amplification of an internal positive control (IPC), a portion of the cytochrome b gene (found in males and females), and a Y-specific (male only) DBY gene will allowed us to assess sex-ratio from a sample of guano collected at the entrance to an abandoned mine and positively identify a *C. townsendii* maternity roost.

Climate Change Modelling Reveals Major Shifts in Suitable Habitat Niches for Western North American Bats

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Climate change is affecting the distribution and abundance of numerous organisms, including bats. Species with narrow ecological niches may be more greatly affected than generalists. Some bat species could benefit by increasing density or expanding ranges, while others, especially those occupying cooler biogeographic and or more restricted ranges, may go extinct. We used presence only modelling to determine how future climate change scenarios may affect the distribution, community composition, and suitable habitat niches for 19 bat species with the centroid of their ranges in Western North America. We used 5,312 species occurrence records obtained from open-source, NatureServe, and state Heritage databases, climatic data from WorldClim, and Maxent and Simapse modelling algorithms to project changes in suitable habitat niches over the next 100 years at three different Green House Gas (GHG) emission scenarios, from moderate to severe. Emissions scenarios were derived from the International Panel on Climate Change. There was a reduction in species diversity and suitable habitat area under increasing GHG emissions scenarios, especially at higher altitudes and latitudes. The average range shift for 16 of the 19 species was approximately 200 km northwest under the moderate emissions scenario and 400 km under the most severe scenario. While the range of some species such as *Corynorhinus townsendii* and *Leptonycteris* changed little or expanded slightly, others such as *Myotis thysanodes* and *Antrozous pallidus* contracted significantly. These results will be used to inform climate adaptation strategies and conservation actions to conserve the species most affected by climate change.

Title: Combining Acoustic Monitoring of Bats with Other Species for Monitoring Projects in Northern Alberta

Delanie Player

Matrix Solutions Inc., Grande Prairie, Alberta

Acoustic monitoring of the landscape is a non-invasive, effective method for determining species diversity and behavior patterns of bats. However, acoustic monitoring units can also be used to record other species using the landscape (amphibians, birds) at the same time as collecting data on bats.

Here I will provide some history on wildlife monitoring in Alberta and challenges with conducting field surveys in a large portion of the province. I will then provide some examples of wildlife monitoring programs that we've designed from 2013-2016 that use acoustic recording units (SM3BATs) to record all wildlife at a given site and the value that this has brought to the various monitoring programs. I will also describe some of the challenges we've had with programming, data collection and data analysis and what we've learned over the past few years by combining bat monitoring with monitoring for other species.

Static Long-term Acoustic Monitoring for Migratory Bat Detection

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Long-term operation of solar powered zero crossing monitors along predicted flight corridors or near refugia for long distance migrants in California have provided evidence of seasonality and temporal pattern of migratory activity by *Lasiurus* sp. and *Tadarida brasiliensis*, as well as showing over ocean movements by these and other species. From museum collections, Cryan identified the Pit River in northern California as a likely route from the midcontinent to the Central California north-south corridor for migrant *Lasiurus cinereus*. A monitor installed in the Pit River canyon recorded marked pulses of fall *L. cinereus* activity. In late summer and fall, monitors along the Cosumnes River on the floor of the Central Valley recorded multi-night pulses of greatly elevated *Lasiurus blossevillii* activity in several

years. On San Nicolas Island, the outermost of the California Channel Islands, spring and larger fall pulses of *L. cinereus*, *L. blossevillii*, and, notably, *Lasiurus xanthinus* activity as well as *T. brasiliensis* and 50 kHz *Myotis* presumably reflect displaced migrants. The only bat specimen in museum collections from this island is a *Myotis californicus*. Some level of bat collection and, more recently, acoustic inventory has occurred on most of the other Channel Islands from which *L. xanthinus* records are absent. Long-term acoustic installations can provide information on seasonality of bat activity including migratory behavior, as well as the presence of rare bats and vagrants.

NABat: The Program, Recent Advances, and Unmet Challenges

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North American bats face unprecedented risks from continuing and emerging threats including white-nose syndrome, wind energy development, and habitat loss. Many species of bats are thought to be experiencing unparalleled population declines never before documented. To better understand the true ecological consequences of these large-scale population reductions, the North American Bat Monitoring Program (NABat) was conceived. As a statistically robust and standardized bat monitoring program, NABat is focused on the 47 species of bats that are shared by Canada, United States, and Mexico and is designed to be a multi-national, multi-agency coordinated bat monitoring program. The goal of NABat is to provide managers and policy makers with the information they need on bat population trends to effectively manage bat populations, detect early warning signs of population declines, assess species vulnerability to potential threats, and measure recovery. Since implementation in 2015, NABat monitoring is now occurring in more than 39 states and 10 Canadian provinces. As monitoring data increases through time, NABat will provide analyses of status and trends, document changes in species distributions, help focus conservation efforts, and monitor efficacy of conservation and adaptive management efforts. We will present an overview of the NABat program, discuss available resources for NABat partners, and identify goals for NABat in 2017 and beyond. Despite a long history of resource managers monitoring the echolocation calls of bats to understand presence and habitat use, substantial challenges remain. A key element of NABat is cross-boundary state and federal agency coordination and collaboration to prioritize monitoring and share limited resources for the collection of bat echolocation data. As a means of generating discussion and identifying potential solutions, we present challenges faced by NABat related to the interpretation, processing, and analysis of data being collected over large spatial extents by a multitude of NABat partners.

The Role of Accidental Bat Translocation in the Fungal Transmission Dynamics of *Pseudogymnoascus destructans*

Tory Rhoads and *Karen Blejwas

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Reports of possible accidental translocations of bats via railway and small ships date back to the 1800's, but the advent and growth of modern modes of transportation, including the automotive industry, commercial aviation, cruise lines and containerized cargo shipment have drastically increased the potential for human-mediated bat transport. Although a review by Denny Constantine (2003) noted the implications of bat translocations for the transmission of infectious diseases, the potential for translocated bats to play a role in the spread of White-nose Syndrome has received little attention to date and is not addressed in the national response plan. We supplemented the accounts in the Constantine review with additional observations solicited from bat working groups and other scientific listserves. Translocation by watercraft accounted for over half the reports, primarily by way of cargo ship. In at least 33 out of 63 identified cases, the bat was alive, and in 11 of these the bat either escaped or was released. United States air, marine, and surface transport data were compiled and summarized to identify intra- and intercontinental vector routes, as well as the most likely introduction points for bats from overseas. Current and proposed mitigation strategies include broad-scale, transboundary educational campaigns

focused on reducing “hitchhiker bats” and the establishment of reporting mechanisms and response protocols to reduce the risk of infected translocated bats being released into the wild.

Bat Acoustics at Lava Beds National Monument

David A. Riggs

National Park Service, Lava Beds National Monument, Tulelake, CA

For the 2016 season, we implemented a thorough passive acoustic monitoring program compliant with the North American Bat Monitoring Program (NABat). A total of 19 passive sites were chosen, covering 4 complete NABat grid cells over varying ecological niches, in addition to a previously-established mobile driving transect. A total of 14 bat species were positively detected, and per-species spatial and temporal patterns were extrapolated. Additionally, an interpretative Bat Walk program was developed utilizing active monitoring with a Pettersson M500 and SonoBatLIVE.

Acoustic Investigation of a Southern Arizona Bat Roost

Iris Rodden and Don Carter

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In a time of shrinking budgets, there is an increasing need for information to instruct the allocation of limited resources to provide the maximum benefit to wildlife. To guide management decisions, we used full-spectrum passive ultrasonic acoustic recorders to assess bat species diversity and potential vulnerability in an abandoned mine complex in the Las Guijas Mountains in southern Arizona. Recordings took place during summer, fall, and winter between May 2015 and August 2016. We monitored the main mine entrance and a nearby side shaft with ultrasonic passive recorder. Exiting bats were recorded for two hours starting at sunset, and datasets were processed using Sonobat 3. Five species were documented using the main mine: *Myotis velifer*, *M. thysanodes*, *Antrozous pallidus*, *Corynorhinus townsendii*, and *Tadarida brasiliensis*. *Myotis velifer*, *M. thysanodes*, and *Parastrellus hesperus* were detected utilizing the side shaft. Both *M. velifer* and *M. thysanodes* inhabit the mine year-round. The high numbers of exiting individuals and numerous *M. velifer* calls coupled with prior observations of pregnant and lactating females suggests that this is a maternity roost for this species. Because of the possibility of disrupting the maternity roost we decided a bat gate would not be appropriate for the site and a fence will be installed instead. This project demonstrates that the use of non-invasive acoustic sampling to inform project planning can minimize negative effects on local bat species and would be a valuable addition as a standard pre-planning activity.

Bat Grid 2.0: Integrating the Original Bat Grid and the North American Bat Monitoring Program in Oregon

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The original Bat Grid, which was conducted by the U.S. Forest Service and Bureau of Land Management in Oregon and Washington from 2003-2010, established baseline distributional data for bats throughout Oregon and consequently the initial framework for the North American Bat Monitoring Program (NABat). Recently, a collaborative initiative was developed to acoustically monitor at original Bat Grid survey locations and contribute to the NABat program through surveys conducted at new locations selected according to the NABat master sample survey design. This initiative, referred to locally as “Bat Grid 2.0”, is led by Oregon Department of Fish and Wildlife (ODFW) with assistance by federal agencies and other partners. In 2016, ODFW and partners successfully surveyed for bats in 92 grid-cell sample units during the first year of a two-year pilot effort. All 15 species with established ranges in Oregon were detected in at least one grid cell. We will present on our methods for coordinating a state-wide and multi-partner effort and provide insight on successes and challenges. We envision the methodology refined

through this pilot study will benefit state conservation needs and NABat more broadly.

Climbers for Bat Conservation: Citizen Science for Understanding Bat Use of Cracks and Crevices

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Some North American bat populations have been decimated by White Nose Syndrome (WNS). Most of these population impacts have been in eastern North America, but WNS appears to be moving westward. The dramatic population declines at cave and mine hibernacula have made the severity of WNS clear, yet there are many regions of North America where bat roosts are more dispersed and less conspicuous, making it more challenging to document population-level impacts. It is possible that there are large colonies of bats in inconspicuous rock cracks and crevices. Finding such roosts would provide locations for monitoring bat population persistence in regions where cave and mine roosts are unknown. We developed a collaboration with the rock climbing community in northern Colorado to enroll rock climbers as information resources for bat roost locations. The project, called Climbers for Bat Conservation (<http://climbersforbats.colostate.edu>), brought bat biologists, land managers, and climbers together to discuss the pros and cons of collaborating and how best to develop the collaboration. Climbers for Bat Conservation has engaged the climbing community by hosting climbing nights at local gyms and conducting bat surveys with climbers. Climbers are submitting information via iNaturalist, postcards, and climber feedback on The Mountain Project (www.mountainproject.com). Most submissions have been of singular roosting bats, but several accounts have reported >100 bats in crevices. Future effort will use groups of climbers to target specific climbing routes where large numbers of bats are suspected.

Little brown bat (*Myotis lucifugus*) maternity colony monitoring in northwestern Colorado: Site fidelity and early efforts to assess tag loss

Robert A. Schorr and *Jeremy L. Siemers

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North American populations of the little brown bat (*Myotis lucifugus*) have undergone precipitous declines due to White Nose Syndrome (WNS). Most of these population impacts have been in eastern North America, but WNS recently has been documented in the West. The dramatic population declines at cave and mine hibernacula have made the severity of WNS clear, yet there are many regions of North America where bat roosts are more dispersed and less conspicuous, making it more challenging to document population-level impacts. In western North America there are fewer known hibernating colonies that would allow diagnosis of dramatic population changes. Thus, monitoring maternity colonies may be a valid method of documenting persistence of western populations. We have conducted mark-recapture of two little brown bat maternity colonies in northwestern Colorado. In the third year of the project we provide insights into little brown bat roost site fidelity, and discuss temporal roost use patterns for individuals. Additionally, we document preliminary efforts to determine passive-integrated transponder tag loss by developing an individual-based wing photograph library.

NABat in Colorado

*Jeremy Siemers¹ and Tina Jackson²

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We present a summary of pilot data collected in Colorado following the North American Bat Monitoring Program (NABat) from 2014 to 2016. Data collection in 2014 began with a preliminary understanding of the methods and a draft protocol. We collected data using both mobile and stationary transects, but abandoned mobile transects in 2016. We collected data at 9 100-km² grid cells in 2014, 30 in 2015, and 50 in 2016. Our current effort represents a survey of 1.8% of grid cells in Colorado. Acoustic data were

limited for some species that are peripherally present or rare in Colorado, emphasizing the need for alternative survey methods to evaluate the status of those species within the state. We will discuss challenges and our remedies to those challenges as NABat is implemented in Colorado.

Multi-Scale Occupancy Estimation Using NABat Data in Colorado: Effects of Noise, Clutter, and Weather

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In recent years, there has been increased interest in understanding the influence of anthropogenic noise on both aquatic and terrestrial organisms. Bats are of particular concern due to their use of echolocation as a means of interacting with their environment and finding prey. This study used data collected via acoustic monitoring throughout Colorado using protocols outlined in the North American Bat Monitoring Program (NABat). We investigated how noise pollution affects occupancy of four Colorado bat species with different distributions and echolocation frequencies: *Lasiurus cinereus* (low frequency, widespread), *Eptesicus fuscus* (low frequency, urban-adapted), *Myotis ciliolabrum* (high frequency, widespread), and *Myotis lucifugus* (high frequency, urban-adapted). Noise pollution is defined by impact level, which is the difference between existing and natural sound levels. Differences were found in the effect of noise pollution on occupancy among focal species. By utilizing a design with a broad spatial scale, our results will be widely applicable and will provide valuable insight into soundscape management that enhances bat conservation.

Habitat Selection of *Corynorhinus townsendii* in Volcanic Caves at Lava Beds National Monument

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The expansion of white-nose syndrome (WNS) threatens to affect bat population dynamics in the western United States. The degree of this effect is unknown, and warrants increased efficiency and power in bat monitoring to inform distribution models and disease surveillance. Monitoring of all bat species, including those suspected to survive the infection, should be emphasized. Annual occupancy and abundance surveys of Townsend's big-eared bat (*Corynorhinus townsendii*) hibernacula have been conducted in volcanic caves at Lava Beds National Monument, northeastern California, since the late 1980s for this species of special concern. Additionally, cave microclimate has been recorded using HOBO dataloggers at sites designated for long-term monitoring by the Klamath Inventory and Monitoring Network. Lava Beds maintains a database of the physical features of 700+ caves that vary substantially in morphology and microclimate. In other regions, cave microclimate and morphology have been used to assess which caves provide the cold, stable conditions necessary for *C. townsendii* to hibernate. Here, we used generalized linear models to examine the relationship between *C. townsendii* abundance and cave temperature, relative humidity, length, number of entrances, and passage depth to evaluate whether cave microclimate or morphology can predict *C. townsendii* occupancy and abundance. Such results could improve efficiency of population trend monitoring, a key tool for anticipating and managing the potential impacts of WNS in western North America.

Progress and Limitations of Bat Acoustic Species Classification

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Factors that influence and limit confident acoustic species classification include bat behavior, ambient conditions, microphone deployment and type, and analytic approaches from data extraction to classification from that data. As a still nascent and technologically intensive endeavor, biologists can encounter a bewildering array of options, decisions, and contrary guidance on the interpretation of results.

Different approaches all have validity, so long as users recognize and keep within the boundaries of known limitations for each, and avoid hazards common to all. This presentation will provide guidance and recommendations for avoiding unobvious hazards, acquiring uncompromised recording data, and appropriate use and interpretation of classification analytical approaches.

Conservation of Historic Building for *Corynorhinus townsendii*, and Site Faithfulness Following Substantial Roost Disturbance and Renovation

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We observed a maternity colony of Townsend's big-eared bat (*Corynorhinus townsendii*) occupying the historic Carrington Ranch House on Carrington Coast Ranch along Highway 1 near Salmon Creek in Sonoma County in 2014. The structure was proposed for renovation, which could have resulted in permanent loss of roosting habitat for the colony, or abandonment of the roost due to this species' high sensitivity to human disturbance at roosts. Concurrently, *C. townsendii* had been proposed as a candidate for protection as an endangered or threatened species under the California Endangered Species Act. Rather than conducting full renovation with the resulting cause permanent loss of habitat for the colony, the Sonoma County Agricultural Preservation and Open Space District (District), current owners of the property, agreed to apply for a Safe Harbor Agreement with the California Department of Fish and Wildlife (CDFW) to conserve the roost for at least 10 years. We worked with the District and CDFW to develop measures to avoid or minimize direct mortality during building stabilization using increasing levels of disturbance to induce roost abandonment after maternity season but prior to winter torpor, followed by modifications to improve roost habitat inside the building. Several individuals remained inside the building during stabilization construction activities and after, displaying greater tolerance to disturbance than predicted for this species. Post-construction monitoring conducted in 2016 showed an increase of approximately double (n=106) the originally observed population (n~50).

Does the Size and Tree composition of Monterey Pine Habitat affect Bat Activity and Diversity?

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The Monterey pine (*Pinus radiata*) habitat is both unique and rare. Although the species is found as a landscape tree in many parts of the world, its native range is small and localized. The Monterey pine habitat today occupies about 1,400 acres in the Monterey Peninsula of California. Native Monterey pines often occur in conjunction with coast live oaks (*Quercus agrifolia*), but the shade from the oaks inhibits the growth of seedling Monterey pines, thus threatening this habitat. The fires that would normally regulate the population of oaks are controlled due to their location near developed areas. We hypothesized that larger patches of Monterey pine habitat had higher bat activity and a higher diversity of bats than smaller patches of the same habitat. We used 10 bat detectors (Wildlife Acoustics SM2+) to measure bat activity and to determine the number of species occurring in each habitat patch. We deployed one bat detector in each of 5 small (0.5 – 1 acre) and 5 large (20 – 370 acres) habitat patches, and determined the percentage of pine trees versus oak trees with 100-ft. transects. We accepted the null hypothesis because bat activity was not higher in larger patches of Monterey pine habitat.

White-Nose Syndrome Surveillance in the Pacific Northwest: Winter 2017 Field Work

Shawn Thomas

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Bat Conservation International's (BCI) Subterranean Program led field efforts in the winter of 2017 to conduct white-nose syndrome (WNS) surveillance in the Pacific Northwest (PNW). BCI's Conservation

and Science Programs secured funding through private philanthropic dollars to assist PNW states (Washington, Idaho, Oregon) in conducting WNS surveillance to help inform WNS/*Pseudogymnoascus destructans* (Pd) presence/absence and spread in and around the King County, WA epicenter. Project planning was a cooperative effort with State and Federal land managers, and field work was conducted in sites prioritized for surveillance, with dual goals of sampling to detect WNS/Pd and characterizing winter bat use. Surveillance followed the USGS National Wildlife Health Center protocol, and due to rare presence of hibernating bats in sites visited, the majority of sampling followed environmental soil and substrate collection methods. Collectively, site lists developed by state leads included 30 sites to potentially be visited by BCI (WA-18, ID-7, OR-5). Site access proved to be the most challenging component of the work; steep, rugged terrain covered in snow and downed trees conspired with record winter weather to limit the number of sites that could be visited during the hibernation season. Late spring surveillance was planned for some of the more remote sites in WA that could not be accessed in winter, though many sites were ultimately not visited in 2017. Results from WNS surveillance sample analysis are pending; subterranean habitat surveys conducted in tandem with surveillance largely revealed minimal winter bat use of the sites visited, though these data will help inform knowledge of winter bat behavior in the PNW and direct prioritization of sites for surveillance in forthcoming winters. The project was a successful collaboration between numerous groups, including BCI, Washington Department of Fish and Wildlife, Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, U.S. Forest Service, and Bureau of Land Management.

Developing a Modified Version of the National White-Nose Syndrome Decontamination Protocol for Non-Subterranean Bat Roosts

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Washington Department of Fish and Wildlife, Olympia, WA

An important component of Washington Department of Fish and Wildlife's white-nose syndrome (WNS) management strategy is limiting any human-assisted spread by implementing decontamination after working with bats or in their roosts. The National WNS Decontamination Protocol is currently being followed at caves and mines and seems to be very applicable to this habitat type, but not as much for other habitats that many of Washington's bat species utilize (e.g., bridges, talus slopes, cliffs). There has been some question about the necessity of this national protocol at these non-subterranean roosts and whether a modified version of it would be appropriate. The idea would be to create steps for decontamination that incorporates elements of the national protocol, while allowing for easier cooperation and still limiting the human-assisted spread of WNS. A PNW WNS decontamination task team was developed that includes state and federal agencies to discuss this as well as other topics, such as decontamination/cleaning at PNW show caves. We developed a PNW WNS decontamination guideline that includes a WNS exposure risk flow diagram to help determine whether the national protocol or the modified version of it should be implemented and step-by-step instructions on how to implement both methods of decontamination. This guideline is in draft form currently and welcomes and encourages feedback.

Understanding the Impacts of White-Nose Syndrome on Washington's Bat Population

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Washington Department of Fish and Wildlife (WDFW), other state and federal agencies, tribal nations, and non-governmental organizations are in ongoing collaborative efforts to understand how detrimental white-nose syndrome (WNS) will be on bat populations after its arrival in Washington in March 2016. Little is known about the winter roosting ecology of many Pacific Northwest (PNW) bat species, (e.g., use of hibernation, habitat selection). Due to this, making inferences of WNS impacts on Washington bat populations proves difficult. Our management objectives include (1) elucidating the roosting ecology for species that are potentially susceptible to WNS (e.g., *Myotis* species), (2) determining the geographic

distribution of WNS, and (3) identifying suitable environmental reservoirs for WNS. Acoustic monitoring was implemented in October 2016 near the initial WNS case to characterize winter bat activity and the associated habitat. Preliminary results show a drop in activity from little brown bats/40kHz myotis in mid-November, suggesting use of hibernation or migration. Active surveillance is being conducted within a 100 mile radius of the initial case targeting hibernacula and maternity colonies of those species potentially susceptible to WNS. Currently, surveillance has been conducted at 8 sites; 3 caves, 4 abandoned mines, and 1 bunker. WDFW and our partners (e.g., US Forest Service, Bureau of Land Management, National Park Service, Bat Conservation International) plan to sample additional sites (n = 35) in early spring 2017. Ongoing partnerships aim to increase understanding of the impacts of WNS on PNW bat populations, provide further insight into unknown life history traits, and foster collaborative management efforts to preserve and protect PNW bat populations.

Use of Acoustic Monitoring to Detect Cave Use and Unknown Hibernacula of Bats on Extinct Lava Flows in New Mexico

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We used acoustic detectors to monitor bat activity at El Malpais National Monument of western New Mexico, where at least 10 hibernating species occur and are susceptible to WNS. We collected nightly bat calls from March 2013 to May of 2014 at 5 different known cave sites, as well as bat calls from 15 random grid cell stations from July 2013 to May 2014. Although the number of bat calls varied individually between month and location for the 5 caves, 4 out of these were used as hibernacula, as well as summer roosts. Counts recorded at each grid cell also varied seasonally. However, using the trends noted for the cave locations as a guide, we were able to determine that 8 out of the 15 grid cell sites had large numbers of calls during emergence times that would suggest a hibernaculum near the site of acoustic detection. Our analytical model shows the importance of nightly and long-term monitoring with predictors of activity across seasons. By using a small-scale approach throughout the US, we could better understand general bat presence and locations of roosts/hibernacula, which may provide knowledge suitable to help us more swiftly address the urgent threats to key habitat.

USGS: This information is preliminary and subject to revision.

How Rare? Limits of Detection of a Genetic Assay for Species Identification from Guano

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At WBWG in 2015 we reported on and have since published the development and coverage of a genetic assay for identifying bat species across Chiroptera from guano. Here, we explore the limits of detection of the Species from Feces assay (nau.edu/batdna), which uses high-throughput amplicon sequencing to identify bat species from hundreds of fecal pellets simultaneously, for increased utility and decreased costs. In controlled tests, we determined how rare guano from a bat species can be in a pooled sample and still be detected, and examined whether read number reflects the proportion of a species' feces. We further examined the sensitivity of the assay, and new applications, by testing soil samples collected at roosts and guano fertilizer of unknown age. Finally, to illustrate effectiveness of the approach, we identified bat species that contributed to guano samples collected from across >40 subterranean roosts in the southwestern U.S. For limits of detection, we found that all bat species in mock communities were detected to a 1:192 fecal DNA dilution along with other high concentration bat species. In practice, soil and fertilizer samples readily PCR amplified bat DNA, with species-level discrimination. Bat species were also genetically detected in all mines (1-4 species each), whereas in only 58% of mines were bats

visually identified. We show that the Species from Feces assay is a sensitive, powerful, and practical means to survey roosts.

Utilizing Large Acoustic Detector Arrays to Account for Spatiotemporal Variation in Bats

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Bat activity varies on the landscape both temporally and spatially. Biased conclusions can result by failing to account for this variation within a study design. A typical way to account for this variation is to increase sampling effort. This can be achieved by either increasing the number of sampling sites to address shifting spatial patterns and/or extending the sampling period to account for decreases in nightly activity. Ultimately researchers attempt to strike a balance between number of sites and number of nights due to resource constraints such as the number of available acoustic detectors or experienced crew members. As acoustic technology has advanced, equipment costs have decreased while computer processing ability and digital storage capabilities have increased. This allows researchers to better mitigate for spatiotemporal variation. For our study, we deployed dense arrays of simultaneously deployed acoustic detectors (n = 48) at 5 study sites across Nebraska to better visualize this variation. This enabled us to assess whether overall activity within a study area was changing night-to-night or simply shifting spatially. Occupancy analysis was utilized to determine associated habitat and weather variables that affected detection probability for the northern long-eared bat and the evening bat. Additionally, activity graphs allowed for the visualization of hourly activity levels across a site and habitat classes. Temperature and relative humidity was positively associated with detection probability. Across all nights, clear activity periods emerged but activity varied night to night based upon environmental effects. Results from this study provide a better understanding of how bat activity varies in space and time enabling managers and researchers to create improved study designs and decrease inherent bias.

Sharing Acoustic Data to Help Conserve Bats over Their Full Annual Cycle

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Conservation efforts for most species of bats across western North America are impeded by a lack of basic information on their seasonal whereabouts. In particular, wintering areas and the timing and destination of migratory movements are largely unknown. Over the past decade, the use of remotely-deployed, echolocation monitoring stations to ascertain seasonal species presence and activity patterns of bats at local scales has grown explosively. Nevertheless a central clearinghouse for the resulting records, which could help elucidate seasonal patterns of species presence at the largest spatial scales, did not exist. The Bat Acoustic Monitoring Portal (BatAMP; <http://batamp.databasin.org/>) is an existing, open access, web-based tool that enables upload and display of echolocation monitoring data. BatAMP allows results from local echolocation monitoring or research efforts to be dual-purposed to help understand regional- or continental-scale phenomena such as impacts from climate change, White-nose Syndrome, or wind energy development; as well as to document changes that may occur over multiple years. To date, results from over 100,000 detector-nights across 16 states and 1 province have been uploaded to BatAMP, dwarfing all previous compilations of bat species occurrence. As such, BatAMP is a unique and underutilized tool for understanding broad-scale patterns in seasonal activity of bats. We demonstrate the capabilities of BatAMP for visualizing patterns of bat activity that occur at large spatial scales and over multiple seasons. We will also solicit feedback on impediments to participation in BatAMP.

A Review of Bat Hibernacula in the Western United States: Implications for White-nose Syndrome Surveillance

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Detection of white-nose syndrome and its causative agent in bats has primarily been documented via surveillance of caves and mines, where bats tend to form large winter aggregations across eastern North America. This monitoring paradigm will be challenging in the western United States because the whereabouts and behaviors of most western bat species during winter are largely unknown. We provide the first comprehensive synthesis of western bat hibernacula surveys, drawing on best-available winter survey information from state and federal land and wildlife management agencies. We compiled 3850 winter bat survey records from 2398 unique structures across 11 western states reported between the winters of 1916 through 2017. *Myotis* were reported to be found in 21.4% of the structures searched while *Corynorhinus townsendii* was found in 42.3%. Group sizes of *Myotis* were smaller than for *C. townsendii* and counts of ≥ 100 *Myotis* were reported from only 9 caves in 4 widely-separated states. We developed regression models to explore patterns among winter counts of bats, geography and environmental conditions. Predictions from these models to a set of un-surveyed locations underscored the rarity of large colonies available for discovery in the West. The winter survey results we compiled do not match the much larger numbers of bats evident across western landscapes during summer, strongly suggesting that most bats are wintering in highly over dispersed, unobserved locations. We recommend that alternative methodologies be employed to discover the winter locations of bats and conduct disease surveillance and monitoring.

From Concept to Implementation: Lessons Learned from Getting NABat Started in Nebraska

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A Plan for the North American Bat Monitoring Program lays the foundation for a nationwide monitoring effort. The plan is purposely flexible in how coordinators can implement the program in order to fit the capabilities and needs of diverse organizations. However, some managers unfamiliar with bats, acoustic monitoring, and/or NABat would like additional guidance on how to implement the program. Without this guidance, some people have hesitated to begin sampling. In 2015, The Nebraska Cooperative Fish and Wildlife Research Unit secured funding to begin summer acoustic monitoring under NABat and began sampling the following year. We will provide the framework used to implement summer acoustic monitoring in Nebraska. We will cover the entire process from the pitch and securing funding through the first year of implementation including: budgeting, equipment, site selection, data processing, and scheduling. Our design is meant to serve as an example, not a required process. Our hope is to provide a framework that can be modified to fit the needs of various coordinators. We will suggest questions that coordinators should answer to help design and implement NABat within their needs and resources.

Long-term Trends of Hibernating Bat Abundance in Southern Idaho: Implications for Conservation and Management

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Bats are being impacted by many threats, including disturbance and modification of hibernacula, as well as white-nose syndrome. Little is known about long-term estimates of abundance and use of caves by bats in the western USA. Estimating population abundance from counts of hibernating colonies at these features is important for bat conservation and management, as well as monitoring for white-nose

syndrome. We used a generalized additive mixed model to investigate long-term population trajectories of Townsend's big-eared bats (*Corynorhinus townsendii townsendii*) and western small-footed myotis (*Myotis ciliolabrum* ssp.) using 283 surveys in 49 hibernacula from 1984 to 2016 in three study areas in southern Idaho, USA. A model comprised of the interaction between year and area was the most supported. Estimated relative abundance of Townsend's big-eared bats fluctuated over time, population changes were non-linear, and varied across the three study areas since 1984. Relative abundance for that species has increased in two areas and has decreased in one area over 30 years. Also, counts were not affected by when surveys were conducted during winter for Townsend's big-eared bats, possibly because these bats are easily detectable when hibernating. Relative abundance of western small-footed myotis has fluctuated significantly but has remained stable over the past 30 years. Our data provide long-term population trajectories of Townsend's big-eared bats and western small-footed myotis prior to the arrival of major threats to bats in southern Idaho.

Bat Mortalities at Wind-energy Facilities in Southern Idaho

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Wind-energy development is expanding across the western USA, and unprecedented mortality rates of bats have occurred at many of these facilities. Southern Idaho provides important seasonal habitat for many species of bats. Little is known, however, about bat mortalities in southern Idaho—as well as the western USA—from wind-energy facilities. We described bat mortalities (gender, species, and age) at three wind-energy facilities in southern Idaho from 2011 to 2014. We analyzed 667 carcasses across those three facilities, and of those carcasses that were identifiable ($n = 635$), 46% were hoary bats (*Lasiurus cinereus*), 29% were silver-haired bats (*Lasionycteris noctivagans*), 13% were big brown bats (*Eptesicus fuscus*), and 5% were little brown myotis (*Myotis lucifugus*). Of those species; 59% were adults, 15% were juveniles, and for 26% we could not determine age due to advanced carcass decomposition or other factors. For identifiable individuals ($n = 332$), 51% were males and 49% were females. Also, one wind-energy facility accounted for 95% of big brown bat mortalities (70 adults—17 males and 15 females—and 7 juveniles, 26% of all carcasses recovered at that facility), which is one of the highest percentages of big brown bat mortalities at a wind-energy facility compared with other studies conducted in the USA. Our results provide managers with basic information about bat mortalities at wind-energy facilities in southern Idaho, which can be used for mitigation efforts, as well as for land-use planning for bats and their habitat in this area.