BAT RESEARCH NEWS

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Front Cover

The characteristic white fungus (*Geomyces destructans*) associated with white-nose syndrome covering the nose and wings of a *Myotis lucifugus* (little brown myotis). The photo was taken by Greg Turner (Pennsylvania Game Commission, Harrisburg, Pennsylvania) in March 2011 at Barton Cave**,** Fayette County, Pennsylvania. Thanks, Greg, for sharing another of your photos with us.

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Letters to the Editor

Editor's Note: Unlike technical articles, letters are not peer-reviewed, but they are edited for grammar, style, and clarity. Letters provide an outlet for opinions, speculations, anecdotes, and other interesting observations that, by themselves, may not be sufficient or appropriate for a technical article. Letters should be no longer than two manuscript pages and sent to the Feature Editor.

Confirmation of White-nose Syndrome in Bats of Europe and Implications of This Discovery toward Understanding the Disease in Bats of North America

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White-nose syndrome (WNS) is an infectious disease of the skin of hibernating bats caused by the fungus *Geomyces destructans*. The disease was first identified in 2007 and is estimated to have killed over 5.5 million cave-hibernating bats in North America (United States Fish and Wildlife Service, 2012). Within 3 years of arrival of the disease, bats have disappeared from long-established winter colonies, and many populations of hibernating bats across the northeastern United States have experienced 95–100% mortality (Turner et al., 2011).

One of the most intriguing aspects of this unprecedented disease is that *G. destructans* also colonizes the skin of multiple species of hibernating bats in at least 12 European countries (Martínková et al., 2010; Puechmaille et al., 2010, 2011; Wibbelt et al., 2010). Furthermore, a new study (Pikula et al., 2012) confirms that fungal lesions on a bat from the Czech Republic are indistinguishable from those diagnostic of WNS in bats of North America. With this letter, we hope to draw attention to recent pathological findings associated with WNS in European bats and emphasize the importance of comparative analyses between continents for understanding this emerging wildlife disease.

White fungal growth on the muzzle of hibernating bats in Europe resembles the fungal growth on muzzles of bats with WNS in North America (Martínková et al., 2010; Puechmaille et al., 2010), and photographs from Europe document affected bats as early as the 1980s (Feldmann, 1984). Subsequent genetic and morphological analyses have confirmed the identity of this European fungus as *G. destructans* (Martínková et al., 2010; Puechmaille et al., 2010, 2011; Wibbelt et al., 2010).

Pikula et al. (2012) provide the first documentation that *G. destructans* can cause the characteristic skin erosions or ulcers that define WNS in the bats of Europe. These new findings show that WNS occurs in bats of both Europe and North America. However, the intriguing difference between North America and Europe is that infection by *G. destructans* in Europe has not been associated with unusual mortality (Martínková et al., 2010; Puechmaille et al., 2010, 2011; Wibbelt et al., 2010).

In North America, WNS apparently has spread from a group of closely spaced

hibernacula in New York, including a tourist cave (Blehert et al., 2009). Analyses of the sequence of nucleotides of DNA from marker regions of ribosomal RNA indicate that isolates of *G. destructans* from North America and Europe are closely related (Martínková et al., 2010; Puechmaille et al., 2010, 2011; Wibbelt et al., 2010). More detailed genetic analyses of isolates of *G. destructans* cultured from bats collected in New York further support the concept of a spread of a single clonal genotype (Rajkumar et al., 2011), indicating dispersal from a point of introduction. Although the genomic sequence of the European isolate of *G. destructans* is not yet complete, historic photographic evidence (Feldmann, 1984) suggests that *G. destructans* was present in Europe at least 30 years prior to its detection near Albany, New York, suggesting introduction of this pathogen from Europe. Differences in mortality due to WNS between bats in North America and Europe, however, are not yet understood, and factors leading to mortality are likely more complicated than simple differences in host immunity. Similar questions surround apparent differences in mortality from WNS among species of hibernating bats in eastern North America (Cryan et al., 2010; Turner et al., 2011).

Many requirements must be met for an infectious agent, particularly a fungus such as *G. destructans*, to be a successful pathogen. These factors include the host (bats), the disease agent (*G. destructans*), and the environment that they share (caves and mines). For example, conditions within hibernacula, such as temperature and humidity, may influence the rate of growth of the fungus and production of infectious fungal spores. Where bats choose to hibernate within caves and the size and density of their hibernating clusters may also influence amplification and spread of *G. destructans*. Populations of hibernating bats in eastern North America are significantly larger than those in Europe (see species accounts in Barbour and Davis, 1969 and Dietz et al., 2009), which may create conditions more conducive to the spread of the fungus.

There also may be differences in winter habitat selection, hibernation behavior, and physiology of bats between Europe and North America that account for differences in mortality (Willis et al., 2011). The average mass of hibernating little brown bats (*Myotis lucifugus*) in North America is 6.5 g (Thomas et al., 1990), whereas the average hibernating mass of the greater mouse-eared bat (*Myotis myotis*) that recently was identified with WNS in Europe is 26 g (Pikula et al., 2012 and references therein). It is possible that larger bats may be relatively less susceptible to the effects of infection with *G. destructans*.

Not all North American bats infected with *G. destructans* die (Fuller et al., 2011; Meteyer et al., 2011). Survival probably depends on the infectious dose of *G. destructans* to which a bat is exposed and the timing of infection. For example, it is likely that severe infection early during hibernation leads to extensive skin invasion and ulceration by spring. Conversely, a less severe infection beginning late in the hibernation season may progress only to a more superficial and localized infection. In addition, conditions extrinsic to the hibernacula, such as climate, may affect the length of hibernation (McNab, 1974). Warmer climates, with shorter hibernating periods, might lessen the effects of infection and increase the chances for survival.

Current rates of sustained mortality among North American bats with WNS are unprecedented (Frick et al., 2010; Turner et al., 2011). The mortality rate is outpacing the rate at which survivors can likely adapt, recover, reproduce, and eventually replace the 5–6 million bats that have died from WNS (United States Fish and Wildlife Service, 2012). There is no evidence to support a hypothesis that populations of European bats

experienced a similar mass mortality from exposure to *G. destructans*, resulting in a population in equilibrium with this pathogen. It may also be premature to assume that infection by *G. destructans* does not compromise the health of bats in Europe. The recent findings of WNS lesions in European bats suggest that *G. destructans* may pose a threat on that continent as well, although more subtle than the threat to North American bats (Martínková et al., 2010; Puechemaille et al., 2010, 2011).

Presently, there are no means to reduce or avert mortality from WNS in North American bats, and it is unlikely that a solution will be discovered in the near future. Preventing human dispersal of *G. destructans* to uninfected hibernacula is the only practical management tool currently available. Ongoing research to understand better the ecology of the disease, physiology of hibernating bats, and mechanisms of fungal pathogenesis provides the greatest promise for identifying points of intervention to break the cycle of disease. Investigation of the differential mortality due to WNS between Europe and North America may provide the insight needed to develop strategies to mitigate the lethal effects of WNS. Teams incorporating the specialized skills and creative energies of multidisciplinary researchers throughout the world will be important if this ecologically important mystery will be solved.

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RECENT LITERATURE

Authors are requested to send reprints or PDF files of their published papers to the Editor for Recent Literature, Dr. Jacques P. Veilleux (Department of Biology, Franklin Pierce University, Rindge, NH 03461, U.S.A., e-mail: **veilleuxj@franklinpierce.edu**) for inclusion in this section. Receipt of reprints is preferred, as it will facilitate complete and correct citation. However, if reprints and/or PDF files are unavailable, please send a complete citation (including complete name of journal and corresponding author mailing address) by e-mail. The Recent Literature section is based on several bibliographic sources and for obvious reasons can never be up-to-date. Any error or omission is inadvertent. Voluntary contributions for this section, especially from researchers outside the United States, are most welcome and appreciated.

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Importancia de los Murciélagos de Nicaragua

Los murciélagos son beneficios.

Insectívoros

Murciélago bilistado café *(Saccopteryx bilineata)*

- Los murciélagos que se alimentan de insectos ayudan a controlar plagas perjudiciales para los cultivos y para la salud humana.

Murciélago Moloso Negro *(Molossus rufus)*

- Incluso los murciélagos que viven en nuestras casas eliminan miles de insectos cada noche.
- Los murciélagos usan llamadas de alta frecuencia (ecolocación) para encontrar presas y volar por la noche.

Nectarívoros

Murciélago lengüilargo *(Glossophaga soricina)*

- Muchos arboles frutales como las plantas de bananos son polinizadas por los murciélagos, los cuales se alimentan del néctar de las flores.

Murciélago nectarívoro naranja *(Lonchophylla robusta)*

- Son murciélagos nectarivoros especializados en la polinización de las flores al utilizar sus largas lenguas para tomar el néctar.

Frugívoros

Murciélago frutero común *(Artibeus jamaicensis)*

Dispersadores de semillas

Murciélago común de cola corta (*Carollia perspicillata)*

- Los murciélagos frugívoros de cola corta ayudan a dispersar las semillas de al menos 70 especies de plantas neotropicales.
- Los murciélagos frugívoros dispersan las semillas en el bosque ayudando en la regeneración.

Carnívoros

Murciélago carnicero menor *(Chrotopterus auritus)*

- Los murciélagos carnívoros (comen carne) comen roedores, aves y otros animales pequeños.
- La tala de árboles destruye el hogar de muchos de nuestros murciélagos.

Murciélagos de las cuevas

Murciélago fantasma *(Mormoops megalophylla)*

- Las cuevas de lava de Parque Nacional Volcán Masaya son el hogar de más de 40.000 murciélagos insectívoros que ayudan a controlar las plagas de los cultivos y beneficiar la salud humana.

Murciélago Enmascarado *(Pteronotus personatus)*

- 100 especies de murciélagos conviven en Nicaragua y la mayoría se alimentan de insectos
- La mitad de los mamíferos terrestres en Nicaragua son murciélagos.

Pescadores

Murciélago pescador mayor *(Noctilio leporinus)*

- Los murciélagos pescadores utilizan la ecolocalización para detectar a sus presas, y capturan a los peces con sus largos pies en la superficie del agua.
- Los murciélagos no son ciegos, no se atascan en el pelo, y no todos son portadores de rabia.

Vampiros

Murciélago vampiro común *(Desmodus rotundus)*

- De las 100 especies de murciélagos de Nicaragua solo 3 de ellas se alimentan de sangre, y solo una de ellas, (el vampiro común) se alimenta de sangre de mamiferos y principalmente del ganado vacuno, ya que las otras dos se alimentan de sangre de aves.

Hacedores de tiendas

Murciélago listado hacedor de tiendas *(Uroderma bilobatum)*

- Los murciélagos viven a menudo en grupos complejos, y los grupos sociales consisten de machos y hembras de diferentes edades.
- Algunos murciélagos que comen frutas y viven en grupos familiares hacen "tiendas" en hojas grandes como refugio.

Murciélago blanco Centroamericano hacedor de tiendas *(Ectophylla alba)*

- Este pequeño murciélago blanco se alimenta de frutas y vive en pequeños grupos debajo de grandes hojas que les dan protección.
- Los murciélagos tienen crías cada 1-2 años y pueden vivir hasta 20 años.
- Nicaragua es el hogar de murciélagos muy poco frecuentes.

¿Como podemos ayudarlos?

- No mate a los murciélagos creyendo que todos son vampiros.
- Eduque a sus amigos y familiares sobre la importancia de los murciélagos.
- No moleste a los murciélagos en cuevas, arboles o en sus lugares de refugio.
- Replantar arboles en nuestra comunidad y principalmente a orillas de los ríos para aumentar la disponibilidad de refugios y alimento para los murciélagos.

Colaboración: Organization for Bat Conservation • BatWatch Nicaragua 2011 • Paso Pacifico

Para Más Información: www.batconservation.org • www.pasopacifico.org

ORGANIZATION FOR BATCONSERVATION

PASO PACÍFICO
Making connections for conservation

Editores: Rob Mies • Fiona Reid • y Arnulfo Medina-Fitoria

Creditos de los Fotos: • George Smiley • Dick Wilkins • Steve Gettle • Tim Carter

NEWS from OUR SUBSCRIBERS

Nicaragua Bat Watch Trip
submitted by Rob Mies, Organization for Bat Conservation

I joined Fiona Reid and an international group of bat enthusiasts on a journey deep in the rainforests of Nicaragua in November 2011. The goals of the trip were to identify bats occupying a poorly surveyed region of Nicaragua and to allow the group to participate in hands-on field work—e.g., surveying for roosts, use of bat detectors, and capture-release techniques—with local bat biologists and international experts. We worked with local bat biologists (Arnulfo Medina Fitoria and Octavio Saldaña Tapia), park rangers, and students to survey lava tubes at Masaya National Park outside the capital city Managua. Harp traps were used to temporarily detain over 500 bats representing all 5 species of mormoopids.

The majority of our time was spent at Refugio Bartola, a lowland rainforest site in southeastern Nicaragua located just outside Indio-Maíz National Park at the confluence of the San Juan and Bartola Rivers. Each morning we searched the rainforest for bats that were roosting in hollow trees or branches, under fallen logs, in tents of large leaves, under banks, or in crevices. In the afternoon, we located netting sites and prepped gear for a full night of surveying.

Over the 8-day trip, 40 bat species were documented including 2 species not previously recorded in Nicaragua (*Furipterus horrens* and *Thyroptera tricolor*). We also documented *Cyttarops alecto*, which was previously known only from one specimen captured in 1971 in northeast Rama in an oil palm plantation. The group raised funds to create a poster that dispels the many myths surrounding bats and educates the people in Nicaragua about the importance of bats. "Importancia de los Murcielagos de Nicaragua" posters (see p. 12) will be distributed throughout Nicaragua by the Organization for Bat Conservation and Paso Pacifico. For more information, please contact rmies@batconservation.org.

Request from your Editor, Margaret Griffiths: If you have bat-related news items—what's happening in your lab or agency; what's new with your students; or students, what's new your major professor—please consider sharing those items with us. Send news items to the Editor, Margaret Griffiths (margaret.griffiths01@gmail.com).

ANNOUNCEMENTS

Basically Bats Wildlife Conservation Society, Inc. Announces Two Student Research Awards for 2012-2013

Basically Bats Wildlife Conservation Society, Inc. announces student research awards for the 2012-2013 academic year. Two research scholarships ($3,000 each) will be awarded to two qualified students during the Fall of 2012. The scholarships will be awarded for research directly related to white-nose syndrome (WNS) in North American bats. All students, including postdoctoral students, who are enrolled in an accredited U.S. college/university during the 2012-2013 academic year are eligible to apply. Applications should include a brief (1–3 pp.) description of the WNS-related project, a budget for the project that includes how the funds will be used, applicant's curriculum vitae (CV), and a brief letter of support from the student's advisor/supervisor. Applications are competitive and will be reviewed by at least two experts in

ANNOUNCEMENTS (cont.)

the field. **Deadline** for receipt of applications is **July 20th, 2012**. Applications should be submitted (in .PDF format) to: Dr. Steve Burnett at sburnett@clayton.edu.

2012 Renewal Notices — *Bat Research News*

You should have received a renewal notice for the 2012 volume-year by now. If not please let the Editor, Margaret Griffiths (margaret.griffiths01@gmail.com) know as soon as possible. In order to keep subscription rates as low as possible, renewal notices were sent via e-mail whenever possible (if an e-mail address was not available, the notice was sent via the post). We at *BRN* hope you will renew your subscription for 2012. Thank you!

Change of Address Requested

Will you be moving in the near future? If so, please **send** your **new postal and e-mail addresses** to Margaret Griffiths (margaret.griffiths01@gmail.com), and include the date on which the change will become effective. Thank you in advance for helping us out!

Request for Manuscripts — *Bat Research News*

Original research/speculative review articles, short to moderate length, on a bat-related topic would be most welcomed. Please submit manuscripts as MSWord documents to Allen Kurta, Editor for Feature Articles (akurta@emich.edu). If you have questions, contact either Al (akurta@emich.edu) or Margaret Griffiths (margaret.griffiths01@gmail.com). Thank you for considering submitting some of your work to *BRN*.

FUTURE MEETINGS and EVENTS

11–13 April 2012

The 15th Australasian Bat Society Conference will be held on 11–13 April 2012 at the University of Melbourne, Parkville (approximately 3 km north of Melbourne's central business district), Victoria, Australia. Check http://ausbats.org.au/ for more details.

24–27 October 2012

The 42nd Annual North American Symposium on Bat Research (NASBR) will be held on 24–27 October 2012 at the Conrad San Juan Condado Plaza in San Juan, Puerto Rico. Check the NASBR website for updates and announcements — http://www.nasbr.org/.

2013

The 43rd Annual NASBR and the 16th International Bat Research Conference will be held in Costa Rica, dates and city TBA. See the NASBR website for updates — http://www.nasbr.org/.

2014

The 44th Annual NASBR will be held in Albany, New York, in October 2014, dates TBA. See the NASBR website for future updates — http://www.nasbr.org/.

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Front Cover

The photograph of *Desmodus rotundus*, the common vampire bat, was taken by Edvard Magalhães, a speleologist who does field work with Dr. Mariella Freitas (Federal University of Viçosa, Brazil). Many thanks to Edvard and Mariella for sharing another photo with us.

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Bat Research News is published four times each year, consisting of one volume of four issues. *Bat Research News* publishes short feature articles and general interest notes that are reviewed by at least two scholars in that field. *Bat Research News* also includes abstracts of presentations at bat conferences around the world, letters to the editors, news submitted by our readers, notices and requests, and announcements of future bat conferences worldwide. In addition, *Bat Research News* provides a listing of recent bat-related articles that were published in English. *Bat Research News* is abstracted in several databases (e.g., BIOSIS).

Communications concerning feature articles and "Letters to the Editor" should be addressed to Dr. Al Kurta (akurta@emich.edu), recent literature items to Dr. Jacques Veilleux (veilleuxj@franklinpierce.edu), and all other correspondence (e.g., news, conservation, or education items; subscription information; cover art) to Dr. Margaret Griffiths (margaret.griffiths01@gmail.com).

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Mating Eastern Red Bats Found Dead at a Wind-energy Facility

Donald I. Solick, Jeffery C. Gruver, Matthew J. Clement, Kevin L. Murray, and Zapata Courage

Western EcoSystems Technology, Inc., 415 W. 17th Street, Suite 200, Cheyenne, WY 82001
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At 0830 h on 3 September 2010, a male and a female eastern red bat (*Lasiurus borealis*) were found dead on the ground at a wind-energy facility in Somerset County, Pennsylvania. The bats were discovered in an open gravel parking lot, 6 m from the Operations and Management building and 130 m from the nearest wind turbine. The building was located in open grassland, on a high ridgeline (ca. 900 m ASL) in the Appalachian Mountains. The carcasses were fresh and had no obvious signs of injury (e.g., broken limbs, blood). The pair was clasped together, venter to venter, in what appeared to be a copulatory position (Fig. 1). The male's uropatagium was curled around the posterior of the female, and his jaws were locked onto the fur of her lower chest. We did not have a collection permit, so the bats were not handled or removed for further examination. As such, the cause of death could not be determined, and it could not be verified whether intercourse had occurred.

Eastern red bats are one of the few vertebrate species known to mate during flight. Males initiate copulation during flight, and the pair drop to the ground until intercourse is completed (Cryan and Brown, 2007; but see Dodd and Adkins, 2007). All accounts of mating behavior by eastern red bats depict the male on top of and behind the female, with both bats facing forward and the male's posterior curved beneath the rear of the female (Dodd and Adkins, 2007; McConnell, 2007; Saugey et al., 1989, 1998; Steuwer, 1948). The male is often described as gripping the dorsal fur of the female with his thumbs and biting the nape of her neck. The bats we found were positioned differently, which requires explanation. The bats may not have joined together correctly in the air and were, therefore, more susceptible to injury when they hit the ground. Or perhaps the bats coupled successfully in the air but re-positioned themselves after falling to the ground and sustaining lethal injuries. Alternatively, the bats may not have been mating at all and were engaged in antagonistic behavior. Bell (1980) reported a rabid hoary bat (*Lasiurus cinereus*) attacking other bats during flight and bringing them to the ground, and Hall (1946:156) observed two fighting hoary bats falling to the ground during apparent swarming activity, although these were both males. The position of the bats we found was similar to a typical nursing position, but juvenile red bats are weaned by late July, well before these bats were found (Kunz, 1971). Furthermore, the bright red coloration of the male suggests it was an adult and would not have been nursing (Timm, 1989). While various scenarios are possible, we find copulatory behavior to be the most plausible, because this event occurred during the breeding season (Cryan and Brown, 2007), it involved a male and a female, and no wounds were present that would indicate aggressive fighting.

Dead bats are found at most wind facilities, but the underlying reasons for these fatalities are poorly understood (Cryan and Barclay, 2009; Kunz et al., 2007). Most fatalities occur during fall migration and involve species that roost in foliage or trees and migrate long distances (Arnett et al., 2008; Kunz et al., 2007), such as eastern red

Figure 1. A male (left) and a female eastern red bat found dead at a wind-energy facility in Somerset Co., Pennsylvania.

bats. Tall structures on the landscape may serve as rendezvous points for migratory bats during the fall breeding season (Cryan and Brown, 2007), and reproductive bats may mistake turbines for tall trees, thereby placing themselves at risk of collision with moving turbine blades when looking for mating opportunities (Cryan, 2008). Although no previous evidence has been published that indicates migratory bats actually exhibit mating behavior near turbines, our observation suggests that at least some eastern red bats mate—or attempt to mate—at wind-energy facilities.

Although eastern red bats are killed by wind turbines, it seems unlikely that the bats we observed collided with a turbine or the Operations and Management building during presumed copulatory flight, because the carcasses were found away from these structures. Bats killed by colliding with windows are typically found within a meter of buildings they have struck (Timm, 1989), and greater than 80% of dead bats at wind-energy facilities are found at a distance less than half the maximum height of a turbine tower and rotor (U.S. Fish and Wildlife Service, 2011). The turbines at this facility (General Electric SLE 1.5-megawatt) have rotors that are 38-m long and towers that are 80-m tall, suggesting that most fatalities would fall within 60 m of the turbine.

Barotrauma, or internal damage to lungs and other organs caused by extreme changes in air pressure at the tips of moving turbine blades, is another potential cause of bat mortality at wind farms (Baerwald et al., 2008). Sublethal injuries from barotrauma, such as hearing impairment or internal damage, could allow bats to move away from turbines before debilitation and death occurs (Klüg and Baerwald, 2010; U.S. Fish and

Wildlife Service, 2011). Murphy and Nichols (1913:11) reported that a pair of mating red bats "remained together about half a minute, flying unsteadily the while, with all four wings beating," so coupled bats can maintain flight for some time. However, it seems unlikely that bats suffering sudden internal hemorrhaging would sustain coupled flight for the ≥ 100 m required to reach the Operations and Management building.

We suggest the bats died upon impact with the ground after attempting to initiate copulation in the air. Of the 14 published records of mating by red bats (reviewed in Cryan and Brown, 2007), eight describe bats coupling during flight and then dropping to the ground where copulation took place. The height at which mid-air coupling occurs has not been published. However, red bats in Kentucky were observed chasing one another at night at heights between 2 and 3 m shortly before landing on the ground to mate (L. Dodd, University of Kentucky, pers. comm.). In Virginia, chasing occurred during the day between 6 and 12 m, and a pair of bats was observed falling to the ground from a height of ca. 5 m (S. McConnell, pers. comm.). Mating red bats have fallen onto mown grass (McConnell, 2007), football fields (Saugey et al., 1998), the bank of a pond (Steuwer, 1948), and pavement (Glass, 1966; Saugey et al., 1989).

Each of these events occurred on flat, open ground, which may be due to observer bias, although it may simply indicate that red bats avoid mid-air mating over brushy vegetation or rocks. In either case, it is apparent that bats may sometimes fall on hard ground and be injured or killed. Indeed, in an account of red bats falling to pavement, Glass (1966:40) reported the "superior bat, presumably a male, disengaged and flew off, but the female was stunned by the fall and picked up." Furthermore, a pair of eastern red bats that was found on a driveway in northern Vermont on 19 August 2010 clearly had died while mating; the bats were engaged in a standard copulatory position and displayed signs of blunt-force trauma, although the cause of death was unclear (R. Smith and A. Bennett, Vermont Fish and Wildlife, unpublished data).

Our observation, along with the others cited above, suggests that colliding with the ground is a source of mortality for eastern red bats, particularly in developed areas dominated by hard surfaces. Furthermore, our observation suggests that eastern red bats mate at wind-energy facilities, a behavior hypothesized to be a cause of elevated turbine collision rates among migratory tree bats. However, it is unlikely that collisions with the ground are a significant cause of death in red bats at wind-energy facilities. If so, we would expect that at least some paired red bats would have been found during fatality searches around wind turbines, but we are unaware of any such observations.

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BOOK REVIEWS

Bats of the United States and Canada. Michael J. Harvey, J. Scott Altenbach, and Troy L. Best. Johns Hopkins University Press, Baltimore, Maryland.
224 pp., 2011. Paperback: ISBN: 978-1-4214-0191-1. ($24.95 U.S.)

As someone who does a lot of outreach or "bat talks" to groups of all ages, one of the staples of my outreach kit has been the booklet entitled *Bats of the United States* (M. J. Harvey, T. L. Best, and J. S. Altenbach. 1999. Arkansas Game and Fish Commission, Little Rock, Arkansas). With only 64 pages, *Bats of the United States* was a concise, well-designed, and informative booklet with a brief introduction followed by a series of short paragraphs (ca. 15 pages) on 20 topics covering the basics of bat biology, followed by accounts of the 45 species of bats found in the United States. The booklet was published by the Arkansas Game and Fish Commission, in cooperation with the Asheville Field Office of the U.S. Fish and Wildlife Service, and made freely available to anyone upon request. Years ago, I asked for some of these booklets from Bob Currie at the Ashville Field Office, and he sent me a box. That box is now empty, and I have only one copy left that I guard very closely.

Where did all the booklets go? Each was given to teachers and librarians after I gave a "bat talk" so that students and library patrons would have access to one of the most straightforward and well-presented books on bats of the United States. I also sent books to members of the community, who asked for information about animals that they did not appreciate or understand. The remaining booklet that I now guard in my office is one of the first things that I give to new undergraduates to read as an introduction to our region's bats and also the first book that I give to elementary and high school students when they drop by my office asking questions about bats. This all speaks to the utility of the work. Knowing that a new version was being published, I was excited to receive and read it.

The authors have now expanded the booklet into a book. The new version is appropriately retitled *Bats of the United States and Canada*, because all 20 species of bats in Canada also occur in the United States, and is published by Johns Hopkins University Press. The basic format of the book has remained the same, but it is expanded, especially the sections that are not species accounts. The book has an introduction, followed by 36 sections (up to page 90) on topics dedicated to the basic biology of bats. Forty-seven species accounts follow and, as in the original booklet, the species accounts are organized by family. The addition of two species from the booklet to the book reflects the inclusion of accounts for the dark-nosed small-footed bat (*Myotis melanorhinus*) and the Arizona bat (*M. occultus*). A new addition to the book, which was not present in the booklet, is a brief description of four phyllostomid species from the Caribbean and Mexico that occur accidentally in the southern United States. This section on "Species of Accidental Occurrence" follows the 47 species accounts. The book ends with a concise summary of the ecological importance of bats and why their conservation should be paramount. A useful list of all species (and subspecies) described, ordered by family, with their conservation status and a notation of whether they are found in Canada, can be found in the Appendix (in addition to the species being listed in the Table of Contents).

The major change from the booklet to the book is in the section dedicated to the biology of bats. This section now constitutes the first half of the book and is clearly organized into topics, many of which are the same as in the previous version, albeit expanded. Importantly, fundamental additions regarding threats to the conservation of bats and non-invasive techniques for the study of bats have

been added. Although the earlier version contained a single description of "Threats to Bats," additional sections now focus specifically on white-nose syndrome and wind turbines. Likewise, the original summary labeled "Research Techniques" has been expanded to include sections on inventories, thermal imaging, nets and traps, banding, radio-telemetry, and acoustic identification. Other topics on the biology of bats that are covered include classification, biology, reproduction and longevity, and behaviors, such as echolocation, foraging, swarming, migration, and homing. Other sections describe the benefits of insectivorous bats, summer habitat, winter habitat and hibernation, bats as food, bat as bombs, how bats use mines and bridges, control of nuisance bats, how to attract bats, rabies, and histoplasmosis. Each section is introductory rather than comprehensive, and in a few cases, some important information, especially for beginners, is missing. For example, the description of acoustic identification is limited to discussion of one system (AnaBat), even though many other options are available. This is a minor issue and is more likely a consequence of the short, introductory nature of the book, as opposed to an oversight.

The 47 species accounts are as informative as in the first booklet and supported by the same high-quality photographs of each species that were taken by Scott Altenbach. The species accounts are meant for a general audience and not intended for identification, because some of the accounts do not provide diagnostic characteristics, per se. Instead, the accounts give very good introductions to species, and unlike other species accounts (e.g., *Mammalian Species*) meant for a professional audience and laden with mensural characters and diagnostic features, the accounts in the new book focus on basic biology and regional information. For example, most species accounts would not let the reader know that evening bats (*Nycticeius humeralis*) often roost with Brazilian free-tailed bats (*Tadarida brasiliensis*) in the Southeast, but this information has come in handy for me in the past. As another example, the account for the western small-footed bat (*M. ciliolabrum*) depicts suitable habitat in both Alberta and Nebraska. Most species accounts incorporate descriptions of roosting behavior, flight behavior, times of activity, and habitat use. Describing this type of general biology and infusing regional information into the accounts are some of the great qualities of this book and a testament to the lifetime of knowledge and authority that Mick Harvey, Scott Altenbach, and Troy Best bring to this work. In addition, the authors do a good job of pointing out what we know and do not know about many of the species, and this is helpful for students of all ages, including those beginning their research careers.

Overall, I would recommend this book to anyone interested in an up-to-date introduction to bats and their biology, in the United States and Canada. I will certainly buy copies for my lab, because as a one-stop resource for an overview on species of bats in the United States and Canada, this new book is an excellent starting point. Having said this, though, I am sad to say "goodbye" to the concise booklet format, because it was such an inexpensive and invaluable resource for teaching and outreach.

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Bats in Captivity, Volume Three: Diet and Feeding—Environment and Housing. **Susan M. Barnard (Editor). Logos Press, Washington, D.C.** 420 pp., 2011. Hardcover: ISBN: 978-1-934899-06-9 ($89.95 U.S.). Softcover: ISBN: 978-1-934899-07-6 ($67.95 U.S.).

In the preface to *Bats in Captivity, Volume Three: Diet and Feeding—Environment and Housing*, the editor notes that no one knows when bats were first held in captivity, but there is little doubt that most of the 1,200 or so species of Chiroptera have been (and still are!) problematic to maintain in zoos and research facilities. Although bats make up nearly 20 percent of all mammalian species, in his 769-page seminal tome on the management of captive mammals, Crandall (1964. Management of wild mammals in captivity. Chicago. University of Chicago Press) devoted only seven pages to chiropterans! Fortunately, since that publication, a great deal has been learned about the biology, behavior, and husbandry of bats, and huge advances have been made toward keeping bats in captive environments.

This volume, the third in a series of books edited by Susan M. Barnard, contributes to the recent wealth of information on bats. The first two installments of *Bats in Captivity* were *Volume One: Biological and Medical Aspects* and *Volume Two: Aspects of Rehabilitation*. Similar to the previous volumes, this third reference book draws on the expertise of researchers, biologists, and managers from around the world. It is divided into nine chapters, with 22 contributing authors.

The first four chapters focus on nutrition and feeding, and the last five cover various aspect of housing, including enrichment. As in most edited volumes, the chapters vary in quality, and some information is repeated in multiple chapters. Additionally, the authors are given a great deal of latitude with respect to their presentation styles, and as a result, the book does not have a consistent format or feel, although these comments should not diminish the importance of this book.

The book's first chapter provides an excellent and detailed overview on what is and is not known about the nutritional and dietary requirements of the Chiroptera. Although the nutritional needs of bats are the focus, the authors make a point that diets must be practical (e.g., do not feed insects with hard exoskeletons to weak-jawed species of bat), flexible (to allow for seasonal changes in physiology), and enriching (to address the occupational needs of bats and provide contentment). The chapter concludes with seven extremely useful appendices that contain nutritional values for various fruits, vegetables, insects, fish, birds, and mammals that can be fed to bats.

The second chapter covers the diet and feeding of various micro- and megachiropterans, and is presented as a compilation of 11 papers. These papers range from a 27-page summary covering the feeding strategies and dietary needs of insectivorous bats to a one-page discussion on feeding hairy-legged vampire bats (*Diphylla ecaudata*). At the end of the chapter, there are six valuable appendices that cover the diets and body measurements of select insectivorous bats in nature, species of plant visited and consumed by New and Old World fruit bats, and the approximate pH of foods offered to captive fruit bats.

The remaining two chapters that focus on diet and feeding cover the various strategies employed for successfully rearing and collecting insects for the food of captive bats. Insectivorous bats have historically been the group that has been the most difficult to maintain in captivity, largely because diets have been nutritionally deficient or led to obesity. Although not explicitly discussed in

these chapters, the ability to provide captive colonies of insectivorous bats with sufficient quantities of appropriate, live insects will greatly enhance their physical and psychological well-being, enable species to be maintained long-term, and facilitate the efforts of researchers to address challenges for conservation, such as white-nose syndrome.

The fifth chapter bridges the two main topics of the book and provides an interesting discussion on environmental enrichment for bats, with a focus on various aspects of dietary/foraging enrichment and design of enclosures. Also included is a brief overview of training as enrichment. The chapter concludes with a short section on the importance of evaluating the different forms of enrichment offered to bats and assessing the risks and benefits of various enriched habitats.

In the next three chapters, the reader is treated to an extremely interesting argument on how captive environments should supply the specialized roosting conditions used by different species of bat, a short discussion on an inexpensive mechanism to provide humidity to enclosures, and requirements for maintaining colonies of phyllostomids in the laboratory. The final chapter is a collection of eight papers discussing the environmental and housing parameters for various micro- and megachiropterans. The requirements for insectivorous bats, Old World fruit bats, and New and Old World nectarivorous bats are covered in some detail, and there are brief accounts for three species of vampire and the Australian ghost bat (*Macroderma gigas*).

Almost all chapters and papers contain black-and-white images and/or illustrations. Most are clear and help augment the text. However, a few are of lesser quality (e.g., photo of a feeding *Diaemus youngi* on page 101) or provide little value to the reader (e.g., image of a plastic food pan on page 113) and could have been omitted.

Other than unevenness in the quality of the material presented in the chapters, the only other issue I had with the book is that many chapters and contributed papers end very abruptly and would have benefited by having a short summary paragraph. These concerns aside, Susan Barnard has put together another extremely valuable reference. Although *Bats in Captivity, Volume Three: Diet and Feeding — Environment and Housing* may have a limited audience, this book is a "must have" for curators, managers, or keepers at zoos, researchers maintaining bats in laboratories, or any individual with a passion for this fascinating and unique group of mammals.

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Island Bats. **Theodore H. Fleming and Paul A. Racey, Eds. University of Chicago Press, Chicago, Illinois.** 560 pages, 2010. Cloth: ISBN: 9780226253305. ($65.00 U.S.)

Island Bats presents a collection of works from a special symposium of the Association for Tropical Biology and Conservation that was held in Miami, Florida, in 2004, with a few, additional, invited contributions. The compilation covers an impressive breadth of topics and contains 16 chapters organized into three parts—Evolution, Ecology, and Conservation—each of which contains a diversity of specific research questions, cases, and technical approaches. The focus on bats on islands may seem narrow, but as stated by the editors, islands have served as natural laboratories throughout the history of the study of evolution and ecology, and bats, as a group, provide ample diversity to refine our

deepening understanding of large-scale patterns and processes.

Part 1: Evolution of Island Bats includes four chapters concerned with interactions between the current and historical geography of various groups of islands (the Philippines, southern Wallacea, and the Caribbean) and the origins and evolution of the diversity of the bats that are found there. Common to these chapters is the application of molecular markers, population genetics, and phylogenetic analyses to estimate the historical direction and degree of gene flow and the resulting amount of reproductive isolation among the islands' bats. These genetic patterns of population size, isolation, and divergence are examined within the context of the geographic and geologic history of the islands, as well as the ecology of the bats, to identify forces driving the evolution of bats on islands.

Expectedly, the authors find that historically fluctuating ocean-crossing distances, areal extent of islands, and climatic and habitat gradients are strong explanatory variables, though they do not clarify observed patterns for all species to the same degree. Also discussed in Part 1 is the difficulty in attributing population patterns to past habitat because of a lack of historical information and recent, rapid, human-induced changes. The first set of chapters is well written, with clear concern for a broader audience. Although some readers might find the accompanying explanations of molecular analyses frustratingly dense and the variety of techniques across the chapters confusing, I think that the expanded explanations of methods and analyses in a volume such as this are very useful.

Part 2: Ecology of Island Bats contains six chapters ranging widely from physiological ecology (energetics) to community ecology (succession and response to disturbance) to habitat selection (the use and importance of caves). A seventh chapter addresses the potential role that flying foxes (Pteropodidae) play in the still unsolved mystery of neurodegenerative disease among the Chamorro people of Guam. Though an interesting story, this latter chapter seems to have little to do with the general ecology of bats on islands and relates more to the ecology of a particular human-bat interaction and the history of human consumption of flying foxes in the region.

Most chapters in this section are concerned primarily with patterns of species diversity in the Caribbean and the relationship of diversity with island size, frequency and degree of natural disturbances (hurricanes and volcanic eruptions), availability of habitat (especially caves), and habitat fragmentation. Underlying causes of the patterns of diversity are complex and difficult to quantify, though these chapters are successful in uncovering many factors that potentially contribute to the complexity of communities on particular islands. Other chapters discuss physiological adaptations for life on islands and the role of bats in ecological succession in tropical forests and outline the complexity and challenges of establishing stable communities on islands. Additionally, I see this section as an invaluable collection of information on natural history that comes only from intense and time-consuming field study. The works presented in Part 2, as quantitatively difficult as they are, provide valuable information about the lives of the bats on islands and the dynamic interactions of bats with their surrounding habitat.

Part 3: Conservation of Island Bats contains four chapters that highlight the need for basic data on use of habitat and other aspects of natural history for most species. Threats to insular populations are clear and include genetic isolation, frequent natural disturbances, and human impacts. The primary threats of habitat destruction and disturbance are clearly increasing, as the human population grows and technologies

develop that make the harvesting of animals and alteration of native habitats easier and more profitable. Common themes in these chapters are setting priorities for conservation initiatives, identifying areas for protection, and developing educational programs—all of which require basic ecological information about the bats at risk. Habitat requirements, vulnerability to disturbance, and degree of population isolation and differentiation are of major importance in setting conservation agendas. Furthermore, as noted particularly for bats on Madagascar (Ch 13), systematic and taxonomic questions, such as specific or subspecific status, often affects the level of protection afforded various populations.

Overall, the importance of the diversity of works in this collection comes into focus most clearly through the lens of the final chapters on conservation in Part 3. Individually, the works presented in Parts 1 and 2 stand on their own as valuable contributions to their subfields, ranging from population genetics to macroecology to evolution. However, the final conservation chapters clearly outline the challenges to enacting meaningful conservation programming, for a diversity of areas, with varying challenges, and each chapter articulates the need for continued research of the type presented in the first two parts of this book, as well as the need for continued synthesis of that type of research.

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RECENT LITERATURE

Authors are requested to send reprints or PDF files of their published papers to the Editor for Recent Literature, Dr. Jacques P. Veilleux (Department of Biology, Franklin Pierce University, Rindge, NH 03461, U.S.A., e-mail: **veilleuxj@franklinpierce.edu**) for inclusion in this section. Receipt of reprints is preferred, as it will facilitate complete and correct citation. However, if reprints and/or PDF files are unavailable, please send a complete citation (including complete name of journal and corresponding author mailing address) by e-mail. The Recent Literature section is based on several bibliographic sources and for obvious reasons can never be up-to-date. Any error or omission is inadvertent. Voluntary contributions for this section, especially from researchers outside the United States, are most welcome and appreciated.

ANATOMY

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NEWS from OUR SUBSCRIBERS

Kunwar Bhatnagar submitted the following news item: The following item was excerpted from the May 2012 issue of *The Scientist*. It says that in Guam three species of bats have fallen prey to the brown tree snake, *Boiga irregularis*.

> "Although most island residents never encounter the nocturnal tree-dwelling snakes, they've had a particularly woeful impact on Guam's native bird, lizard, and flying-mammal species. The Micronesian kingfisher now exists only in captivity, and the Guam flycatcher is extinct. Only one of Guam's three native bat species has been sighted since 1968, and endemic lizards have been decimated....."
>
> "An 80 mg-dose of acetaminophen, which is toxic to snakes, is stuffed inside the frozen carcass of a mouse neonate. The neonate is glued to a 'flagger'... When the mouse is tossed from a helicopter, 'it sort of rainbows'... and the streamer tangles in the forest canopy where the snakes reside....." Such traps have reduced the number of snakes.

From: Richards, Sabrina. 2012. It's Raining Mice. The Scientist, May, pp. 23, 25.

Request from your Editor, Margaret Griffiths: If you have bat-related news items—what's happening in your lab or agency; what's new with your students; or students, what's new your major professor—please consider sharing those items with us. Send news items to the Editor, Margaret Griffiths (margaret.griffiths01@gmail.com).

ANNOUNCEMENTS

2011 National Bat Monitoring Programme Annual Report

The National Bat Monitoring Programme Annual Report for 2011 has been published and is available online at http://www.bats.org.uk/pages/nbmp_annual_report.html. The report presents the latest bat species population trends from this long running program, which is a partnership between the Bat Conservation Trust, the Joint Nature Conservation Committee, Countryside Council for Wales, and Defra.

Change of Address Requested

Will you be moving in the near future? If so, please **send** your **new postal and e-mail addresses** to Margaret Griffiths (margaret.griffiths01@gmail.com), and include the date on which the change will become effective. Thank you in advance for helping us out!

Request for Manuscripts — *Bat Research News*

Original research/speculative review articles, short to moderate length, on a bat-related topic would be most welcomed. Please submit manuscripts as MSWord documents to Allen Kurta, Editor for Feature Articles (akurta@emich.edu). If you have questions, contact either Al (akurta@emich.edu) or Margaret Griffiths (margaret.griffiths01@gmail.com). Thank you for considering submitting some of your work to *BRN*.

11th Annual Great Lakes Bat Festival

Celebrate the International Year of the Bat at the 11th Annual Great Lakes Bat Festival, presented by the Organization for Bat Conservation, at the Southfield Pavilion (Southfield, MI). The festival will feature activities for children, families, educators, and conservation professionals, and will include exhibits, live animal programs, hands-on activities and crafts for kids, and presentations by bat experts. Janell Cannon, award-winning author of "Stellaluna," is one of many featured speakers. For all ages and free. More information available at http://batconservation.org/drupal/bat-festival

FUTURE MEETINGS and EVENTS

24–27 October 2012

The 42nd Annual North American Symposium on Bat Research (NASBR) will be held on 24–27 October 2012 at the Conrad San Juan Condado Plaza in San Juan, Puerto Rico. Check the NASBR website for updates and announcements — http://www.nasbr.org/.

12–16 August 2013

The 43rd Annual NASBR and the 16th International Bat Research Conference will be held in San Jose, Costa Rica. See the NASBR website for updates — http://www.nasbr.org/.

2014

The 44th Annual NASBR will be held in Albany, New York, in October 2014, dates TBA. See the NASBR website for future updates — http://www.nasbr.org/.

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Front Cover

The cover photograph shows a solitary *Murina ussuriensis*, the Ussurian tube-nosed bat, flying above a fox. The photo was taken at a site (44 1 9.9N, 144 58 11.6E) just next to the Shiretoko World Natural Heritage site, at 19:16, August 17, 2003 (53 min after sunset), and was submitted by Dr. Hirofumi Hirakawa (Forestry and Forest Products Research Institute, Toyohira, Sapporo, Japan). Thank you, Hiro, for sharing this rare photo with us!

BAT RESEARCH NEWS

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Bat Research News is published four times each year, consisting of one volume of four issues. *Bat Research News* publishes short feature articles and general interest notes that are reviewed by at least two scholars in that field. *Bat Research News* also includes abstracts of presentations at bat conferences around the world, letters to the editors, news submitted by our readers, notices and requests, and announcements of future bat conferences worldwide. In addition, *Bat Research News* provides a listing of recent bat-related articles that were published in English. *Bat Research News* is abstracted in several databases (e.g., BIOSIS).

Communications concerning feature articles and "Letters to the Editor" should be addressed to Dr. Al Kurta (akurta@emich.edu), recent literature items to Dr. Jacques Veilleux (veilleuxj@franklinpierce.edu), and all other correspondence (e.g., news, conservation, or education items; subscription information; cover art) to Dr. Margaret Griffiths (margaret.griffiths01@gmail.com).

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Back issues of *Bat Research News* are available for a small fee. Please contact Dr. Margaret Griffiths (margaret.griffiths01@gmail.com) for more information regarding back issues. Thank you!

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Letters to the Editor

Editor's Note: Unlike technical articles, letters are not peer-reviewed, but they are edited for grammar, style, and clarity. Letters provide an outlet for opinions, speculations, anecdotes, and other interesting observations that, by themselves, may not be sufficient or appropriate for a technical article. Letters should be no longer than two manuscript pages and sent to the Feature Editor.

Potential Spring Mating Behavior in the Eastern Pipistrelle (*Perimyotis subflavus*)

Luke E. Dodd and Joseph S. Johnson

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On 5 April 2012, we were conducting a harp-trapping survey of bats at the entrance to Colossal Cave, which is on the property of Mammoth Cave National Park, Edmonson County, Kentucky (N 37° 11' 15.5", W 86° 4' 25.4"). The sky was overcast at dusk, with a temperature at sunset of 13°C. An individual bat was observed at 1921 h CST (ca. 10 min after sunset), flying in a looping pattern (ca. 2–3 m off the ground), outside the cave entrance. Following this behavior, the bat attempted to enter the cave and became entangled in plastic "garden" netting that was used to create a funnel around the harp trap (Kunz and Kurta, 1988). The bat was removed, identified as an eastern pipistrelle (*Perimyotis subflavus*), and quickly released.

The bat continued to fly in a looping pattern and eventually another bat flew in pursuit of the first individual. Within 1 minute, the two bats landed on the bole of a white oak (*Quercus alba*), 7 m above the ground. The bats remained in view (ca. 10 m away) throughout the observation period, and we deduced that copulation was occurring because one individual was mounted on the other at all times, both bats were of the same species, and it did not appear that the mounted individual tried to escape from the other. One bat took flight into the forest canopy 4 min after the assumed copulation began, followed by the second bat 1 min later. Immediately following this observation (1928 h CST), another pair of bats was observed exhibiting a similar looping flight pattern and landed on the bole of a tulip poplar (*Liriodendron tulipifera*) at a height of 9 m. These bats took flight after ca. 1 min, and we could not determine their species.

Mating in *P. subflavus* occurs from autumn to spring. Although most mating is assumed to take place during autumn swarming, the spring mating that does occur corresponds with the time of ovulation in this species (Fujita and Kunz, 1984; Gutherie, 1933) and likely provides females with an opportunity for re-insemination if viable spermatozoa are lost during hibernation (Krutzsch and Crichton, 1986). Although the overall number and viability of spermatozoa carried by male bats through hibernation are likely reduced (Racey, 1979), the males of this species are adapted to a shorter period of sexual dormancy than other bats in North America (Krutzsch and Crichton, 1986).

Vincent and Whitaker (2007) observed mating in *P. subflavus* on three instances within a hibernaculum from the end of February to the middle of March in western Indiana. The timing of our observations in

central Kentucky extends these dates into spring by almost a month and documents presumed copulatory behavior outside a hibernaculum. If fertilization and implantation took place following our mating observation, the minimum 44 days needed for gestation would place parturition in mid-May (Fujita and Kunz, 1984). Although such a date is earlier than expected for the region, it is consistent with the spring of 2012 being one of the warmest in recent years (University of Kentucky, College of Agriculture, Weather Center: wwwagwx.ca.uky.edu).

Observations of spring mating for other bats in North America that hibernate underground are sparse. LaVal and LaVal (1980) observed mating in the northern bat (*Myotis septentrionalis*) as late as 10 April. Other members of this genus, the gray bat (*M. grisescens*) and Indiana bat (*M. sodalis*) have been reported to mate in April in the hibernacula as well (Cope and Humphrey, 1977; Saugey, 1978). Our observations suggest that, at least for *P. subflavus*, spring mating may take place outside the hibernaculum.

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BOOK REVIEW

Bats of Texas. Loren K. Ammerman, Christine L. Hice, and David J. Schmidly. Texas A&M University Press, College Station, Texas.
xvi + 305 pp., 2012. ($35.00 United States)

Co-authors Loren Ammerman and Christine Hice team up with David Schmidly to produce the new edition of *Bats of Texas*. They build on the solid foundation of the first edition, originally published by Schmidly in 1991, and incorporate a vast amount of information that has come to light in the intervening 21 years. They add one additional bat (*Lasiurus xanthinus*) bringing the total count of species in Texas to 33, four of which are known from only one specimen in the state. These four and a list of five "Hypothetical Species" that have been documented close to the border of Texas prepare the user for any bat, local or vagrant, that may cross her path. With its sturdy, flexible binding and identification keys, this book is perfect for taking into the field and its detailed species accounts, richly illustrated with 46 color photographs and 28 range maps, make it a useful desk reference for amateurs and professional biologists alike.

The new edition follows the same format as the first and has four main sections: Introduction, Illustrated Keys to the Bats of Texas, Accounts of Species, and Literature and References. The first section provides an extensive introduction to bats, both globally and in Texas, covering their classification, distribution, evolution, flight, echolocation, roosts, reproduction, and diet, as well as public health concerns and conservation measures. The new edition also describes tools for studying bats, ranging from older methods, such as mist nets and harp traps, to the latest advances in bat detectors, thermal infrared imaging, and molecular techniques. In addition, the authors discuss various threats, such as white-nose syndrome, climate change, and wind turbines, as well as novel conservation strategies, like the "chiroptorium," that were not known when the first edition was published. The introduction includes several useful tables of information, such as body measurements, species distribution among 12 ecological regions of Texas, and seasonal occurrence by month of each of the 33 species, plus a list of fossil bats from the state and a summary of rabies prevalence in bats in Texas and the entire United States.

Two dichotomous keys to the bats of Texas, one of external characters and the other of skulls, comprise the second section of the book. Both are accompanied by 99 of Carson Brown's beautiful illustrations depicting body parts that are commonly measured, such as the forearm, hind foot, and ears, and diagnostic features, including fur patterns, degree of tail extension from the uropatagium, and morphology of the calcar and tragus. Measurements in the keys are presented in metric units, as they are throughout the book. Other than use of total body length to distinguish among species of yellow bats, all measurements/characters that appear in the external character key are easily taken/seen on live specimens. Both keys are essentially the same as those in the first edition, except for some minor changes in differentiating among species of *Myotis*.

The third section, making up the bulk of the book, contains the species accounts. Each is divided into nine parts: Etymology, Subspecies, Description, Distribution, Life History, Status, Remarks, Specimens Examined, and References. The authors describe each species' physical appearance and explain how to differentiate it from similar species, which is particularly valuable for the nine species of *Myotis* occurring in Texas. They provide additional assistance with the species of *Myotis* by compiling their salient morphological characters into a table

for easy reference. They discuss any taxonomic or systematic changes or debate in the 'Remarks' subsection.

Each account includes a synopsis of the species' global distribution, as well as a detailed description of its geographic and temporal occurrence in Texas. Range maps, created from data associated with over 9,000 museum specimens, depict the distribution of each species in Texas. On each map, individual capture localities are denoted by symbols, whereas the full range is indicated with shading; simple lines delineate boundaries between the ranges of subspecies. To save space, the authors have listed the many specimens that were examined on a website, http://www.batsoftexas.com/, instead of including them in the book as was done in the first edition.

To me, the most valuable aspect of the new edition is the expanded information on life history accompanying each species account. The authors incorporate data, gathered both inside and outside of Texas, from published sources, personal communications, and their own research to produce thorough descriptions of the lives of bats of Texas. The authors describe the roosting requirements of the bats, their migratory patterns, foraging strategies and habitat, diet, reproduction, litter size, longevity, predators, and special adaptations. These sketches make the bats come alive and underscore how much has been learned about North American bats in the last 20 years. The accounts are complemented by large, color photographs by J. Scott Altenbach, portraying each species either roosting or in flight. Each account is brought to a close with a sub-section on the species' status that details its rating by the International Union for Conservation of Nature, U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department, or other agencies, and also discusses potential causes of population declines.

Literature and References, the final section, deserves mention in its own right. This part of the book spans nearly70 pages and includes more than 1,200 references, over 800 more than presented in the first edition.

Bats of Texas is much more than a simple guide book. It is incredibly thorough, well researched, and scientific in tone, which may make it out of reach for young naturalists. However, because more than two-thirds of the species in the United States occur in the state, the book should have a wide readership well beyond Texas.

Cullen K. Geiselman, Houston, Texas
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RECENT LITERATURE

This issue's Recent Literature section was compiled as a joint effort by Anne Griffiths (master-of-all-trades and daughter of the Managing Editor), Tom Griffiths (former Editor of *BRN* and husband of the current Managing Editor), Jacques Veilleux (Editor for Recent Literature), and Margaret Griffiths (Managing Editor). The managing editor thanks each of them for their help.

Authors are requested to send reprints or PDF files of their published papers to the Editor for Recent Literature, Dr. Jacques P. Veilleux (Department of Biology, Franklin Pierce University, Rindge, NH 03461, U.S.A., e-mail: **veilleuxj@franklinpierce.edu**) for inclusion in this section. Receipt of reprints is preferred, as it will facilitate complete and correct citation. However, if reprints and/or PDF files are unavailable, please send a complete citation (including complete name of journal and corresponding author mailing address) by e-mail. The Recent Literature section is based on several bibliographic sources and for obvious reasons can never be up-to-date. Any error or omission is inadvertent. Voluntary contributions for this section, especially from researchers outside the United States, are most welcome and appreciated.

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NEWS from OUR SUBSCRIBERS

From **Dr. Wayne Davis**, the founder and original publisher of *Bat Research News*: "I appreciate receiving *BRN* and always read it all. I used to see red bats and *Eptesicus* here in town [Lexington, KY] frequently but have not seen a bat for 10+ years, although I often look. I have been playing with Carolina wrens and prothonotary warblers for the last several years. I build and give away special nest boxes for them and have the warblers nesting along several waterways here in central Kentucky."

Dr. Davis began publishing *Bat Research News* under the title *Bat Banding News* in 1960. Beginning with Volume 5(1) in 1964, the title was changed to *Bat Research News*. In the first issue of volume five, Dr. Davis explained his decision for the change of title.

"Two reasons for the change. First I am interested in all phases of bat biology and not just those aspects that can be investigated through banding. Second is political: bat banding sounds too much like nit picking and to many people bat research sounds worth while, but bat banding sounds trivial." *Bat Research News*, 5(1): 1, January 1964.

We thank you, Dr. Davis, for your foresight in starting *Bat Research News*, and for the many years of faithful service to our journal, and to bats and other wildlife as well. All of us associated with *BRN*—editorial staff and subscribers—appreciate your efforts!

Margaret Griffiths, Managing Editor and Publisher, *Bat Research News*.

Congratulations to **David Redell** (Wisconsin Department of Natural Resources). David was recognized by the U.S. Fish & Wildlife Service and presented with their Silver Eagle Award. The Silver Eagle Award is the Service's highest honor and is given in recognition to people who have made an impressive contribution to wildlife conservation and management.

David has made significant contributions to bat conservation throughout Wisconsin. He has identified major hibernacula, developed monitoring techniques, and advanced our knowledge of basic bat ecology. His studies have led to the development of appropriate management and protection of Wisconsin's hibernacula and bat population. Even before the threat of white-nose syndrome, David recognized the need to more actively manage bat populations and created the Wisconsin Bat Program, which includes statewide data collection utilizing citizen scientists, white-nose syndrome surveillance, maternity roost monitoring, and a comprehensive education and outreach effort. In addition, David established the Wisconsin Bat Conservation Fund, an endowment to support these bat conservation efforts into the future.

Congratulations, David, for receiving this award and also for your work with bats throughout Wisconsin and beyond.

Request from your Editor, Margaret Griffiths: If you have bat-related news items—what's happening in your lab or agency; what's new with your students; or students, what's new your major professor—please consider sharing those items with us. Send news items to the Editor, Margaret Griffiths (margaret.griffiths01@gmail.com).

ANNOUNCEMENTS

2013 Bat Conservation International Student Research Scholarships

Bat Conservation International is accepting applications for its 2013 BCI Student Research Scholarships. Grants of up to $5,000 each will be awarded for the 2013–2014 academic year. Grants will be awarded for research that is directly related to bat conservation, with an emphasis on projects that document roosting and feeding habitat requirements of bats, their ecological and economic roles or their conservation needs. Students enrolled in any college or university worldwide are eligible to apply for BCI scholarships. Applications are competitive and will be reviewed by bat scientists outside BCI. The **application deadline** for 2013 scholarships is **15 December 2012**. Information and the online application form are available at http://www.batcon.org/scholarships.

Request for Manuscripts — *Bat Research News*

Original research/speculative review articles, short to moderate length, on a bat-related topic would be most welcomed. Please submit manuscripts as MSWord documents to Allen Kurta, Editor for Feature Articles (akurta@emich.edu). If you have questions, contact either Al (akurta@emich.edu) or Margaret Griffiths (margaret.griffiths01@gmail.com). Thank you for considering submitting some of your work to *BRN*.

Change of Address Requested

Will you be moving in the near future? If so, please **send** your **new postal and e-mail addresses** to Margaret Griffiths (margaret.griffiths01@gmail.com), and include the date on which the change will become effective. Thank you in advance for helping us out!

FUTURE MEETINGS and EVENTS

24–27 October 2012

The 42nd Annual North American Symposium on Bat Research (NASBR) will be held on 24–27 October 2012 at the Conrad San Juan Condado Plaza in San Juan, Puerto Rico. Check the NASBR website for updates and announcements — http://www.nasbr.org/.

5–7 December 2012

The International Symposium on the Importance of Bats as Bioindicators will be held on 5–7 December 2012 in Granollers (Barcelona), Spain. Please see the following website for more information: http://es.amiando.com/bats_as_bioindicators_symposium_2012.html.

11–13 January 2013

Bat Conservation and Management, Inc. and SonoBat are hosting a SonoBat Software Training Workshop at the Airport Best Western in Albany, New York, from 11–13 January 2013. The course will highlight current acoustic inventory techniques with a focus on the use of the latest full-spectrum bat detectors and echolocation call analysis. More information can be found at:
http://www.batmanagement.com/Programs/2013AlbanySBS/2013AlbanySBS.html.

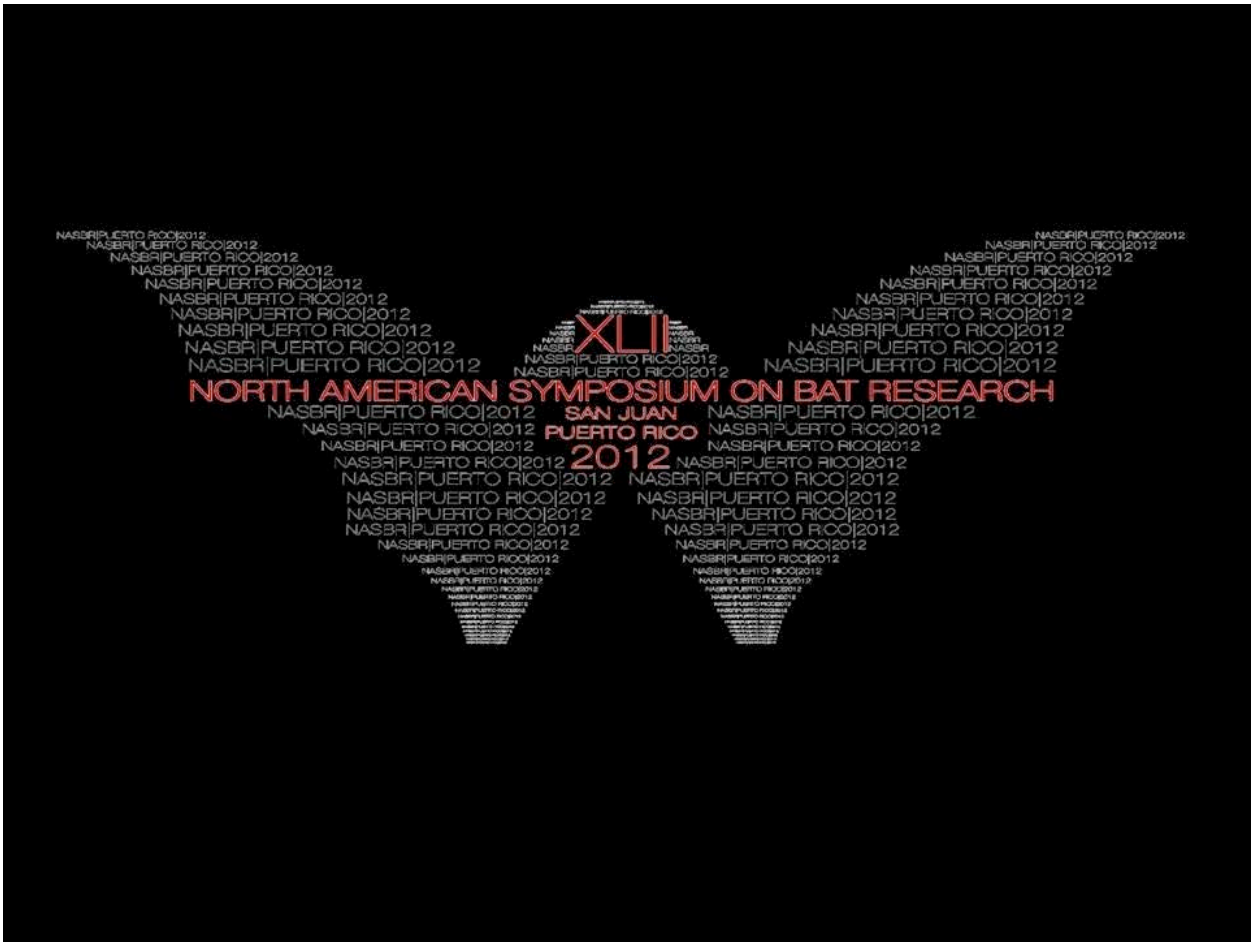
12–16 August 2013

The 43rd Annual NASBR and the 16th International Bat Research Conference will be held in San Jose, Costa Rica. See the NASBR website for updates — http://www.nasbr.org/.

2014

The 44th Annual NASBR will be held in Albany, New York, in October 2014, dates TBA. See the NASBR website for future updates — http://www.nasbr.org/.

BAT RESEARCH NEWS



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Communications concerning feature articles and "Letters to the Editor" should be addressed to Dr. Al Kurta (akurta@emich.edu), recent literature items to Dr. Jacques Veilleux (veilleuxj@franklinpierce.edu), and all other correspondence (e.g., news, conservation, or education items; subscription information; cover art) to Dr. Margaret Griffiths (margaret.griffiths01@gmail.com).

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Acoustically Detecting Indiana Bats: How Long Does It Take?

Shannon Romeling, C. Ryan Allen, and Lynn Robbins

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Introduction

Echolocation calls of many species of bats can be quantitatively identified, with a high degree of accuracy (Britzke et al., 2011; Corcoran, 2007; Fukui et al., 2004; Krusic and Neefus, 1996; Parsons and Jones, 2000; Preatoni et al., 2005; Russo and Jones, 2002; Rydell et al., 2002), and acoustic detectors are commonly used for surveying communities and assessing habitat use (e.g., Ahlen, 1981; Duffy et al., 2000; Murray et al., 1999; O'Farrell and Gannon, 1999; Russo and Jones, 2002). Despite increased use of acoustic techniques, few studies have examined the level of survey effort (number of detectors or length of time that detectors should be employed) that is needed for accurate determination of species richness or levels of activity. Hayes (1997), for example, monitored acoustic activity of bats flying over third-order streams in Oregon and concluded that sampling for less than 6–8 consecutive nights was likely to produce biased estimates of activity. In southern Nevada, Skalak et al. (2012) determined that detection of 90% of the species with a single detector required an average of 21–46 sampling nights, depending on season. The probability of detecting species also increased with the number of detectors that were employed (Skalak et al., 2012).

Traditionally, mist-netting has been the primary method recommended by the U.S. Fish and Wildlife Service (USFWS, 2007) to gain information on activity of and to demonstrate presence/probable absence of Indiana bats (*Myotis sodalis*), an endangered species that occurs in the eastern and midwestern United States. Use of acoustic techniques for studying Indiana bats has been limited, due to the high similarity in echolocation calls among species of North American *Myotis*, which previously inhibited identification completely or produced many false positives (Murray et al., 2001). Recent advancements in acoustic identification, using automated mathematical models, have shown that members of this genus can be separated with a much higher degree of accuracy when longer duration search-phase calls recorded in noncluttered environments are examined (Allen et al., 2011; Britzke et al., 2011; Corcoran, 2007).

The USFWS (2012a) has proposed a shift to initial acoustic surveys for Indiana bats to determine their presence/probable absence in an area. The proposed guidance requires acoustic surveys, using a single detector, for two complete nights, between 15 May and 15 August. The primary goal of our project was to use previously recorded data to assess the length of time needed to make acoustic detections of Indiana bats in an area where they are known to be present to verify whether a 2-night acoustic survey was adequate to detect Indiana bats.

Although summer residency has been the main focus of the U.S. Fish and Wildlife Service, it is clear that threats to Indiana bats can occur outside the summer maternity season (15 May–15 August). For example, Indiana bats have been killed at wind farms during fall migration (e.g., USFWS, 2012b). Therefore, in addition to assessing the length of time needed for acoustic detection of Indiana bats during summer, we also examined activity of Indiana bats during the

fall migratory season (16 August–31 October).

Methods

Study area.—We acoustically sampled bats in three study areas in four counties of northern Missouri, using techniques consistent with the proposed guidelines (USFWS, 2012a). All three sites were in landscapes consisting of a mosaic of agriculture and forested riparian habitat, mostly surrounding "losing" streams (Lobb and Femmer, 2012). Local forests were dominated by shagbark hickory (*Carya ovata*) and eastern cottonwood (*Populus deltoides*).

Data collection.—Echolocation calls were collected between 15 May and 31 October 2008–2011, by ultrasonic detectors (Anabat II, Titley Electronics, New Ballina, Australia), placed in waterproof cases, with the microphone facing into a polyvinyl chloride tube with a 90° bend. Detectors were placed ca. 1.5 m above the ground. Each detector was powered with a 12-V external battery, attached to a 6-W solar panel, and set to record from 30 min before sunset until 30 min after sunrise. Compact flash cards containing stored recordings of echolocation calls were downloaded every 7–14 days. Only complete nights of recording were included in the analyses. Numerous detectors were present on the three sites; however, only 19 detectors in known foraging habitat of Indiana bats were used in these analyses.

Foraging habitat was established by radio-telemetry of female Indiana bats. Distance of detectors from roost trees and capture locations was determined in ArcMap 9.3.1 (Environmental Systems Research Institute, 2008). Detectors were an average of 2,753 ± 2,382 (*SD*) m from a primary roost tree containing at least 30 Indiana bats, 1,052 ± 1,064 m from any tree containing Indiana bats (primary or alternate), and 716 ± 1,173 m from a location where an Indiana bat was captured. Average distance between a detector and the closest location of an Indiana bat (capture or roost) was 434 ± 939 m. Eighty-six Indiana bats were captured, and at least two primary roost trees were found in each of the three study areas. There is no guarantee that Indiana bats were continually present throughout the survey period, but in all cases, Indiana bats were captured and foraging data were collected, at or near the site of each detector, during the same year that acoustic recordings were made.

Identification of calls.—Data were first analyzed using an automated method—Bat Call Identification (BCID, Kansas City, Missouri)—on files containing a minimum of three search-phase pulses. The BCID software was written in C++ beginning in 2007, based on parameters of call files that were provided by many researchers, predominantly from Missouri State University and Truman State University. The reference library contained 1,728 call files from 12 eastern species, including 248 sequences attributable to Indiana bats. Echolocation calls were recorded primarily from light-tagged bats, with some recordings from hand-released and free-flying individuals included, when there was no question as to the species being observed. Our analyses showed that, overall, the software was ca. 96% accurate to species and 99% accurate to a species group. Species groups consisted of a "low-frequency group," containing species for which the normal echolocation call contained at least some frequencies below 30 kHz; *Myotis,* which included the three species present in Missouri—Indiana bats, little brown bats, (*M. lucifugus*) and northern bats (*M. septentrionalis*); and a "mid-frequency group," containing non-*Myotis* bats having a minimum frequency greater than 30 but less than 50 kHz. The software also was 98% accurate for call files of Indiana bats, when tested against the species in this reference library.

The BCID software begins by applying a filter to all recorded files, which is intended to eliminate noise, as well as fragmented and non-search-phase calls. Parameters are extracted in AnalookW (Titley Electronics, New Ballina, Australia) and then individually compared to known quantitative ranges of parameters of search-phase calls and given a corresponding weight of importance based on a range of those particular parameters for any given species (Britzke et al., 2011; Murray et al., 1999). Parameters with tighter ranges and less overlap with other species receive increased weight. The weights are totaled to provide preliminary identification of individual pulses within a sequence (i.e., a group of search-phase pulses residing in a single call file), and logic tests are then conducted on the full sequence to determine a species group (low-frequency, mid-frequency, *Myotis*) and reduce false positive rates. Once a species group has been determined, other possible species are eliminated from consideration, and individual pulses are then re-identified, resulting in an initial determination of the species. Finally, species with overlapping call structures are compared using pairwise comparisons of Mahalanobis distance to a multivariate centroid of all known calls for that species (Mahalanobis, 1936).

After automated results were obtained with BCID, all sequences that were identified as Indiana bats were visually and independently confirmed (qualitative identification) by at least two experienced observers. Only when sequences were identified as Indiana bats by the automated program and verified by both experienced observers as not having the obvious characteristics of the other local myotids—little brown bats and northern bats—were the sequences attributed to Indiana bats. All observers were from Missouri State University, which has conducted research in the field of echolocation for over a decade, specifically focusing on automated identification and differences in echolocation call structure among bats in the eastern United States (Allen et al., 2011; Britzke et al., 2011; Murray et al., 1999, 2001).

Analysis of data.—Data were separated into two periods: summer (15 May–15 August) and fall (16 August –31 October) and analyzed in three ways. First, recordings were examined for the longest gap in days, for each detector, that did not result in the recording of at least one sequence of calls by an Indiana bat.

Second, all data from 15 May to 31 October were analyzed in approximately biweekly (2-week-long) intervals. Within the biweekly periods, data were analyzed using consecutive 2-day recording periods to have a smaller time scale from which to draw conclusions. Because the 2-day periods were only analyzed biweekly to discern smaller-scale temporal patterns in the data, there is one possible period missing for the last and first day between each biweekly period. For example, using 2-day periods over just 5 days, with one detector, yielded the following periods: days 1–2, days 2–3, days 3–4, and days 4–5. In this example, 5 days of recording produced four 2-day periods. Failure of detectors also would modify the number of available 2-day periods. A failure on day 3, for instance, would result in only two 2-day periods: days 1–2 and days 4–5.

Finally, consecutive 5-, 10-, and 20-day recording periods were also analyzed, within the seasons of summer and fall. The number of 5-, 10-, and 20-day recording periods was determined simply by counting all possible consecutive periods of corresponding duration for each detector, and then we determined how many contained at least one call of an Indiana bat. Even use of 20-day periods did not result in 95% of all periods of that duration containing at least one sequence from Indiana bats in an area where we knew that they were present (see Results).

Consequently, we continued to increase the length of consecutive-day periods, until we determined the minimum size of the recording period that resulted in 95% of all periods containing at least one sequence from Indiana bats.

Results

A total of 882 detector-nights were completed during summer (15 May–15 August), and 123,721 identifiable sequences were recorded. During this period, 515 (0.4%) of the sequences were identified as Indiana bats, and 234 (26.5%) of the nights contained at least one sequence attributable to an Indiana bat. During fall (16 August–31 October), 724 of 62,281 identifiable sequences (1.2%) were identified as Indiana bats, and 321 (28.3%) of 1,134 detector-nights contained at least one sequence attributable to an Indiana bat.

The longest gap between detections of an Indiana bat by any one detector, ranged from 4 to 39 days, with an average of 15.5 ± 10.7 days during summer, and 3 to 42 days, with an average of 17.8 ± 10.5 days during fall. When divided into biweekly intervals, 6.6–50.0% of the available 2-day periods contained at least one pass by an Indiana bat (Fig. 1). When analyzed using consecutive 5-, 10-, and 20-day periods, at least one Indiana bat was recorded in 60.7, 78.2, and 90.9% of the available periods, respectively (Fig. 2). However, a minimum period of 28 consecutive days was needed for ca. 95% of those detector periods to contain at least one sequence of calls from an Indiana bat (1,267 28-day periods contained at least one Indiana bat sequence out of 1,332 available 28-day periods). Twenty-eight days in summer and fall both resulted in 95.1% of the recording nights detecting at least one Indiana bat. Using the recommended two days of recording during the recommended survey period of 15 May–15 August (USFWS, 2012a), we would have falsely assumed Indiana bats to be absent during 59.5% of the available 2-day survey periods.

Discussion

Two detector-nights are insufficient to determine presence/probable absence of Indiana bats in our study areas during the recommended survey period. Between 15 May and 15 August, a maximum of 50% of the consecutive 2-day periods within the biweekly intervals contained one or more sequences actually identified as having been produced by an Indiana bat (Fig. 1). To have at least 95% of available periods contain one call attributable to Indiana bats, 28 consecutive days of recording were required. This suggests that at least 4 weeks of constant acoustic recording would be necessary to obtain 95% confidence in detecting Indiana bats in areas where they are known to be present.

We suggest that researchers with long-term acoustic data, from areas where Indiana bats have been captured, examine their data in a similar manner and determine how long a detector should be employed to detect Indiana bats with a high level of confidence. This would show the effect of geographic variation, if it exists. Additionally, we intend to investigate the probability of detection using occupancy modeling (MacKenzie et al., 2002) or maximum entropy analysis (Skilling, 1989) and examine the effect of covariates on detection probability, thus furthering our understanding of those variables that affect the likelihood of detecting Indiana bats.

The determination of probable absence is critical before activities begin that could negatively affect recovery of this species. Until biologists can be confident that a certain level of acoustic effort will result in probable absence being determined correctly at least 95% of the time, we recommend that the current netting protocol remain in place and simply be augmented with an acoustic sampling protocol (Robbins et al., 2008).

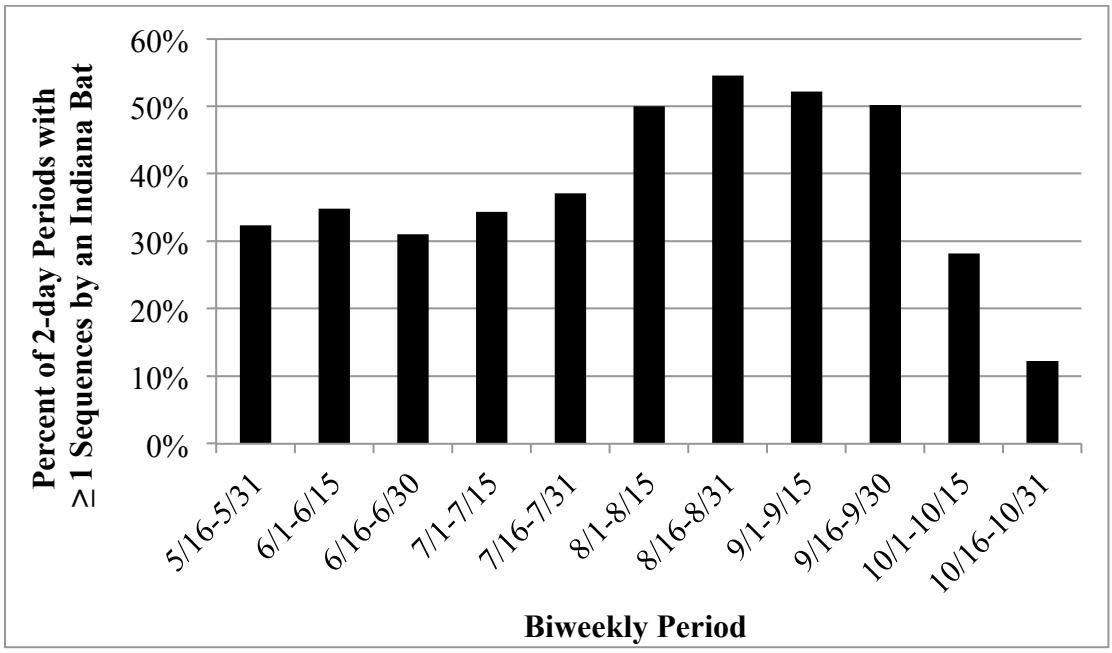

Figure 1. Percent consecutive 2-day periods containing at least one sequence of calls by an Indiana bat, during approximately biweekly intervals, from 15 May to 31 October.

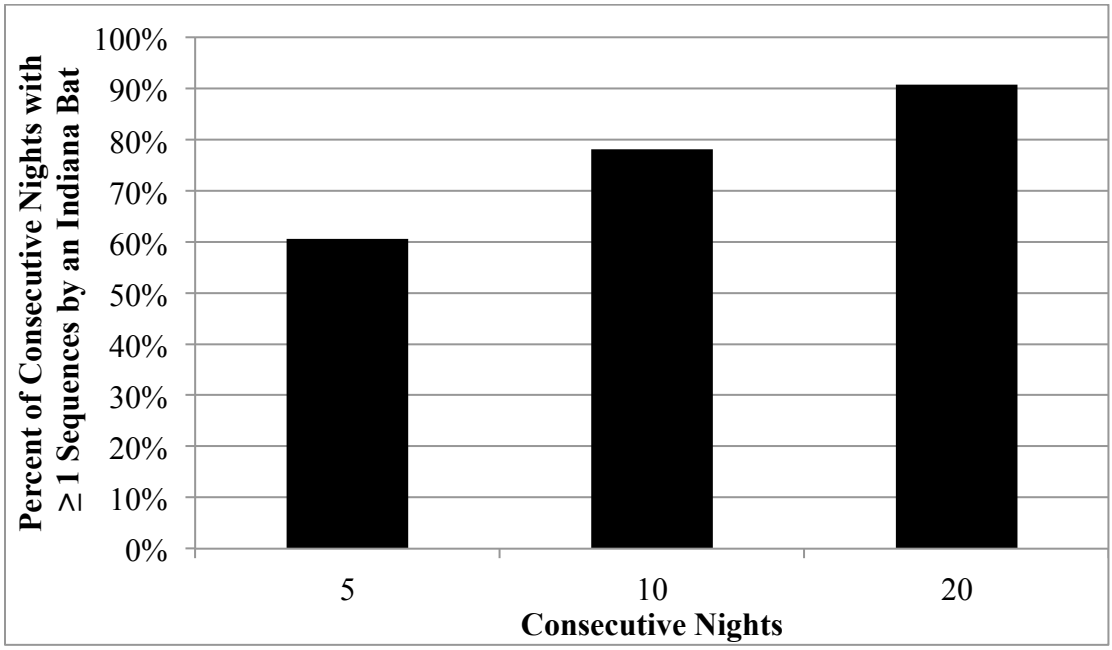

Figure 2. The percent of consecutive 5-, 10-, and 20-day periods containing at least one sequence of calls by an Indiana bat, during the recommended survey period (USFWS, 2012b) of 15 May–15 August.

Although Robbins et al. (2008) concluded that supplementing mist nets with acoustic sampling could enhance the probability of determining the presence or absence of Indiana bats, they also found that captures and detections of Indiana bats varied substantially among their sampling periods. Our findings support this conclusion, because the number of recorded calls by Indiana bats varied substantially within our biweekly intervals (Fig. 1). Furthermore, the longest gaps in detecting an Indiana bat ranged from 4 to 39 days in summer. If a short sampling period, such as the recommended 2 days (USFWS, 2012b), is used, timing of the survey may significantly impact the results.

Additionally, from analyzing data outside the range of the recommended protocol (16 August–31 October), we found that the three biweekly periods with the highest detections of Indiana bats were 16 August–31 August, 1 September–15 September, and 16 September–30 September, all of which are outside the current recommended survey period (USFWS, 2012b). Increased detection in fall could be a result of the dispersal of maternity colonies following weaning, presence of juveniles, increased foraging to build fat supplies, and/or the passage of migratory individuals. Our data suggest that acoustic surveys can be used to determine presence of Indiana bats outside the traditional maternity season, when these bats still face potential threats.

Acknowledgments

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Letters to the Editor

Editor's Note: Unlike technical articles, letters are not peer-reviewed, but they are edited for grammar, style, and clarity. Letters provide an outlet for opinions, speculations, anecdotes, and other interesting observations that, by themselves, may not be sufficient or appropriate for a technical article. Letters should be no longer than two manuscript pages and sent to the Feature Editor.

Notes on the Diet of *Tonatia bidens* (Phyllostomidae) in Paraguay

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Tonatia bidens is a small (27–34 g—Smith, 2009) phyllostomid bat that is locally distributed from northeast Brazil, east of the Amazon River, south to eastern Bolivia, Paraguay, and northern Argentina (Barquez et al., 1999; dos Reis et al., 2007; Paca et al., 2012). Though the species is a habitat generalist, it apparently occurs at low density throughout its range. Distributional records from Paraguay are few, and little has been published about the ecology of the species in that country (López-González, 2005). Myers et al. (1983) captured specimens over an isolated pond in thorn scrub and over a stream flowing through high tropical forest, and Myers and Wetzel (1983:10) noted that the stomach of a specimen from the High Chaco contained large amounts of insect chitin and an "unidentified whitish pulp."

A roost of a single adult of this species was located at the headquarters of the Parque Nacional Defensores del Chaco at Madrejón, Alto Paraguay (S 20˚37'49" W 59˚52'51"), and was visited by day on 13–14 September 2012. The roost was in an unused bathroom of an abandoned building. The room was poorly lit, and the bat hung in the darkest corner of the room, directly above an accumulated guano pile. The animal became agitated when illuminated with a flashlight, chirping audibly and eventually flying to a new location within the bathroom, but quickly returning when the light was removed. The bat departed the roost at 1750 h on 14 September, when it was dark inside, but still about 20 min before sunset. An examination of the dung pile revealed several identifiable remains.

Plant remains consisted of the large (13–16 by 11–13 mm) central seed of the mistol (*Ziziphus mistol*, Rhamnaceae). The fruit of this plant is a drupe (16–19 by 14–18 mm), and the fleshy outer pulp is frequently consumed by indigenous groups within the Chaco because of its sweetness (F. Mereles, pers. comm.). Several of these plants were found within 50 m of the roost, suggesting that the fruits may have been harvested nearby.

Wing covers and hind legs of a katydid (*Belocephalus* sp.) and paired wings of a large dragonfly (Aeshnidae) also were discovered. Both insects were large. For the katydid, the length of the femur was 21 mm, and the wings of the dragonfly were 47-mm long. Esbérard and Bergallo (2004) listed Blattaria, Coleoptera, Hemiptera, Lepidoptera, Orthoptera, and Thysanoptera among the insect remains found at roosts of *T. bidens* and mentioned that large wings and legs were typically discarded. Although several partial exoskeletons of millipedes (Polydesmida)

also were present in the dung pile, their occurrence is likely related to the consumption of detritus by these arthropods and not to the diet of the bats.

Vertebrate remains consisted of the right and left manus of an adult bird, the tropical parula (*Parula pitiayumi*). Nine primary feathers were still attached to the left manus, and eight, to the right; length of the longest primary was 47 mm. In addition, a single, yellow breast feather was found attached to fecal material. This observation provides further evidence of the consumption of birds by *T. bidens* (Barquez et al., 1999; Esbérad and Bergallo, 2004; Martuscelli, 1995). Mean body mass of adult *P. pitiayumi* in the Paraguayan Chaco is 7.3 g (Smith et al., 2008), representing a quarter to a third of the typical mass of *T. bidens* (López-González, 2005; Paca et al., 2012). Martuscelli (1995) noted that birds taken by *T. bidens* in the Atlantic Forest of Brazil weighed between 4 and 24 g and suggested that size was the main factor in selection of avian prey. The data presented here are consistent with the conclusions of Esbérard and Bergallo (2004), who believed that *T. bidens* is a foliage-gleaning omnivore that includes large arthropods and small vertebrates in its diet.

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Abstracts of Papers Presented at the

42nd Annual Symposium of the North American Society for Bat Research
San Juan, Puerto Rico
25–27 October 2012

The following abstracts are from papers presented at the 42nd Annual North American Society for Bat Research (NASBR). Local host for the Symposium was Armando Rodríguez-Durán, Universidad Interamericana de Puerto Rico. Meeting abstracts were compiled by Gary Kwiecinski, Shahroukh Mistry, and Frank Bonaccorso, Program Directors for NASBR, and edited for publication by Margaret Griffiths, Publisher/Managing Editor, *Bat Research News*. Abstracts are listed alphabetically by first author's last name. Student award recipients are indicated by an asterisk (*) next to the title of the paper. Contact information for authors who attended the 42nd Annual NASBR are available in the section following the abstracts.

Lost in the Dark: Spatio-temporal Variation in Bat Activity
Amanda Adams, Western University, London, ON

Effective management and conservation strategies for biological communities require a thorough understanding of structure and function. The structure of a community, the number of species, and the distribution of those individuals can vary dramatically both temporally and spatially. When attempting to characterize the structure of a community it is important to consider the advantages and limitations of various sampling techniques. When and how to sample is a question that is typically decided by time availability, manpower, and equipment limitations. I hypothesized that not only the sampling methods and effort will have an effect on the depiction of a community, but also the statistical methods used to analyze that data. I deployed stationary acoustic transects with six microphones at two heights in order to see how multiple microphones give different depictions of the temporal and spatial variation of bat activity within a site. I found that detector height and number of microphones used within a site effect the ability to detect variability in activity patterns and species' differential use of space and time. I also found that failure to account for spatial and temporal autocorrelation statistically can also impact measures of bat activity. My research addresses what sampling effort and statistical analysis are effective for representing bat activity levels in a temperate location and to what extent different practices can give different representations of the same community, an important step towards standardizing sampling protocols for management.

The Role of Water Sources in Organizing Bat Assemblages in Arid Environments
Rick Adams, Katelin Craven, and Laura Heiker, University of Northern Colorado, Greeley, CO

As to what forces structure insectivorous bat assemblages remains elusive. Although some evidence has pointed to resource partitioning around food, there are few data showing that insects are a limiting resource in most habitats. A potential competitive factor that has received no attention is limited water accessibility in arid environments where high concentrations of bats 'swarm' at small water sources to replenish losses from evaporation. Uniquely, small water sources bring together species that ordinarily would not compete because of ecomorphological differences. To test this hypothesis we pooled all mist-net data gathered across our field area (~100 km^2) to produce an overall proportional abundance curve for the assemblage. This curve was then compared to curves generated from four water sources where high-density, multi-species 'swarming' occurred. Our results indicate consistency in rank and proportional species abundances for the assemblage as a whole and for ensembles present at individual water sources. The Shannon Diversity Index (H') for all bats captured (n = 2,299) was 1.65, which was consistent with those calculated for the four swarming sites: Ingersol Quarry (n = 147) 1.50; Geer Canyon (n = 522) 1.61; Shadow Canyon (n = 475) 1.51 and Bear Creek (n = 458) 1.61. Thus the overall assemblage structure mimicked those documented at swarming water holes despite differences in sample size and species-specific domination patterns at any given site. We also found species-specific temporal partitioning and apparent population size effects among species having greater temporal overlap when visiting, thus further indicating competition and resource partitioning.

Bat Species Identification from Zero Crossing and Full Spectrum Recordings with New Techniques using HMMs and Fisher Scores
Ian Agranat, Wildlife Acoustics Inc., Concord, MA

A new classification technique for the identification of bats to species from their echolocation calls is presented. The technique utilizes Hidden Markov Models (HMMs), Fisher scores, unsupervised clustering and balanced Winnow pairwise classifiers. Three different datasets are compiled and split in half for training and testing classifiers. Combined, the data include 9,014 files (bat passes) with 226,432 candidate calls (pulses or extraneous noise) representing 22 different species of bats found in North America and the United Kingdom. Some files are of high quality consisting of hand-selected search phase calls of tagged free flying bats while others are from a variety of field conditions including both active (attended) and passive (unattended) recordings made with a variety of zero crossing and full spectrum recording equipment from multiple vendors. Average correct classification rates for the three datasets on test data are 100.0%, 97.9%, and 88.8% respectively with an average of 92.5%, 72.2%, and 39.9% of all files identified to species. Most importantly, classifiers in the third dataset for two species of U.S. endangered bats, *Myotis sodalis* (MYSO) and *Myotis grisescens* (MYGR), have a correct classification rate of 100% and 98.6% respectively and identify 67.4% and 93.8% of all files to species, suggesting that the classifiers are well suited to the accurate detection of these endangered bats.

Band of Brothers: Protecting Bats in Latin America and the Caribbean
Luis Aguirre, Bernal Rodríguez-Herrera, and Rodrigo Medellín, Universidad Mayor de San Simón, Cochabamba, Bolivia; Estación Biológica La Tirimbina, Sarapiquí, Costa Rica; Universidad Autónoma de México, México

Latin America harbors a vast diversity of bats, with over 300 species living in a variety of ecosystems, form coastal areas in the Caribbean to highlands in the Andes. There, bats play crucial roles in providing ecosystem services such as pollination, seed dispersal, and insect pest control, among others. However, this importance is contrasted by a large number of threatened species in the region (57 according to IUCN) and even more when considering the level of threat at a country level. To minimize these effects, Latin American bat researchers and conservationists responded by constituting in 2007 a regional network of 17 countries affiliated to the *Red Latinoamericana para la Conservación de los Murciélagos* (RELCOM). Here, we describe this regional initiative and the impact it has to protect bats. The network seeks to guarantee the persistence of healthy bat species and viable populations in Latin America and that in all the countries their importance is acknowledged and recognized. In 2009 we developed a strategy that is orienting all our conservation efforts. It identifies 5 Threats, 25 Goals, 35 Objectives and Indicators. Several actions have been accomplish regionally, including the creation of a network of Important Bat Conservation Areas/Sites, education campaigns coordinated regionally, courses and congresses, among others. By the passion and commitment of all RELCOM members, conservation of bats in Latin America is growing fast and steady, and it is foreseen a big impact on local policies.

A Regional, Interactive, Economic Model for Assessing Ecosystem Services Provided by Bats
Sybill Amelon and Larry Godsey, USDA Forest Service, Columbia, MO; University of Missouri Center for Agroforestry, Columbia, MO

Bats provide important contributions to ecosystems including predation of agricultural and forest insects. Assigning even an approximate economic value to ecosystem services is difficult, often resulting in these services being assigned a lower priority for funding or action than those for which economic values are more readily calculated. While general estimates of economic value exist, an adaptive and interactive model to assess economic value of services provided by bats is needed. We initiated this study to provide more specific estimates of the economic value of bats for ecosystem services through the development of a financial model allowing users to modify input variables as new research or information becomes available. We used Missouri as a pilot area and designed our model based on ecological regions within the state. We estimated the economic impact based on agricultural production systems, tree species and additional resources that are unique to these regions. We used currently available data on levels of insect consumption by eastern U.S. bat species to estimate quantities of agricultural and forest pests consumed by geographic extent of species. Our pilot economic model identifies key services provided by insectivorous bats and estimates values to parameterize the model. The output is an estimate of economic value by regional area or county. We will discuss challenges, future opportunities and outputs associated with our model.

Natural Circulation of Marburg Virus in *Rousettus aegyptiacus* Populations in Southwestern Uganda
Brian Amman, Serena Carroll, and Jonathan Towner, Centers for Disease Control and Prevention, Atlanta, GA

Marburg virus (family *Filoviridae*) causes sporadic outbreaks of severe hemorrhagic fever (HF) in Africa. The Egyptian fruit bat (*Rousettus aegyptiacus*) has been implicated as a likely natural reservoir, based most recently on the isolation of infectious virus directly from bats caught at the Kitaka mine, Uganda where miners fell ill with Marburg HF in 2007. The ecological drivers that lead to virus spillover to humans are poorly understood. Within a year, two separate cases of Marburg HF occurred in American and Dutch tourists respectively after visiting Python cave, Uganda, a tourist attraction 25 miles from Kitaka mine. Python cave also contained large numbers of *R. aegyptiacus*. These two cases prompted a long-term ecological investigation of *R. aegyptiacus* in Python cave to determine if: 1) the *R. aegyptiacus* in the cave carried infectious Marburg virus similar to that found in the tourists; and 2) what ecological factors might influence virus transmission and spillover to humans. In this report, we present results from our investigation in which we find that: 1) approximately 2.5% of the estimated 40,000 bats is actively infected with Marburg virus; 2) the sequences from *R. aegyptiacus* virus isolates closely matched those from the tourists; and 3) older juveniles approximately 6 months of age are 5–6 times more likely to be actively infected than adults tested at the same time. These data present the first long-term study of filovirus circulation in its natural reservoir.

Preliminary Assessment of Migration Patterns of Tree Bats in Northern Indiana Using Stable Isotope Analysis
Lily Arias, Jed Sparks, and John Whitaker, Indiana State University, Terre Haute, IN; Cornell University, Ithaca, NY

Few studies have evaluated isotopic signatures of hydrogen in bats to estimate geographic origins and to track their movements. The goals of this study were to locate the potential geographic origin of bats killed at a wind farm in northern Indiana during their fall migration. Hair samples were collected from *Lasiurus borealis* (n = 8) and *L. cinereus* (n = 11) in September and October 2010. Samples were analyzed for hydrogen isotopes at the Cornell University Stable Isotope Laboratory. Isotope values were transformed into precipitation units by using regression equations published in the literature. Independent analyses were run based on sex and month of capture. Likelihood-of-origin maps based on measured isotopic composition and an IsoMAP isoscape were developed and overlapped onto distribution maps. Maps of potential origin show that male *L. cinereus* captured in September migrated from north of Canada, possibly Manitoba. Females migrated from south of Manitoba. Only one male of the species was captured in October. Male and female *L. borealis* captured in September originated in North Central United States or south of Quebec and Ontario. Males captured in October came from Ontario, Quebec, or south of Manitoba. Females migrated from the Manitoba region. We concluded that several bat populations are being killed during their fall migration to the south. Broad regions of potential geographic origin resulted when using a single isotope approach. In future studies carbon isotopes will be analyzed, migratory distances will be measured, and samples from *Lasionycteris noctivagans* will be included.

A Morphological Cladistic Analysis Lesson Plan for Higher Education Using Chiroptera as the Model Group
Maria Armour, Bridgewater State University, Bridgewater, MA

Phylogenetic analysis can be a challenging concept to grasp for undergraduate biology students. This cladistic analysis lesson utilizes the amazingly diverse Order Chiroptera as a model to introduce students to major biological concepts such as: phylogenies, morphological traits (shared and unique characters), and hierarchical classification. The lesson is intended for one, two-hour meeting with students majoring in Biological Sciences. Problem-based learning techniques are used to help further develop students' reasoning and communication skills. Small groups are given a series of photographs depicting representative bat families and their external anatomical features. Morphological characters are then scored as being either ancestral or derived. Using their resulting data matrix, students then identify the most parsimonious tree for Chiroptera and discuss their results with the class. To conclude, students are educated on the rather recent addition of molecular data into phylogenetic research. The goal is for students to develop both a deeper understanding of bat classification and core knowledge of cladistic methods. They will have acquired many of the building blocks of organismal biology while gaining a richer appreciation of an oft-misunderstood and underrepresented order.

Winter Activity of Red Bats and Other Vespertilionid Bats of Western Indiana
Robert Arndt, Steven Lima, and Joy O'Keefe, Indiana State University, Terre Haute, IN

We know little about bat activity during the winter months in relatively cold climates, especially away from large roosts like caves. We thus examined bat activity from fall through spring of 2011-2012, in western Indiana, where at least 10 species of vespertilionid bats are known to overwinter. Our study site was located on the edge of a 2.5-ha field surrounded by forested habitat in western Vigo County. Data were collected using an Anabat SD2 detector, which was activated on most nights from August to March. The Anabat was placed near an ultraviolet light source (3.5 m above the ground) that attracted insects, creating a foraging patch for bats. All files were analyzed using a North American bats filter in AnalookW and subsequently verified as bat pulses. Only red bats were active during the coldest months of the winter with a marked increase in detections when nightly temperatures were greater than 0°C. Such detections were higher in the hours immediately after dusk, and generally increased with temperature above 0°C. During December and January there were no detections of other bat species, despite the unusually warm winter of 2011-12 (averages 2.3–3.4°C above normal for November through February). However, big brown bats were detected in November and March. For all species, the number of winter detections was minute compared to the detections recorded in the fall. The activity pattern for red bats suggests that they may feed during the winter months, possibly facilitated by physiological or behavioral adaptations.

Genetic Population Structure of Little Brown Bat Maternity Colonies in Nova Scotia, Canada
Krista Arseneault, Timothy Frasier, and Hugh Broders, Saint Mary's University, Halifax, NS

Myotis lucifugus, the little brown bat, is a widespread species across North America. This species is a hibernating bat with an annual cycle involving communal hibernation. Mating occurs during the autumn and winter, followed by individuals moving to hibernacula. Once individuals arise in the spring, females will gather at maternity colonies to give birth and raise young. Previous studies suggest that the maternity colonies are structured through maternally-directed site fidelity, indicating that females return to their birth site each year to raise young. Females will remain within these colonies until the young have weaned. Approximately 30 individuals were selected from each of 12 maternity colonies within mainland Nova Scotia, covering an area of approximately 19,200 km^2. A 300-bp segment of the hypervariable region II of the mitochondrial genome was analyzed. Preliminary results showed 43 unique haplotypes within 390 individuals. Of the 43 haplotypes, 4 haplotypes were shared among 10 of the 12 colonies. Of the remaining haplotypes, more than 15 were unique to single sampled individuals. Further analysis will look at the relationship between haplotypes to understand the structuring of maternity colonies and provide inference of female site fidelity. Results of this study will be used along with results of population structuring of bats during the remainder of the year to make inferences about their annual movement.

Climate and Reproduction of Big Brown Bats over an 11-year Period in Indiana
Giorgianna Auteri, Joy O'Keefe, Brianne Walters, and Allen Kurta, Eastern Michigan University, Ypsilanti, MI; Indiana State University, Terre Haute, IN

Understanding variations in conditional breeding probabilities is increasingly important in light of changing stressors, such as climate change and habitat alterations. Such information can be helpful in identifying potential risks to bat populations in the near future, as well as in making conservation and management decisions. We investigated the subject of potential effects on juvenile sex ratios and female reproductive conditions by analyzing capture data from a long-term monitoring project in Hendricks County, Indiana. We looked at the effects of changes in precipitation, temperature, and the Palmer Drought Severity Index on juvenile sex ratios, female reproductive rates, and dates of first flying juvenile and first lactating female, in the most frequently captured species, the big brown bat (*Eptesicus fuscus*). From 2002 to 2012, 1,221 big brown bats were caught, 282 of which were juveniles and 619 of which were reproductive females. We assembled monthly climatic data for April, May, and June, as well as for combinations of those months. We found no significant correlations between reproductive parameters and climatic variables, with the exception of a negative correlation between precipitation in May and date of first volant juvenile (r = -0.64), indicating that heavy rains in spring may promote birth or development of the young. The lack of any obvious influences of our parameters on reproduction may mean that big brown bats in the region are somewhat resilient to natural fluctuations in climate in the region.

Bats as Inspiration for Flight Control Engineering
John Baillieul and Kenn Sebesta, Intelligent Mechatronics Laboratory, Boston University, Boston, MA

Throughout most of the twentieth century, flight control systems of piloted aircraft relied on small numbers of complex and expensive sensors that could provide real-time data on velocity, altitude, and position. The appearance of inexpensive and low power digital sensing and computing technologies over the past twenty years has made it possible to design autonomous and semi-autonomous flight vehicles with performance capabilities that greatly exceed those of piloted aircraft. In order to realize the full range of potential capabilities, engineers have become interested in the ways in which flying animals process sensory information to achieve extraordinarily agile flight though cluttered environments under a wide variety of challenging conditions such as low light and high wind. This talk will describe ongoing research that is aimed at extracting information from recorded observations of bats and other animals in a variety of flight regimes. The emphasis will be on our attempt to infer how animals react to what they sense in the environment, and how this translates into the motions that are observed. Progress toward the ultimate goal of replicating animal flight behaviors in an engineered system will be described.

Carnassial-like Notches in the Lower Molars of Bats Evolved Convergently Multiple Times
Charles Baker and Nicholas Czaplewski, Sam Noble Oklahoma Museum of Natural History, Norman, OK

We examined the lower molars of bats of 269 extant and extinct species in 23 families, specifically searching for the occurrence of structural features on the talonid crests, the cristid obliqua, and postcristid. We term the structure "carnassial-like notch" for its resemblance to similar features on the carnassial teeth of carnivorans. Carnassial-like notches occur only in those bat families with plesiomorphic molar morphology and insectivorous or insectivorous-omnivorous dietary habits. The notches are absent in the derived teeth of many fruit- and nectar-feeding bats. The notches are visible with sufficient magnification only in unworn or little-worn molars; they become obliterated with progressing tooth wear. We define and describe three types of notches according to their appearance in differing views of the talonids. Of the 19 extant families of Chiroptera examined, 9 families include members that possess carnassial-like notches. These are Megadermatidae, Nycteridae, Phyllostomidae, Furipteridae, Thyropteridae, Mystacinidae, Natalidae, Vespertilionidae (Murininae and Kerivoulinae only), and Miniopteridae. In several extinct bat families for which lower molar fossils are available, notches were not found on the talonids; these families include Onychonycteridae, Palaeochiropterygidae, Icaronycteridae, Archaeonycteridae, Philisidae, and Speonycteridae. When mapped on a phylogenetic tree of bat families, the distribution of notch types among clades indicates that carnassial-like notches probably evolved independently at least five times in bats, suggesting an unrecognized functional importance for the structures. An alternative interpretation, that notches evolved once, would require that the notches were lost in about as many groups as they are present in.

Sebaceous Lipid Profiles of Bats with Wing Damage Associated with White-nose Syndrome
Ashley Banks, Evan Pannkuk, Cheyenne Gerdes, Alison Greco, Leon Spencer, Brett Savary, Thomas Risch, and Nathan Fuller; Boston University, Boston, MA; Arkansas State University, Jonesboro, AR; Arkansas Biosciences Institute, Jonesboro, AR

Survivors of white-nose syndrome show clinical signs of infection in the form of severe wing damage. The behavioral, ecological, and physiological repercussions of this damage are still unknown and are likely to be profound given the extent to which wing tissue is compromised. We studied the effect of wing damage on the chemical composition of the lipid portion of sebum. We sampled 248 *Myotis lucifugus* in New England from the early (May), middle (June), and late (July) active season. Sebum samples were collected by pressing SebuTape™ Indicator Strips to damaged wing tissue for one minute and then extracted with chloroform-methanol. High performance thin-layer chromatography readily detected major lipid classes correlating to cholesterol, sterol ester, and squalene in tissue. Gas Chromatography/ion trap Mass Spectrometry (GC/MS) of the trimethylsilyl esters detected the presence of lipid species found in high abundance in bat sebum, specifically 16:0 fatty acid, 18:0 monoacylglyceride, squalene, and cholesterol. GC/MS of the transesterified fatty acid methyl esters (FAMEs) indicated an abundance of 18:0 FAME, with lower amounts of 16:0, 18:1, 18:2, and 20:0. No statistically significant differences in free sterol vs. esterified sterol between groups were detected by a fluorometric coupled enzyme assay; however bats with more severe damage showed a general trend toward higher free sterol. Wing damage severity also corresponded with lower levels of total lipid. These results suggest that sebaceous gland function may be compromised by wing damage, but that cutaneous sterol synthesis may be stimulated by tissue damage.

Usage of Alpha Numeric Fluorescent Tags for Chiropteran Mark/Recapture
Mike Barandiaran, Francheska Ruiz-Canino, and Isha Alexander, U.S. Fish and Wildlife Service

Mark/recapture studies of bats in Vieques have been conducted since 2008 with the intent of determining density of species and movement of individuals. At the beginning of our study we used collaring (Gannon) as the primary marking technique and came across previously marked individuals with wing bands. In 2008, we collared 25 individuals: *Noctilio leporinus, Stenoderma rufum*, and *Artibeus jamaicensis.* There were no recaptures that season or in subsequent seasons; however, two bats captured later in the 2008 season showed hair loss around the neck. In the 2008 and 2010 seasons, we came across 22 *A. jamaicensis* individuals marked with numbered aluminum wing bands; 7 wing bands had to be removed because of infection. Because diverse problems arise with different marking techniques, we sought a new technique for marking bats. In 2008, we started using Alpha Numeric Fluorescent Tags previously used on fish, amphibians, and reptiles. In 2008 and 2010 we marked 209 individuals (tagged either under the subcutaneous layer of the ventral side of either the right leg or forearm) and to date have had 60 recaptures, with over 83% identifiable tags. Yellow tags with black numbers/letters seemed to have the best readability after long-term recapture of *N. Leporinus* and *A. jamaicensis*. The Alpha Numeric Fluorescent Tags appear to be a good method for individual identification of bats as they are less harmful, offer high retention, are easily detectable, provide high survivability of animals for short- and long-term studies, and are suitable for fieldwork with proper training.

Are Migratory Tree-bat Populations Declining?
Robert Barclay, Erin Baerwald, and Ed Arnett, University of Calgary, Calgary, AB; Theodore Roosevelt Conservation Partnership, Washington, DC

Migratory, tree-roosting bats in North America have faced several novel environmental changes that may result in population declines. These include climate change, habitat loss and alteration, and wind-energy facilities. One of the most common questions we are asked by government agencies and wind-energy companies is, "are the fatalities at wind turbines significant from a population perspective?". Without the data necessary to construct population-viability analyses, this is a difficult question to answer. To address the question, we compiled fatality data from wind facilities across North America and tested whether there was evidence suggestive of population declines. Of sites with multi-year data (up to five years), the majority had corrected fatality rates that declined over time, a significant effect. All six sites in southwestern Alberta had declines, and in the region, overall fatalities declined by 78% from data collected between 2005 and 2008, and those collected from 2009 to 2011. One interpretation of these results could be that populations of migratory bats have declined over the years, potentially due to turbine-related fatalities, but also to climate change and habitat loss. Another interpretation is that bats learn to avoid wind-turbines. To assess this alternative explanation, other long-term data, such as acoustic counts of activity, capture rates, rabies-submission rates, etc. may be useful. However, depending on the geographic structure of populations of these species, population changes may differ in areas or migratory paths with wind facilities compared to areas/paths without wind facilities. We present predictions that may allow the hypotheses to be tested.

Distribution and Roosting Habitat of North Dakota Bats
Paul Barnhart and Erin Gillam, North Dakota State University, Fargo, ND

In North Dakota, relatively little is known about the distribution and habitat use of bat species. As bat populations continue to be at risk due to a variety of factors, it is imperative to document key characteristics of bat populations in poorly studied areas so that appropriate conservation plans can be developed. The objective of this research was to gather baseline data about bat populations throughout North Dakota so that conservation and mitigation efforts can be made to counter the declining bat population trends. Both physical capture and passive acoustic detection were deployed in each study area. Captured bats were identified, fitted with light tags, and then released and recorded to produce a call library for North Dakota. To assess the roosting ecology of bats in North Dakota, select individuals were fitted with a radio-transmitter and tracked to their roosts daily for several days. Once tree roosts were located, we assessed characteristics of the focal tree, roost opening, and surrounding vegetation. For individuals roosting in rock crevices, we assessed opening size, depth, proximity to nearest water source, location on a vertical plane, and temperature. Roost characteristics will be used to model preferred roosting habitat based on the maximum-entropy approach using the program MaxEnt. Preliminary results suggest that three species readily use rock crevices and four regularly select mature cottonwood, green ash, basswood, and quaking aspen trees.

Research is also in progress to document winter roosting habitat in Theodore Roosevelt National Park.

Can Species-specific Acoustic Activity Be Relied Upon to Predict Bat Fatality at Wind Turbines?
Victoria Bennett, Crissy Sutter, Amanda Hale, Alison Costello, and Kevin Heist; TCU, Fort Worth, TX; Normandeau Associates, Gainesville, FL; University of Minnesota, St. Paul, MN

Wind energy is a rapidly growing industry with increasing pressure on developers to select sites with little or no negative impacts on bats. Acoustic surveys are gaining popularity as a pre-construction survey technique; however to date, there are no standard protocols regarding deployment of bat detectors and limited data demonstrating that acoustic activity predicts fatality. To address these needs, we placed four detectors 1-m above ground and two detectors ~85 up on wind turbine nacelles at Wolf Ridge Wind, LLC in north-central Texas in 2010-2011. We compared acoustic activity with fatality data collected at 30 turbines. Using SonoBat 3.04, we identified six species from recorded calls. The percentage of calls recorded for each species varied considerably between the two heights, and species-specific fatality rates were not consistently correlated with activity levels. For example, 10% of calls recorded 1-m above ground were *Lasiurus cinereus*, compared to 50% at the nacelles. And although *L. cinereus* activity near the nacelle was positively associated with observed fatality, the relationship was moderate and nonlinear. In contrast, we found no relationship between acoustic activity and fatality for other species. *Lasionycteris noctivagans* was frequently recorded near nacelles, but comprised < 1% of observed fatalities. *L. borealis*, at the other extreme, was rarely detected near nacelles, and yet comprised 60% of fatalities. Our results indicate that: 1) detectors should be placed at multiple heights to effectively survey bat communities at wind farms; and 2) acoustic surveys do not adequately predict fatality for all species at wind turbines.

Endangered Indiana Bats and Little Brown Bats Partition Resources through Variation in Horizontal Distribution
Scott Bergeson, Timothy Carter, and Michael Whitby, Indiana State University, Terre Haute, IN; Ball State University, Muncie, IN

A species' ability to interact with its environment is largely dependent on its morphological ability. Therefore, researchers are able to gain insights into community structure and resource partitioning by studying the morphological variation within a community. However, when morphological variation is low, resource partitioning must be the result of other factors. This study was conducted in order to investigate foraging habitat selection as a cause of resource partitioning between morphologically similar Indiana bats and little brown bats. Foraging radio-telemetry was conducted on adult females of both species (35 Indiana bats and 15 little brown bats) in two study areas within southern Illinois during the summers of 2003, and 2009-2011. Using a series of home range estimates and Euclidean distance-based habitat selection analyses, foraging home ranges and habitat selection were compared between the two species. Despite roosting within the same patches of bottomland hardwood forest, the two species foraged within different areas. Little brown bats positioned large home ranges ($\bar{x}$ = 2,739 ± 456 ha) over multiple land cover types, and specifically selected for hydric land cover within them, while Indiana bats constricted their much smaller home ranges ($\bar{x}$ = 375 ± 39 ha) within patches of bottomland hardwood forests and selected for land cover at random within them. This suggests that the two species are horizontally distributed within the landscape during foraging periods, thus partitioning resources. It is possible that inter-specific competition is the cause of this partitioning, pressuring little brown bats to forage over extensive areas in order to obtain the nutrition they need.

Winter Activity of Bats in Tennessee: a Possible Refugia from White-nose Syndrome
Riley Bernard and Gary McCracken, University of Tennessee, Knoxville, TN

The white-nose syndrome (WNS) epizootic, caused by the psychrophilic fungus *Geomyces destructans* (Gd), has caused unprecedented mortality of hibernating bats throughout the northeastern United States. Gd was first recorded in Tennessee during winter 2010 and has now been found on four species (*Myotis lucifugus, M. grisescens, M. septentrionalis,* and *Perimyotis subflavus*) in twelve counties. However, unlike in the Northeast, Tennessee has yet to see mass mortalities in the two winters since initial infection. The goal of this research is to evaluate the possibility that winter foraging may play a role in the survival of bats affected by WNS. This preliminary study addresses two main hypotheses: 1) availability of winter food sources in southern latitudes will aid survival of hibernating bats; and 2) bat activity during winter will affect survival of bats infected with Gd. Using ultrasonic detectors and capture data we have established that bats in more southern latitudes are actively foraging on

available insects throughout the winter. Bat calls were recorded during each acoustic survey night (131 sample nights from two caves) regardless of low nightly temperatures. Eight of the nine fecal samples collected during winter 2012 contained recently consumed Lepidoptera, with only one sample described as a winter-pellet. Winter activity and foraging may allow bats in southern populations to survive infection by Gd, establishing a southern refugia for WNS mortality.

Influences of Weather on Reproductive Timing of Missouri Bats, and Effect of Reproductive Status on Nightly Emergence Times

Larisa Bishop-Boros and Lynn Robbins, Missouri State University, Springfield, MO

Reproductive development is the most critical period of a bat's life history. Understanding these reproductive patterns can reveal pivotal information about the population dynamics of Missouri species. Nine species were investigated in this study using March-October capture data collected in 1998, 2001, 2006, and 2008-2012. Data from 487 sites in 22 Missouri counties were collected using mist nets over 540 individual netting nights. A total of 6,356 individuals were captured comprising eleven species. Three reproductive conditions (late pregnant, lactating, and post-lactating) and the timing of volant juveniles on the landscape were used to investigate the influences of temperature and precipitation on the annual rate and timing of reproduction of four bat species in Missouri. Results demonstrate that rainfall the previous or current year would predict changes in bat reproductive timing. Multivariate statistics were used to examine the effects of reproductive status on the intraspecific variation in nightly emergence times of six bat species. Timing of evening emergence also has critical fitness implications for bats. Aerial insect activity typically peaks at sunset, but raptors may still be active. Thus late emergence in bats results in missed foraging opportunities but also reduces the predation risk. Preliminary results indicate significant differences in emergence times of bats are related to energetic considerations associated with differences in age and reproductive state. Heavily pregnant females (less agile flyers) emerge later in the evening, and lactating females emerge earlier (high energy demands and low energy reserves). Juveniles emerged in the late evening (slower, inexperienced flyers).

Detection, Distribution, and Temperature-Dependent Growth of *Geomyces destructans*

David Blehert, Jeffrey Lorch, Michelle Verant, Laura Muller, Justin Boyles, Daniel Lindner, Andrea Gargas, Robin Russell, Michael O'Connor, William Waldrep, Jr., and Gudrun Wibbelt; USGS-National Wildlife Health Center, Madison, WI; University of Wisconsin, Madison, WI; Southern Illinois University, Carbondale, IL; US Forest Service-Center for Forest Mycology Research, Madison, WI; Symbiology LLC, Middleton, WI; Wisconsin Veterinary Diagnostic Laboratory, Madison, WI; University of Chicago, Chicago, IL; Leibniz Institute for Zoo and Wildlife Research, Berlin, Germany

Our ability to define the ecology of white-nose syndrome (WNS) has been limited by difficulties in readily detecting the causative agent, *Geomyces destructans*, in the presence of closely related fungi on the skin of bats and in their hibernacula. We have addressed this challenge by developing a highly specific and sensitive real-time PCR test for *G. destructans* that targets a portion of the multicopy intergenic spacer region of the rRNA gene complex. Subsequently, we have used this test to characterize the distribution of *G. destructans* in soil samples collected in winter 2008-2009 from 55 hibernacula both within and outside the known range of WNS at that time. The fungus was only detected from sites within the known range of WNS at the time the samples were collected, indicating that fungal distribution correlated with manifestation of disease in hibernating bats and further suggesting that *G. destructans* was not widely distributed in North American bat hibernacula prior to the emergence of WNS. We also describe temperature dependent growth performance and morphology for six independent isolates of *G. destructans* from North America and Europe. Optimal temperatures for growth were between 12.5 and 15.8°C, and the upper critical temperature for growth was between 19.0 and 19.8°C. Above 12°C all isolates displayed atypical morphology that may have implications for proliferation of the fungus. These results demonstrate that small variations in temperature affect growth performance of *G. destructans*, which may influence temperature-dependent progression and severity of WNS in wild bats.

Bat House Design and Excluding Bats from Roofs in the Caribbean Region

Lois Blumenthal and Paul Watler, National Trust for the Cayman Islands, Cayman Islands

The bat locally known as the "house bat", Pallas' mastiff bat, *Molossus molossus*, is a common inhabitant of human structures in the Caribbean region. Information and data will be reviewed for 17 years of managing effective,

economical, humane, and environmentally sound bat exclusions from the roofs of homes and businesses in the Cayman Islands. The techniques and criteria used in the mounting of 120 bat houses, each containing colonies of *M. molossus* averaging 200 individuals, will be reviewed and summarized. The Cayman Islands program includes an extensive educational component, including cave and forest protection awareness for species that don't use bat houses. The Cayman Islands program, which also includes public relations, outreach initiatives, and significant community involvement, including donation of utility poles, labor, and other materials, will be summarized.

The Colonization of Hawaii by Hoary Bats
Frank Bonaccorso and Liam McGuire, U.S. Geological Survey, Hawaii National Park, HI; University of Western Ontario, London, ON

The Hawaiian Archipelago, the most isolated cluster of islands on Planet Earth, has been colonized successfully twice by bats. The putative "lava tube bat" is extinct, whereas, the Hawaiian hoary bat, *Lasiurus cinereus semotus,* survives as an endangered species. We conducted a three-stage analysis to identify conditions under which hoary bats may have originally colonized Hawaii. We used the software program *FLIGHT* to determine if fat stores would provide the energy necessary to fly from North America to Hawaii, a minimum distance of 3,665 km. Our modeling variables included empirically measured physiological, morphological, and behavioral data characterizing hoary bat populations from North America. The second step of our modeling process investigated the potential for water to become a limiting factor in flight. And finally, our modeling examined the role that prevailing trade winds may have played in colonization flights. Of our 36 modeling scenarios, 17 (47%) require tailwind assistance within the range of observed wind speeds, and 7 of these scenarios required < 10 $m \cdot s^{-1}$ tailwinds as may be regularly expected due to the easterly Trade Winds. Therefore, the climatic conditions facilitating bats to colonize Hawaii may not be exceptionally infrequent in occurrence, either in contemporary times or at least since the end of the Pleistocene, ~11,000 YBP. The likelihood of multiple colonization events and subsequent isolation may help to explain morphological divergence that exists among extant island populations. For example, bats of the neighboring islands of Maui and Hawaii have striking differences in cranial measurements and pelage coloration.

***Further Evidence for the Basal Divergence of *Cheiromeles* (Chiroptera: Molossidae)**
Wesley Brashear, Sarah Bartlett, and Loren Ammerman, Angelo State University, San Angelo, TX
*** Wesley Brashear** received the **Speleobooks Award**.

Although relationships among members of the free-tailed bat family Molossidae have been addressed using molecular data, missing sequence data and missing taxa have made the basal divergences within this family unclear. In our study, published sequence data for recombination activating gene 2 (*RAG2*) were examined to further elucidate the phylogenetic relationships within the subfamily Molossinae and, more specifically, address which member of this subfamily formed the basal lineage. Maximum likelihood and Bayesian inference analyses of RAG2 sequence data from 64 molossid bats and 5 outgroup taxa supported the genus *Cheiromeles* as the most basal lineage within the subfamily. *Mormopterus* was the next lineage to diverge and formed a monophyletic group (*M. francoismoutoui* and *M. jugularis*). The genus *Chaerephon* was found to be polyphyletic and the genus *Tadarida* formed a paraphyletic clade. These results support recently published phylogenies of Molossinae, provide a better understanding of the early divergences in this group, and call for further phylogenetic inquiry into certain genera.

Bats, Bugs and Pecans: the Role of Insectivorous Bats in a Pecan Agroecosystem in Central Texas
Elizabeth Braun de Torrez, Veronica Brown, Gary McCracken, and Thomas Kunz, Boston University, Boston, MA; University of Tennessee, Knoxville, TN

Bats are commonly recognized for their voracious appetites for nocturnal arthropods; however, little is known about specific prey items or the degree to which they suppress pests. The pecan nut casebearer moth (PNC), *Acrobasis nuxvorella*, is arguably the most devastating pest of pecan trees *(Carya illinoinensis),* damaging up to 85% of the nuts. We investigated patterns of PNC consumption by bats in pecan orchards in central Texas. We captured bats with mist nets, collected fecal samples by holding bats in cloth bags, and monitored PNC abundance with pheromone traps. To document the relative consumption of PNC by bats, we extracted total DNA from guano, used a species-specific primer to amplify the PNC CO1 gene and then used quantitative-PCR (qPCR). We analyzed 400 samples from individual bats. Our results indicate that PNC moths were consumed by five species of bats: *Tadarida brasiliensis, Myotis velifer, Nycticeius humeralis, Lasiurus borealis*, and *Perimyotis subflavus*;

however, both frequency of occurrence (# positive/total bats) and relative quantity (# gene copies/bat) of PNC in the diet varied by bat species. Frequency of occurrence ranged from 2.1% (*N. humeralis)* to 22.9% (*L. borealis)*. The highest relative quantity was also found in *L. borealis.* Temporally, consumption was concentrated around nights of peak PNC activity. Our results show clear differences in PNC consumption between species, perhaps reflecting variation in foraging behavior, and illustrate the importance of encouraging high bat diversity in pecan orchards to facilitate this ecosystem service. Documenting agricultural pest consumption by bats may incentivize landowners to conserve bat habitat on private land.

Other Functions of Torpor

Mark Brigham and Fritz Geiser, University of Regina, Regina, SK; University of New England, Armidale, NSW

Although energy conservation by cold-climate adult endotherms in winter is often viewed as the main function of torpor, recent evidence suggests that this may not always be the case. We examined whether other functions of torpor may be equally or even more important in some instances. Torpor enhances fat storage during migration, apparently permits prolonged female sperm storage in bats, allows reproduction with limited or fluctuating food supply, and delays parturition until more favorable periods. Torpor appears to increase the efficiency of energy and nutrient use during development. Further, torpor reduces water requirements, appears to permit persistence during droughts, reduces the load of some parasites, permits co-existence of competing species, and also reduces the risk of predation and mammalian extinctions. Thus, the functions of torpor are complex and some of these appear to be not just proximate.

Use of Tissue Explants to Assess White-nose Syndrome Susceptibility

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Our understanding of species susceptibility to white-nose syndrome (WNS) has resulted from observation of heavily infected bats in the field. Seven species of bats have been confirmed to be infected with WNS. However, we have not ruled out susceptibility for the 18 or so other species of hibernating bats in North America. The most rigorous test of susceptibility would be to conduct inoculation trials under controlled conditions. However, this requires euthanasia of the bats and outcomes are uncertain because of variation in the hosts and difficulty in maintaining the bats in hibernation conditions appropriate for growth of *Geomyces destructans* (Gd). As an alternative model, we investigated the utility of tissue explants for assessing WNS susceptibility. We took 6-mm biopsy samples from the patagia of gray bats captured at a summer colony. Tissue samples were placed in growth medium and inoculated with Gd following developed protocols. Tissues were cultured at 5°C for 6 weeks and then analyzed. Fungal growth and invasion of the skin were consistent with WNS in samples taken during the hibernation season. Thus, tissue explants appear to be a method that can be used to assess species susceptibility as well as numerous other projects involving treatment of WNS.

Islands May be a Refuge for Bats from White-nose Syndrome

Hugh Broders, Krista Arseneault, Stephanie Beland, Lynne Burns, and Tim Frasier, Saint Mary's University, Halifax, NS; Dalhousie University, Halifax, NS

White-nose syndrome (WNS) is decimating populations of bats that overwinter in temperate areas via hibernation. Since it was first recorded in 2006, WNS has spread thousands of kilometers, is responsible for killing more than 5.5 million bats, and may cause the extirpation of many populations of many bat species, if not species extinction. It is known that some of the species that are susceptible to WNS move hundreds of kilometers and therefore, the animals themselves are likely important vectors for the spread of the disease. However, the degree to which water bodies such as oceanic straits may be barriers to migration or dispersal movements, and hence to transmission of WNS, are not known for WNS-affected species. If oceanic straits are barriers to bat movements, then the bats themselves may not be effective vectors for the spread of the fungus and island populations would be exceptionally important for species conservation. To indirectly assess the extent of bat movements across oceanic straits we sequenced a 300-bp section of the hypervariable II region of the mtDNA from 610 *Myotis lucifugus* from Nova Scotia, Prince Edward Island, Labrador and the island of Newfoundland. We characterized more than 70 haplotypes in the sample set with unique haplotypes found on both islands relative to mainland populations. Given the high proportion of unique haplotypes on the two islands, these preliminary results support the contention that island populations may be isolated from mainland populations and therefore,

should receive the highest level of management protection from other potential vectors (e.g., human transmission).

A Holistic Approach to Bat Conservation: Education, Citizen Science, and Habitat Models
Jessica Buckman-Sewald and Karen Root, Missouri State University, Springfield, MO; Bowling Green State University, Bowling Green, OH

Despite their contributions to ecosystems throughout the world, bats continue to face numerous anthropomorphic pressures, many caused by negative perceptions. This, coupled with the difficulty in studying a highly vagile organism, leads to a general inability to conserve this group of animals. We developed a study that sought to measure and then increase the general public's perceptions and knowledge regarding bats, coupled with an increase in ecological understanding. It was conducted in the Oak Openings Region of Northwest Ohio, which is a biodiversity hotspot, but where little is known about bats. We developed a 5-point Likert scale survey that measured knowledge regarding and attitudes towards bats and it was administered to homeowners, college students, and participants in bat classes at community organizations. We also developed a citizen science program in which volunteers collected data on species presence with an Anabat acoustic monitor. These data were then used to test a model of bat presence that had previously been developed for the area (using the program Maxent). Testing models outside of the originally collected data is often not done, and we demonstrate the usefulness of using citizen science collected data to test and refine habitat models. We found from our educational surveys a strong and positive link between knowledge and attitudes as well as an overall increase in attitudes after exposure to outreach. This held true for our citizen scientists as well, but these volunteers also become bat advocates, going on to conduct their own classes about bats.

***Autumn Population Genetic Structure of *Myotis lucifugus* in Maritime Canada**
Lynne Burns, Timothy Frasier, and Hugh Broders, Dalhousie University, Halifax, NS; Saint Mary's University, Halifax, NS
*** Lynne Burns** received the **Bat Conservation International Award**.

Bats that are year-round residents of temperate areas congregate at the entrances of hibernacula during late summer and early autumn. It is during this autumn swarming season that mating is thought to primarily occur. Therefore, this time period likely has large impacts on the genetic structure of these bat populations. Our goal was to investigate the autumn population genetic structure of *Myotis lucifugus* in Nova Scotia (NS) and New Brunswick (NB), Canada, to better understand the connectivity of populations across the region. We hypothesized that bats from multiple summer locations swarm at common sites for mating. We predicted that genetic structuring would be detected among swarming sites and would display an isolation-by-distance pattern. Wing punch tissue samples from > 750 bats were collected from 12 autumn sites in NS and NB from 2009 to 2011. Samples were amplified at 11 nuclear microsatellites we developed for the species. We quantified genetic variation by evaluating heterozygosity and nucleotide diversity at different swarming sites. Preliminary results suggest a high level of connectivity among swarming sites in the region. Genetic structuring will be further examined by using a model-based clustering method to estimate the number of genetic clusters (# of bat subpopulations) across the region using the program STRUCTURE.

Species Diversity of Bats in the Thumb of Michigan
Grace Carpenter and Allen Kurta, Eastern Michigan University, Ypsilanti, MI

Species diversity of bats over large areas often is correlated with the diversity of available habitats that can provide suitable shelter and food. The Thumb District of Michigan consists largely of a flat lake plain that has been drained and cleared for agriculture, making it more similar in topography and land use to the Great Plains than the rest of southern Michigan, which is more rolling and contains more extensive wooded areas and streams with forested floodplains than is typical of the Thumb. To test whether the bat assemblage in the Thumb differed from other areas of the state, we surveyed bats at 35 locations, for 140 net-nights, in the Thumb in 2011 and 2012, and compared our data with published results from other parts of southern Michigan. Species richness (5) and Simpson's diversity index (.289) were lower, and evenness greater (.385) in the Thumb than elsewhere in Michigan (8, .327, and .374, respectively). In addition, we compared assemblages found in woodlots and wetlands between the two regions. Sites located in woodlots in the Thumb produced lower richness (4), diversity (.236) and evenness (.314) than elsewhere in Michigan (6, .302, and .361, respectively), whereas sites over rivers in the Thumb had lower richness (4) and diversity (.332) but greater evenness (.442) than sites over water

elsewhere in Michigan (7, .347, and .404, respectively). Most differences in diversity appear related to the small size of woodlots and the lack of forested corridors connecting wooded areas in the Thumb.

Metapopulation Structure of *Rousettus aegyptiacus* in Central Africa: Implications for the Potential Distribution of Marburg and Ravn Viruses

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The genus *Marburgvirus* (family *Filoviridae*) contains a single species that comprises two distinct viruses, Marburg virus (MARV) and Ravn virus (RAVV), both of which cause Marburg hemorrhagic fever (MHF) in humans. MARV was first detected in 1967 in monkeys consigned to Germany from Uganda. RAVV was identified from a fatal human case in Kenya 20 years later. The natural reservoirs of both viruses remained unknown until 2007, when an outbreak of MHF was detected in a mining community in southwestern Uganda. The resulting ecological surveys implicated the Egyptian fruit bat (*Rousettus aegyptiacus*) as a potential reservoir host of MARV and RAVV. Surprisingly, the viruses appeared to co-circulate in *R. aegyptiacus* bats inhabiting the cave. Historically, several *R. aegyptiacus* subspecies have been described from the African continent. We sequenced the mitochondrial cytochrome *b* gene and control region (D loop) from hundreds of representative bats from throughout central Africa in order to determine species and/or subspecies boundaries within *R. aegyptiacus* and to test whether MARV and RAVV preferentially associated with particular *R. aegyptiacus* subspecies or genetic lineages. The results indicated that the traditionally described *R. aegyptiacus* subspecies were not valid. The *Rousettus* bats in central Africa appeared to form a metapopulation structure with relatively high genetic diversity and evident gene flow. These results suggest that the risk area for MHF may be much larger than previously thought, given the connectivity of the host population.

Ontogeny of Echolocation and the Larynx in *Artibeus jamaicensis* with Relation to Flight Ability

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

The adult microchiropteran larynx exhibits hypertrophied intrinsic musculature and cartilages reinforced by calcification that apparently evolved in concert with high frequency sonar emission. We documented the ontogeny of echolocation and developmental changes of the larynx in *Artibeus jamaicensis* with relation to flight ontogeny to assess if development among these systems were in parallel or instead ontogeny was asymmetrical and independent. Calls were recorded with Pettersson D240X sonar detectors as individual bats descended from a 1-m perch. Calls were analyzed with Sonobat V. 2.9. High frequency (KHz), low frequency (KHz), and frequency of maximum power (KHz) were used to assess call structure with age and flight ability (flop, flutter, flap, flight, and adult). Degree of laryngeal calcification was assessed by clear and staining. Digital images of cricothyroid muscle cross sections were analyzed with Sigma Scan to quantify changes in muscle fiber diameter (μm). Our results show high frequency increased significantly between flutter and flight stages ($p = 0.008$), low frequency increased significantly between flutter and flap stages ($p = 0.027$), frequency of maximum power increased significantly between flop and flutter stages ($p = 0.045$). Interestingly low, high, and maximum power frequencies all decreased significantly between flight and adult stages ($p = 0.016$, $p = 0.01$, and $p = 0.01$, respectively). Beginnings of cricoid calcification appeared at sites of cricothyroid origin and coincided with the flap stage and significant increases in cricothyroid fiber diameter ($p = 0.04$), whereas the entire cricoid cartilage was calcified in flight and adult stages. We conclude that these systems develop in parallel, indicating that flight and echolocation are developmentally linked.

Little Brown Bats Don't All Roost in Attics: Examining the Use of Natural Roosts by Little Brown Bats

Timothy Carter, Scott Bergeson, and Michael Whitby, Indiana State University, Terre Haute, IN; Ball State University, Muncie, IN

Little brown bats (*Myotis lucifugus*) are known to frequently roost within anthropogenic roosts. However, this abundant species is also found in areas in which barns, churches, abandoned buildings, and other potential anthropogenic roosts are rare. It is reasonable to assume that within these areas little brown bats roost within dead snags, similarly to other *Myotis* spp. There have been a few studies that have reported little brown bats roosting within trees. However, these studies typically describe only a few little brown bat roost trees or were conducted at the northern extent of the species' distribution. Therefore, we conducted research in order to understand the characteristics of little brown bat roost trees, within the central portion of their range, and to

determine how the species' natural roosts compare with those of another *Myotis* sp. Data were collected on little brown bats and Indiana bats (*Myotis sodalis*) within southern Illinois during the summers of 2009-2011 and within south-central Indiana during the summer of 2007. Radio-telemetry was used on female bats of both species in order to locate maternity roosts. Twenty-two and seventy-six little brown bat and Indiana bat roost trees were located over the duration of the study, respectively. While both species roosted within the same habitats and the same tree species, little brown bats tended to roost in crevice/cavity roosts while Indiana bats tended to roost under exfoliating bark. This frequent use of crevice/cavity roosts by little brown bats may be associated with the species' preference for anthropogenic roosts throughout its distribution.

Large Forest Patches Increase Bat Species Diversity in a Fragmented Landscape in Nicaragua
Carol Chambers, Arnulfo Medina-Fitoria, Josè Martinez-Fonseca, Marlon Chaves-Velasques, Samuel Cushman, and Kei Yasuda; Northern Arizona University, Flagstaff, AZ; Paso-Pacífico, Managua, Nicaragua; U.S. Forest Service-Rocky Mountain Research Station, Flagstaff, AZ

Tropical dry forests supply important ecological and economic benefits. However, threats to forests in Central America—such as resource extraction and forest conversion to other land uses (e.g., agriculture)—often result in a fragmented landscape. We surveyed bats on the Paso del Istmo of southwestern Nicaragua. This isthmus, between the Pacific Ocean and Lake Nicaragua, is considered an important passageway for migrating wildlife. Our objective was to increase knowledge of bats and determine impacts of forest fragmentation on bats. We mist- netted bats for 35 nights during the dry season (December 2011–January 2012) and captured 1,476 bats representing 44 species. We recorded a new species for Nicaragua (pale-faced bat, *Phylloderma stenops*) and range extensions for at least two species (chestnut short-tailed bat, *Carollia castanea*; white-throated round-eared bat, *Lophostoma silvicolum*). Three species (Jamaican fruit-eating bat, *Artibeus jamaicensis*; Seba's short-tailed bat, *Carollia perspicillata*; common vampire bat, *Desmodus rotundus*) that are associated with altered forest landscapes—logged or farmed—accounted for 50% of all the bats we captured. Only 5% of captures represented the forest-associated subfamily Phyllostominae. We compared capture rates of individuals and species (number per net hour) to fragmentation indices for capture locations using FRAGSTATS. Capture rates of individuals were higher in areas with extensive young forest but captures of species was positively related to total landscape edge and density of mature forest patches. Despite their scarcity on this landscape, mature forest patches helped maintain a more diverse bat assemblage. Increasing patch size and connectivity will benefit forest-associated bats.

Measurement of Active Gape in Mormoopid Bats
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Bats in the Family Mormoopidae typically show some degree of upturning of the rostrum, or snout, relative to the neurocranium. The upturning is greatest in the genus *Mormoops* (ghost-faced bats) and distinguishes them from the confamilial genus *Pteronotus* (mustached bats) that exhibit only a slightly upturned rostrum. Morphological examination of the craniorostral apparatus has shown maximal structural jaw gape (passive) in *Mormoops blainvillii*, the Antillean ghost-faced bat, to be about 15% greater than *Pteronotus quadridens*, the sooty mustached bat. Functional gape (active) is constrained by soft tissue structures of the jaw. We recorded digital video of restrained adult bats of each species, *M. blainvillii* and *P. quadridens*, and captured frames that represented maximal gape to obtain measurements. Measureable points selected were the base of the anterior margin of upper and lower canines and the center of the eye. Gape distance was converted to gape angle based on the position of the posterior margin of the glenoid fossa relative to the anterior margin at the bases of the upper and the lower canines. The location of the glenoid fossa relative to the eye was determined by geometrical projection using the eye and anterior canine margin as measured from dissected specimens. Maximal functional gape approximated 98° for *M. blainvillii* and 86° for *P. quadriden*s, which represents 85% of structural gape for both species. The 15% greater gape angles for *M. blainvillii* supports the observed diet preference of larger moths with respect to *P. quadridens* whose diet is mostly smaller beetles.

Complementary Acoustic Signals Facilitate Group Cohesion in Spix's Disc-winged Bat
Gloriana Chaverri, Erin Gillam, and Thomas Kunz, Universidad de Costa Rica, Golfito, Costa Rica; North Dakota State University, Fargo, ND; Boston University, Boston, MA

Acoustic signals are important in maintaining group cohesion, particularly in highly mobile species. For these signals to facilitate group cohesion, individuals must be able to recognize, and respond to, calls

emitted by group members. In this study, we document the use and recognition of complementary contact calls in Spix's disc-winged bat (*Thyroptera tricolor*), a species known to form very stable social groups despite using an extremely ephemeral roosting resource. This bat uses two sets of calls: "inquiry," which are emitted by flying bats that are seeking roosts or group mates, and "response," which are produced in reply to an inquiry call by individuals that have already located a roost. Here we test if bats are capable of discriminating between the inquiry and response calls of group and non-group mates using playback experiments. Results show that flying bats can discriminate between the inquiry and response calls emitted by group and non-group members, and maintain contact preferentially with the former. Roosting bats, however, exhibited no preference for group over non-group members, and thus responded indiscriminately. We argue that differences in discriminatory ability may be partly attributed to the costs associated with flight and the potential benefits of recruiting roost mates.

Acoustic Tomography: a New Technique Sheds Light on the Moth Bat Evolutionary Race
Elizabeth Clare and Marc Holderied, University of Bristol, Bristol, UK

A considerable body of research has examined the relationship between bat echolocation and anti-bat adaptations among prey. Most research has focused on insect ears tuned to detect the search and attack phase calls of insectivorous bats. Fewer investigations have considered how the bat perceives the insect, partly because understanding the role of returning echoes is perceptually difficult. A new technique, acoustic tomography, allows us to turn sound impulses into visual signals that can be quantified and interpreted. This technique provides new insight into how echolocation may be perceived by the bat. We combine field and lab experiments and use an artificial "robo-bat" constructed from a sensitive microphone and loudspeaker to scan prey items using acoustic signals. The returning echoes are recorded and converted into visual impulses to generate an image of the prey as perceived in returning echoes by robo-bat. We then test the observations of robo-bat in field experiments. We have identified key morphological adaptations among prey that provide a defense against aerial hawking bats and are independent of the presence of insect ears. Field behavioral experiments suggest the presence of these morphological adaptations may cause the bat to make critical mistakes during an attack. We have also identified key echo components used by gleaning bats to distinguish prey from surface structure (clutter). Acoustic tomography provides novel insights into the perceptual ability of bats and lets us "see what the bat saw" in color.

Effects of Acoustic Filters on Quantitative Species Identification
Matthew Clement, Kevin Murray, Donald Solick, and Jeffery Gruver, Western EcoSystems Technology, Inc., Cheyenne, WY

Various statistical methods have been used to identify bats from time, frequency, and amplitude characteristics of their echolocation calls, but statistical analysis is of little value if call parameters are not accurately measured. Available ultrasonic analysis software packages rely on acoustic "filters" to automatically extract call parameters from sounds. However, different filters may select different sounds, including inappropriate call fragments or non-bat sounds. Such noise can be subjectively edited, but at the cost of objectivity and repeatability. Therefore, our goal was to assess the impact of filter design on the selection of sounds, the measurement of call parameters, and quantitative species identification. To assess filters, we applied published and newly developed Anabat filters to a library of known calls and developed a discriminant function analysis from the filtered data. The most permissive filter selected 55% more passes and 424% more pulses than the most restrictive filter. Filters significantly affected measurement of key call parameters, even after controlling for differential selection of pulses. For example, filters affected estimates of characteristic frequency by up to 4.0 kHz and the least precise filter had standard deviations 3.6 times higher than the most precise filter. Filters also affected the accuracy of quantitative species identification. Correct classification rates ranged from 59.0 to 82.2% and false positive rates ranged from 1.3 to 3.4%, depending on the filter. We recommend that researchers consider the effect of filters on species identification, publish the details of filters used in research, and employ filters that exclude noise without additional editing.

Characterizing Major Histocompatibility Complex Class II Diversity in *Myotis lucifugus*
Kimberly Cohen, Thomas Kunz, and Michael Sorenson, Boston University, Boston, MA

Identifying the role of host immunity in disease resistance is critical in evaluating the ability of populations to recover from outbreaks and epizootics. When considering the role of host immunogenetic variation in disease resistance, genes of the major histocompatibility complex (MHC) are ideal targets of study, due both to their

role as antigen-presenters necessary for various adaptive immune cascades, and also their high sequence polymorphism. We focused on genes of MHC class II, which are expressed in a subset of immune cells and primarily present exogenously-derived peptides. To identify MHC class II genes in the little brown myotis (*Myotis lucifugus*), we BLAST searched mammalian MHC sequences against the little brown myotis genome (Broad Institute) and designed species- and gene-specific primers that successfully PCR amplify MHC class II DRA, DRB, DQA, and DQB genes and transcripts. We concentrated specifically on exon 2, which encodes the highly variable peptide-binding region of each glycoprotein. Using these primers, high-throughput 454 sequencing of DRA, DRB, DQA, and DQB genes will be performed to assess both individual genotypes and gene transcription. Characterizing MHC class II diversity in the little brown myotis further adds to our understanding of the immunogenetics of this species and is requisite to evaluating the possibility of MHC-mediated, and thus heritable, resistance to white-nose syndrome among individuals and populations.

Status of the Response to White-nose Syndrome in 2012

Jeremy Coleman, Mike Armstrong, Ann Froschauer, Rich Geboy, Christina Kocer-Curinga, and Jonathan Reichard; U.S. Fish and Wildlife Service – Hadley, MA; Frankfort, KY; Bloomington, IN

White-nose syndrome (WNS) has caused unprecedented mortality in hibernating bats in eastern North America since its discovery in 2007. WNS continued to spread in 2012, and the disease or the causative fungus, *Geomyces destructans* (Gd), has now been detected in 21 states and 4 provinces. WNS was diagnosed in the federally-listed gray bat (*Myotis grisescens*) in 2012, bringing to seven the number of bat species confirmed with the disease in North America. Gd infection has also been documented in bats throughout Europe, but apparently without associated mortality. The rapid spread and devastating impacts of WNS have presented researchers and natural resource managers with considerable biological and social challenges, and increasing public interaction with moribund bats is of considerable concern. Relatively few tools have become available for managers to combat WNS. Federal (and state) listing under the ESA provides legal authority for government agencies to manage bats, and some state agencies have begun to list certain hibernating bat species. The U.S. Fish and Wildlife Service is also currently assessing three species for potential listing. A coordinated effort is required to manage WNS and conserve bat species. A national response plan, finalized in May 2011, provides the framework for a comprehensive North American response, and presents a model for responding to wildlife disease outbreaks in the future. Collaboration between the multifarious groups and individuals engaged in the WNS response remains critical, and is responsible for the considerable advances we have made in our understanding of this disease.

Modeling the Geographic Distribution of the Little Brown Bat, and the Northern *Myotis* in the Monongahela National Forest

Jason Collins, Eastern Michigan University, Ypsilanti, MI

Predicting the occurrence of a species has practical and diverse applications in ecology, evolution, and conservation biology. Maximum entropy (MAXENT) is an ecological niche model that uses presence information, along with geographic data, such as elevation, land cover, and mean temperature, as predictor variables to approximate the niche and potential geographic distribution of a species. In this study, the geographic distribution of the little brown bat (*Myotis lucifugus*) and the northern myotis (*Myotis septentrionalis*) in the Monongahela National Forest of West Virginia were analyzed using MAXENT. Mist-netting data gathered at over 380 sites between 1997 and 2011 were used to determine presence. A variety of sources yielded biologically relevant features for use in the model including, travel corridors, forest cover, stand information, wetlands, streams and ponds, hydrology, and elevation. Models of foraging preferences were created for both species and compared.

The Effects of Weatherproofing on Acoustic Bat Detection

Allison Costello, Lauren Hooton, and Crissy Sutter, Normandeau Associates, Gainesville, FL

Bat detectors deployed for passive acoustic monitoring are exposed to wind, rain, condensation, and temperature extremes over long periods of time, and require protection from the elements. Weatherproofing can alter acoustic data quality and quantity, and it is important for researchers to understand the effects of weatherproofing when designing an acoustic monitoring program. Various weatherproofing configurations are currently used by researchers, including the use of reflector plates, and the use of a curved polyvinal chloride (PVC) tube—PVC elbow. It has been recommended in the first draft of the Rangewide Indiana Bat Summer Survey Guidance Draft— February 3, 2012, that the PVC elbow configuration is used as the preferred weather

proofing method. The use of the flat reflector plate is currently not accepted. Normandeau's ReBAT bat acoustic monitoring system uses a weather-resistant aluminum housing unit with a large reflector plate (8" x 10") attached to the housing at a 45° angle. To understand the effects of weatherproofing on acoustic data collected with ReBAT, Normandeau investigated detection performance of the detector in both the ReBAT aluminum housing with reflector plate, and the PVC elbow configuration using ultrasonic playback and field trials. Results indicate that ReBAT recorded more files with bat calls, more high frequency bat passes, and had a greater distance of detection compared to the PVC elbow and bare detector. These results illustrate the importance of understanding the effects of weatherproofing on bat detection, especially in acoustic monitoring studies geared specifically at detecting high frequency echolocating bats, such as *Myotis sodalis*.

Foraging Patterns by Bats in Forested, Edge, and Masticated Ponderosa Pine Forest in Boulder County, Colorado

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

We investigated bat foraging patterns and insect activities within ponderosa pine woodlands of three stand types: forested, edge, and masticated. To record sonar calls, we arrayed three Pettersson D240x detectors with digital recorders, moving them among five pseudo-replicated transects and collected insects in forested and masticated stands using black-light traps. Calls were analyzed to species using Sonobat 3.0 and total numbers of calls from 2010–12 were pooled. Overall bat activity was highest in masticated stands (843 total calls recorded), with 369 calls on the edge, and 342 in forested stands. Dunn's test showed that activity was significantly different between uses of masticated stands versus both edge ($z = 3.63$) and forested stands ($z = 3.57$), but there was no significant difference between use of forested stands and edge ($z = 0.06$). Species-specific habitat patterns were mostly consistent with accepted ecomorphological norms (clutter specialist, open area specialist, etc.), except for *Lasiurus cinereus, Myotis thysanodes,* and *M. ciliolabrum*. In 2010–11 the average insect biomass was lower in masticated than in forested habitat: 2010 showed 276.8 mg (sd = 380.9) in forested habitat, whereas masticated areas saw 2.47 mg (sd = 6.4); 2011 showed 13.9 mg (sd = 5.1) in forested stands and 8.7 mg (sd = 6.5) in masticated stands. However, insect biomass was similar in 2012: 14.18 mg (sd = 4.30) forested and 14.20 mg (sd = 3.15) masticated. We will also present data on bat activity patterns with respect to moon illumination and cloud cover. Forest management treatments that promote habitat mosaics are best for supporting bat species diversity particularly under variable environmental conditions.

Winter Energetics of Free-ranging Little Brown Bats

Zenon Czenze and Craig Willis, University of Winnipeg, Winnipeg, MB

For many temperate endotherms (mammals and birds), energy costs are highest during winter but food availability is lowest. Many species depend on hibernation as a result. Hibernation is made up of energy-saving torpor bouts (periods of controlled reduction in body temperature (T_b), which are interrupted by brief periodic arousals to normothermic T_b. What triggers these arousals in free-ranging bats is not well understood. Some temperate bats with intermittent access to flying insects during winter synchronize arousals with sunset. We tested whether hibernating bats from cold climates without access to food, also maintain a circadian rhythm for arousals or whether cues from conspecifics in the same cluster are more important. We used temperature telemetry to monitor skin temperature (T_{sk}) of free-ranging little brown bats hibernating in central Manitoba, Canada where temperatures did not exceed 10°C from October 22 to March 22. We found no evidence that bats synchronized arousals with sunset (Rayleigh's test, $z = 0.2$, $p = 0.82$, $n = 29$ arousals, $n = 15$ bats) but bats were significantly more likely than random to arouse synchronously with other bats in the same cluster ($z = 3.4$, $p = 0.03$, $n = 15$ arousals, $n = 15$ bats). Thus, in the northern part of their range where flying insects are almost never available during winter, little brown bats exhibit no circadian pattern to arousals. However, warming synchronously with others may reduce the energetic cost of arousals. Understanding the huddling behavior of bats during hibernation is important because of its implications for energy and water balance and its potential importance in the transmission of pathogens like *Geomyces destructans*.

Ecological Release and Genetic Signatures of Population Growth in Antillean *Artibeus jamaicensis*
Liliana Dávalos, Nancy Wei and Amy Russell, SUNY Stony Brook, Stony Brook, NY; Herricks High School, New Hyde Park, NY; Grand Valley State University, Allendale, MI

Ecological theory predicts that in the absence of competitors, predators, and parasites, populations will grow. Ecological release is a common feature of species that newly colonize islands. The bat fauna of the West Indies combines endemic genera and species with more recent colonizers. The considerable Pleistocene and early Holocene fossil/subfossil record suggests that *Artibeus jamaicensis* colonized the Lesser Antilles as recently as the early Holocene. In the Lesser Antilles, as in the rest of the West Indies, *A. jamaicensis* is abundant and has no ecological equivalent. If this population has recently colonized the Lesser Antilles, and grown in the absence of ecological constraints, genetic signatures of range and population expansion should be apparent. We tested this prediction using a series of statistics based on equilibrium models of nucleotide and haplotype diversity in the mitochondrial cytochrome *b* gene. To uncover the sensitivity of estimates of the onset of population growth to variation in the substitution rate of this gene, we simulated data with a range of rates corresponding to the order-of-magnitude differences observed even among closely related mammals. We found strong, significant signals of recent population growth among Lesser Antillean *A. jamaicensis*. The estimated date of demographic growth was influenced by the substitution rate. Nonetheless, median substitution rates are consistent with the onset of population growth around the end-Pleistocene. We propose that ecological release following recent colonization explains the genetic diversity of this population, as well as its current abundance in the Lesser Antillean archipelago.

Western Bat Working Group Regional Conservation Status Assessment of Western Bats
Rita Dixon and Angela McIntire, Idaho Department of Fish and Game, Boise, ID; Arizona Game and Fish Department, Phoenix, AZ

In 1998, the Western Bat Working Group (WBWG) held a workshop in Reno, Nevada to assess the conservation status of western bat species. The product of the workshop—*Western Bat Species: Regional Priority Matrix*—was intended to provide states, provinces, federal land management agencies, and interested organizations and individuals a better understanding of the overall status of a particular bat species by ecoregion within its western North American range. Since that time, emerging threats such as climate change, wind energy, and white-nose syndrome necessitate a reevaluation of the existing matrix. In addition, advances in methodology for assessing status provide a means toward deriving more consistent, repeatable, and transparent ranks. To update the matrix, WBWG has embarked upon a reexamination of the status of western bat species by applying NatureServe's methodology for assigning conservation status ranks. We plan to assess status within each of eight Landscape Conservation Cooperatives (LCCs) (i.e., ecologically based conservation regions) that occur in the western United States. For each bat species, regional teams will compile available information for eight core status rank factors—range extent, area of occupancy, population size, number of occurrences, number of occurrences or percent of area occupied with good viability, overall threat impact, and short- and long-term trend. The initial assessment will be presented for review and discussion during the April 2013 WBWG Biennial Meeting in Santa Fe, New Mexico. The WBWG sees this as a necessary first step toward prioritizing conservation actions for bats in the West.

Chiropoxvirus: an Emerging Poxvirus in Bats
Ginny Emerson, Robert Nordhausen, Michael Garner, John Huckabee, Steven Johnson, Ron Wohrle, Whitni Davidson, Kimberly Wilkins, Yu Li, Maureen Metcalfe, Kevin Karem, Inger Damon, and Darin Carroll; Centers for Disease Control and Prevention, Atlanta, GA; University of California, Davis, CA; Northwest ZooPath, Monroe, WA; PAWS Wildlife Center, Lynnwood, WA; Washington State Department of Health, Tumwater, WA

Since 2009, a wildlife hospital and rehabilitation center in the northwestern region of the United States has received several big brown bats with swollen forelimb joints and unable to fly. The bats had no apparent skin or visceral lesions, but their condition progressed rapidly and all were subsequently euthanized. Histologic examination revealed necrosuppurative osteomyelitis in multiple joints, and thin-section electron microscopy revealed poxvirus particles within A-type inclusions. Material from the wing and joint of an affected bat tested positive by poxvirus-specific PCR targeting genomes with low GC content. Phylogenetic analyses of nucleotide sequence data indicate the isolate represents a new poxvirus genus.

Ensemble Structure of Sympatric Insectivorous Bats
Matthew Emrich, Western University, London, Ontario

Bat communities often consist of many species with similar diets. A traditional competitive view of niches suggests that bats partition available resources. From 30 May to 4 August 2011, I placed two, 4-microphone arrays back-to-back, in cluttered, edge, and open habitats on 45 nights and recorded continuously from sunset to sunrise in the vicinity of Windsor Cave in Jamaica. From these recordings I reconstructed flight paths of bats whose echolocation calls were recorded. I also captured bats including *Molossus molossus, Tadarida brasiliensis* (Molossidae), *Mormoops blainvillii*, *Pteronotus parnellii, Pteronotus quadridens, Pteronotus macleayii* (Mormoopidae), using mist nets and harp traps between 13 July and 6 August 2011, and 12 May and 9 June 2012, and took morphological measurements (n = 121) and guano samples (n = 241). Differences in morphology, habitat selection, periods of peak activity, flight speeds, and diets emerged from a comparison among the different insectivorous species. I found sympatric bats differed from one another in at least one of the factors studied. For example each of the species had a unique set of sites that were most often and least often used. Most species were most active in edge habitats except for *P. parnellii*, which was most active in cluttered habitats that were less used by most other species. *T. brasiliensis* and *P. parnellii* were the most selective with their habitat use and *P. macleayii* least selective. The results indicate that multiple methods allow better understanding of interactions in an ensemble of bats.

Comparing Three Bat Acoustic Sampling Methodologies for Large-Scale Surveys
Marina Fisher-Phelps, Dylan Schwilk, and Tigga Kingston, Texas Tech University, Lubbock, TX

Numerous landscapes in North America have features that contribute to low bat densities, such as rare roost sites or clustered feeding areas. Driving transects have been proposed as a method to collect large-scale data on bat presence and activity in low density habitats (e.g., grasslands, rangelands, deserts, croplands), as they can provide greater geographic coverage per night than stationary methods such as point counts. However, this mobile sampling may under-represent activity at any given location along the transect. Our objective was to compare the efficiency of detecting bat passes between point counts and driving transects in a low bat density landscape (Lubbock County, TX). Twice a month for three months, three different survey methods were conducted along the same 15-mile route: a driving transect conducted at 15 mph; a set of five, 10-minute point counts at permanent locations; and a set of point counts at locations randomized each survey night. A Pettersson D1000X time expansion detector was used to continuously sample the driven route and the point counts. Our data suggest that driving transects detect more bat passes for the route than either of the point count methods. By maximizing the sampling area, driving transects effectively measure bat presence in an area with low bat densities without substantially increasing the sampling effort or cost, facilitating an increase in the scale of bat population and habitat studies.

Roost Tree Selection by Indiana Bats in the Southern Ontario Lake Plain, New York State, U.S.A.
Michael S. Fishman and James P. Gibbs, Barton & Loguidice, P.C., Syracuse, NY; State University of New York College of Environmental Science and Forestry, Syracuse, NY

Roost tree protection is critical for conservation of endangered Indiana bats, but available habitat for Indiana bats varies strongly across the species' range; therefore, it is necessary to characterize roost trees regionally to provide suitable guidelines for wildlife managers throughout the species' range. We radio-tracked 20 female and 7 male Indiana bats to roost trees in central New York State during spring 2006 and summer 2007 and 2008. We contrasted attributes of 96 roost trees with those of 191 randomly selected available trees to determine whether bat-selected trees differed from trees available to them. Most Indiana bat roosts were in *Carya ovata*, *Acer* spp., and *Ulmus americana*, with seven other tree species also used. Mean diameter of roost trees was 41.6 ± 7.5 cm and was larger than that of available trees. Most roost trees were used as snags and in proportion to their available sizes by species, except for *Carya ovata*, which was mostly used in the live state, and was selected at larger size classes (> 40 cm DBH) than available. Male and female bats used similarly sized trees, although females used a wider range of sizes of trees than did males. Females preferred *Acer* spp., whereas males preferred a variety of other species. Roost trees in central New York State are similar in size to those in other parts of the Indiana bat's range, but the most frequently selected tree species differ regionally, with differences between roost trees selected by males and females inconsistent among regions.

Effect of Land Use and Host Ecology on Ectoparasitism in Costa Rican Bat Community
Hannah Frank, Chase Mendenhall, Gretchen Daily, and Elizabeth Hadly, Stanford University, Stanford, CA

Bat flies are blood-feeding, often highly host-specific ectoparasites of bats. Their host-parasite dynamics can be affected by numerous aspects of both host and bat fly ecology, including host roost duration, as well as anthropogenic disturbance. We examined the effect of anthropogenic land-use change and host ecology on ectoparasitism of bats living in Coto Brus, Costa Rica, a patchwork of coffee fields and forest fragments. We caught 492 bats representing 29 species, counted and collected their bat flies, calculated intensity (number of parasites per infested host) and prevalence (percent of hosts infested) of parasitism and identified bat flies to species (n = 21 spp.). As in previous studies, parasites were more prevalent on bats living in roosts of longer durations. Intensity did not vary between land-use types; however, parasites were significantly less prevalent on bats caught in forest fragments adjacent to coffee fields than those caught in the nearby forest reserve. Individuals in these fragments were more likely to belong to species that had significantly lower roost durations than bats in other land-use types. When the analysis was restricted to species found in all land use types, there was no correlation between parasite prevalence and land-use type, suggesting that roost duration rather than land-use type drove the observed trend, and that individual exposure to parasites is important. Bat-fly species composition also differed between land-use types. These results indicate that small-scale land conversion does not affect parasitism dynamics within a given species but may affect overall parasitism dynamics through effects on host species communities.

Molting Matters: Understanding Fur Replacement Patterns When Using Bat Fur Samples for Endogenous Marker Analysis
Erin Fraser, Fred Longstaffe, and Brock Fenton, Memorial University of Newfoundland—Grenfell Campus, Corner Brook, NL; Western University, London, ON

Endogenous marker analysis, such as stable isotope and trace element analyses, of bat fur is increasingly being used to provide information about individuals. To interpret results accurately, it is necessary to have a detailed understanding of the molt cycle of the species being studied. Such data do not exist for many species, making it necessary to assume that new fur growth occurs once annually (usually in summer). We reviewed literature on bat molting in order to evaluate this assumption by identifying: 1) apparent trends/exceptions in molt timing; 2) significant knowledge gaps; and 3) best practices in fur sampling when species-specific molt cycles are unknown. We reviewed 19 studies with data on 21 species (7 families). Broadly, we found that most species have one annual period of fur growth during the summer or fall; males tend to begin fur growth earlier than females; and dorsal fur growth often precedes ventral fur growth. There are exceptions for each of these trends; particularly, there is wide variation in the molt cycles of juveniles/subadults and reproductive females. There are data gaps concerning molt cycles in tropical species; the relationship between fur growth and shedding; and the likelihood that individuals may be migrating during part of late summer/fall fur growth (thereby integrating endogenous signals from multiple locations). From a technical perspective, in cases where molting biology is unknown, we suggest that sampling dorsally from adult males may increase the likelihood that fur samples were grown early (during summer residency), as opposed to later (during migration).

Patterns of *Geomyces destructans* Infection across North America
Winifred Frick, Tina Cheng, Kate Langwig, Kevin Drees, Amanda Janicki, Gary McCracken, Jeff Foster, and Marm Kilpatrick, University of California, Santa Cruz, CA; Arizona University, Flagstaff, AZ; University of Tennessee, Knoxville, TN

Transmission is a critical force driving dynamics of infectious diseases, yet very little is known about transmission dynamics of white-nose syndrome (WNS). Determining prevalence, intensity of infection, and transmissibility among individuals in wild bat populations aids development of effective management strategies for controlling spread and mitigating impacts of WNS. In collaboration with agency personnel, we assessed prevalence of *Geomyces destructans* infection by swab sampling ~1,400 bats of 9 species from 80 hibernacula in 18 states during the 2011-2012 winter across enzootic, epizootic, and leading edge regions and along a latitudinal gradient in North America. Prevalence varies by species in highly impacted regions even within the same hibernacula and by region depending on time since WNS was first detected. By non-invasive swab sampling of multiple individuals at sites, we are able to provide early detection methods of presence of *G. destructans* before disease symptoms of mortality and visible infection are apparent. Our results are useful to track spread of *G. destructans* at a continental scale and determining factors associated with risk of arrival of *G. destructans*, disease progression,

and impacts to populations.

White-nose Syndrome of Bats: Communicating North America's Response to a Devastating Wildlife Disease
Ann Froschauer, U.S. Fish and Wildlife Service

White-nose syndrome (WNS) is a disease responsible for unprecedented mortality in hibernating bats in North America. This emergent disease has spread very rapidly from the northeastern to the central United States and eastern Canada since its discovery in January 2007. Biologists estimate over 5.5 million insect-eating bats in 19 states and 4 Canadian provinces have died from this devastating disease. As WNS spreads, the challenges for understanding, managing, and communicating about the disease continue to increase. The U.S. Fish and Wildlife Service is leading a cooperative effort with federal and state agencies, tribes, researchers, universities, and other non-government organizations to research and manage the spread of WNS. Published in 2011, the *National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-nose Syndrome in Bats* provides a strategic framework for the investigation and management of WNS. The *National WNS Plan* recognizes the rapid internal and external flow of information is critical to addressing WNS. As part of the *National WNS Plan*, a *Communications and Outreach Plan* ensures key audiences receive and understand information about WNS in a timely manner. Four strategic goals and action items were identified by the Communications Working Group to foster proactive communication among the WNS Investigative Team; internal audiences of Federal and State agencies, Tribes and international government partners; and external audiences including non-governmental organizations and institutions, elected officials, news media, and the public. A variety of communications strategies and partnerships have been developed and implemented to address these strategic goals.

Infrared Video Population Counts of Ozark Big-eared Bat Maternity and Limited-Use Sites
Brian Fuller, Shea Hammond, and Tom Tomasi, Missouri State University, Springfield, MO; Ozark Plateau National Wildlife Refuge, Colcord, OK

Estimating Ozark big-eared (*Corynorhinus townsendii ingens)* bat populations during emergence from maternity and limited-use sites currently relies on techniques of visual counting with night vision scopes looking for key characteristics (i.e., big ears, flight characteristics, and body size), which are highly dependent on the skill of the observer. Split-second judgment is required to determine an Ozark big-eared bat from a different species exiting the roost and requires several years to master. The need for a different method of counting Ozark big-eared bats that requires little training and skill emerged within the U.S. Fish and Wildlife Service. Therefore, a technique using infrared video cameras and lights to record emergence events was developed and tested against visual counts from experienced counters at five maternity sites. A cumulative comparison between visual and video counts at the five maternity sites reveals no difference (p = 0.689). The repeatability, physical count data, and virtually unlimited amount of time to distinguish bat species allows for accurate counts and requires little experience to complete.

Describing the *Myotis* Superhighway: Characteristics of Aggregated 3D Trajectories through a Cluttered Environment
Nathan Fuller, Diane Theriault, Alison Greco, Zheng Wu, Thomas Kunz, John Baillieul, and Margrit Betke, Boston University, Boston, MA

With a few exceptions, past studies of bat flight behavior have provided only basic measurements of the variables governing bat flight, such as air speed, turning frequency, and measures of habitat use. With recent advances in computational techniques and thermal imaging technology, we are now able to examine flight behavior in unprecedented detail and provide quantifiable measurements of flight dynamics. Through close collaboration with computer scientists and control systems engineers, we have reconstructed the flight trajectories of 405 *Myotis velifer* as they navigate past natural landscape features in Texas. Most bats chose to fly a path that is not a straight line, but rather a sweeping, curved pathway within 3 meters of the edge of the forest. When faced with a natural obstacle, the bats chose one of two paths around it—one cluttered by foliage and the other free of obstructions. Aggregate trajectories were obtained by clustering the bats based on their chosen path around the obstacle. Characteristics and summary statistics of the aggregate paths were calculated at regular intervals along an axis of motion. Features of the aggregate pathways will be discussed, including geometry and shape. These data will be used by our collaborators in an effort to define simplified models of the variables the govern flight and collective behavior. Eventually these models will be integrated into intelligent flight control algorithms that will lead to the development of a new generation of biologically-inspired unmanned aircraft.

Bat Research and Conservation in Ukraine: a Review
Lena Godlevska, Institute of Zoology, Kiev, Ukraine

First published data about bats of Ukraine refer to the end of the 18th Century. However, until quite recently bats had not been of particular research interest here. Data on species distribution, their status, quantity, and roosts were scanty and discrete. The situation started to change at the second half of 1990s when the first Ukrainian bat group was created. Later it was transformed into the Ukrainian Centre for Bat protection (UCEBA—http://kazhan.org.ua). In 1999 Ukraine ratified the EUROBATS Agreement that has promoted further development of bat research and conservation activities in the country. During the following years, Ukrainian bat workers considerably broadened a geographical database for bats and refined information on the distribution of all resident species. Hundreds of bat roosts have been found, examined, and documented. We conducted our first large-scale counts, determined important bat sites, and made first steps toward standardizing a bat monitoring system. Numerous bat conservation initiatives are in development. One of our main goals continues to be raising awareness of bats and characterizing their vulnerability and protection status among the public. We are doing this by: providing publications via governing authorities; doing interviews through mass media via the Web and hotlines; and doing interviews and presentations at public events, specialized workshops, and via official communications. Although there is a lot to do in terms of both research and conservation in Ukraine in the future, many results are already available.

Understanding Obstacle Avoidance in *Myotis velifer* through Analysis of Reconstructed 3D Flight Trajectories
Alison Greco, Nathan Fuller, Diane Theriault, Zheng Wu, Thomas Kunz, John Baillieul, and Margrit Betke, Boston University, Boston, MA

Flight behaviors of bats provide an extraordinary study system for scientists to understand collective behavior, obstacle avoidance, and sensory systems of flying organisms. Until recently, the technologies needed to study bat flight in detail have not existed, thus only simple observations of their flight behaviors were recorded. Using an advanced thermal imaging system, custom software, and 3D imaging techniques, we have reconstructed the flight trajectories of 334 *Myotis velifer* as they traveled along the edge of a forest. Most bats (82.5%) flew along a path following the margin of the forest. When faced with a natural obstacle (a hanging vine), an equal number of bats chose to pass this obstacle along paths that were cluttered and open. Bats that chose to cross the obstacle plane through the less cluttered corridor traveled at a faster average speed, whereas bats that chose the more cluttered corridor past the obstacle moved at a slower average speed while approaching the obstacle (t = 2.57, p = 0.0107) and while passing the obstacle (t = 5.16, $p < 0.0001$). Approach angle also varied with the chosen route around the obstacle 2 m before reaching it (F = 170.38, $p < 0.0001$). These results suggest that bats have already chosen their flight path 2 m before reaching an obstacle and that they prefer to fly near, but not through, clutter. These data will be useful to computational biologists and control systems engineers who seek to develop models to describe bat flight and group behavior.

Comparison of Methods to Estimate the Home Range of *Myotis Sodalis* in Northeast Missouri
Benjamin Hale and Lynn Robbins, Missouri State University, Springfield, MO

The delineation of home range and determination of high activity areas are critical for assessing risk to individuals within a reproductive unit (maternity colony). The onset of white-nose syndrome and the rise in the number of utility-scale wind turbines increase risks to the endangered Indiana bat (*Myotis sodalis*) and therefore, warrant further research on how to delineate home range. A study was conducted in northeast Missouri from May 19 to July 28, 2011. Twelve Indiana bats were fitted with radio-transmitters and tracked for an average of 4.6 nights/bat (49 telemetry locations/bat). Minimum Convex Polygon Analysis (MCP; 100% and 95%), Kernel Analysis (90%, 95%, and 99% combined isopleths), and a method developed by the U.S. Fish and Wildlife Service (USFWS) were used to estimate four different home ranges for each Indiana bat (n = 11) and colony (n = 3). These methods were compared using total area and amount of forest within this area. A repeated measures General Linear Model indicates a significant difference in area among home range methods ($p < 0.01$). Tukey's Pairwise comparison indicates the USFWS method results in a significantly larger area than other home range estimates. Although the USFWS method likely overestimates actual area used, it is a viable method to estimate home range, in the absence of radio-telemetry locations. Near these maternity colonies, three acoustic detectors were set on a gradient of forested to non-forested sites. Acoustic activity decreased in open areas indicating that open areas included in home ranges may be less favorable to Indiana bats.

Ecology and Distribution of *Geomyces* Fungi: an Introduction for Bat Researchers and Wildlife Managers
Mark Hayes, University of Colorado, Denver, CO

White-nose syndrome (WNS) is a devastating disease affecting hibernating bats, first documented in eastern North America. The fungus *Geomyces destructans* is now considered the causal agent of WNS. This overview summarizes the ecology and distribution of *Geomyces* fungi. Species in this genus are common in the soils of temperate and high-latitude ecosystems and are capable of withstanding and thriving in cold, low-nutrient environments. Members of the genus are capable of modifying their metabolism in response to challenging abiotic conditions, including very cold temperatures and low levels of biologically available water. *Geomyces* propagules are dispersed by air currents and wind, by groundwater seepage into caves and soils, on arthropods, on the feathers of birds, on the fur of mammals, and perhaps in clouds and in the atmosphere. Given that the bat species affected by WNS are all insectivorous, flying arthropods may play a key role in the dispersal of *G. destructans*. *Geomyces* propagules are also carried by humans and their clothing and equipment, and *Geomyces* can be more abundant in areas disturbed by humans. Current evidence suggests that the viable propagules of these fungi may be transported long distances by air and ocean currents. Biologists, managers, and others charged with controlling the spread of WNS and the causal agent *G. destructans* into other parts of North America and to other locations in the biosphere will be challenged by a fungal species with broad adaptive potential, capable of surviving and thriving in diverse terrestrial and perhaps even aquatic and marine environments.

Second-Season Estimates of Urban and Rural Bat Species Presence in Sichuan Province, China
Laura Heiker and Rick Adams, University of Northern Colorado, Greeley, CO

Continuing work begun in the summer of 2011, we resurveyed two rural and two urban sites for bat calls in and around Chengdu, Sichuan Province, China from July 25 to July 31, 2012. Using handheld EM3s and mounted SM2s, we recorded calls for two hours at each site, starting from the time of the first bat recorded each night, which typically occurred before sunset. We also mist-netted once at the Chengdu Panda Base and collected hand-release calls of two adult *Pipistrellus abramus*. These recordings aided in identification of calls analyzed with Sonobat 3.1. A total of 3,518 calls were recorded from all four sites (Jinjiang River = 1,099; Jiulidi Park = 1,132; Chengdu Panda Base = 1,236; Longxi Hongkou Nature Reserve = 51). Although echolocation information for Chinese species still is limited, we distinguished a total of seven unique calls. Compared to last year's sampling, new species records were added as follows: Longxi Hongkou (rural)—*Eptesicus serotinus*, *Hypsugo pulveratus*, Vespertilionidae sp.; Chengdu Panda Base (rural)—*E. serotinus*, Vespertilionidae sp.; Jiulidi Park (urban)—*E. serotinus*, *Miniopterus fuliginosus*; and Jinjiang River (urban)—*Hypsugo pulveratus*, *Pipistrellus abramus*, Vespertilionidae sp. Interestingly, despite having about 5% of the activity recorded at the other sites, the rural site of Longxi Hongkou had the highest number of species (four) recorded in this sampling effort. Although sample size is small, results to date show species diversity to be slightly higher at rural sites compared to urban (14 vs. 12). Work on this project is ongoing.

***The Function of the Baculum: a Longstanding Question (partly) Answered**
Anna Nele Herdina, Diane Kelly, Patricia Brennan, Dan Pulaski, Ian Grosse, Taufiq Purna Nugraha, Brian Metscher, and Elizabeth Dumont; University of Vienna, Vienna, Austria; UMass Amherst, MA; Museum Zoologicum Bogoriense, Cibinong, Indonesia
*** Anna Nele Herdina** received the **Luis F. Bacardi Bat Conservation Award**.

Although many authors have suggested that the baculum plays a mechanical role in copulation for bats and other mammals, its specific function is still unknown. In this study we tested the function of the baculum using finite element (FE) models of flying fox penes. We studied penes from seven Indonesian species of *Cynopterus*: *Cynopterus brachyotis, C. horsfieldii, C. luzoniensis*, *C. minutus*, *C. nusatenggara, C. sphinx,* and *C. titthaecheilus* (kindly made available by the Museum Zoologicum Bogoriense). For each species, a resected baculum and an iodine-stained penis were scanned in an Xradia MicroXCT. The microCT stacks were reconstructed and transformed into 3D FE models using Amira, Mimics, and Geomagic Studio, and then analyzed using Strand7. The material properties for bone (Young's modulus: 17,300 MPa, Poisson's ratio: 0.3), corpora cavernosa (Young's modulus: 17 MPa, Poisson's ratio: 0.4), and the other soft tissue of the penis (Young's modulus: 0.035 MPa, Poisson's ratio: 0.4) were taken from published sources. With a pressure of 0.004 MPa applied normal to the surface of each penis, the deformation of the glans penis clearly reflects the shape of the baculum. Therefore, females may be able to perceive the shape and size of the baculum during copulation, and the baculum may allow males to

expand the female cervix to optimize sperm deposition. Our models also support the hypotheses that the baculum protects the distal part of the urethra during copulation and serves as a stiffening element within the soft glans penis tissue.

Patterns of Behavior in Roost Emergence and Return in *Eptesicus fuscus*
Rebecca Hoffman and Christopher Nicolay, University of North Carolina Asheville, Asheville, NC

This study analyzed evening departure and return within a colony of approximately 70 *Eptesicus fuscus* located in a wooded area at ~2450- ft. elevation in the Blue Ridge Mountains of western North Carolina. The colony established itself in a private residence, between the outer slats and inner screen of an attic vent approximately 25 feet above the ground. Individuals roosted one-deep across much of the screen, enabling a view of all members from within the attic. Bats were recorded using a Sony SR12 camera with IR illumination. Vernier temperature sensors were positioned outside and within the roost. The goal of our research was to predict patterns in emergence and feeding duration (empty roost) based on various factors. Data collection has been ongoing since mid-July (n = 24 days reported to date). Emergence occurred shortly after sunset (median = 16 minutes after sunset; range 7–56) and trended closer to sunset as the summer progressed. No relationship between position in the colony and order of departure was apparent. Time of departure was independent of temperatures. Prior to departure, individuals exhibited increased activity and vocalization. Upon return, bats bunched more tightly and nearer to the peak (where the roost was warmest) than they had before departure. Time the roost remained unoccupied ranged from 19–220 minutes (median = 65). No clear association was found between duration of roost vacancy and time of emergence, daily temperatures, month, or lunar phase.

The Influence of Specific Atmospheric Variables on Fall Bat Activity Varies Among Geographic Regions and Species
Lauren Hooton, Crissy Sutter, and Allison Costello, Normandeau Associates, Inc., Gainesville, FL

Long-term monitoring at proposed wind energy facilities (WEFs) over a broad geographic range allows for a unique opportunity to examine broad-scale patterns in activity of the bat species most at risk of turbine-associated mortality. This can allow us to gain a better understanding of how their activity correlates with atmospheric variables. Our objective was to elucidate weather-specific patterns in bat species activity, and to determine which atmospheric variables had the greatest influence on bat activity. We acoustically monitored bat activity from 1 July–31 October at 12 sites over the continental United States, encompassing five states (divided among the West and Midwest) and three years (2009–2011). We examined the relationship between acoustic activity of four species [*Lasiurus cinereus*, *Lasiurus borealis* (not at western sites), *Lasionycteris noctivagans*, and *Tadarida brasiliensis* (western sites only)] and four atmospheric variables: temperature, wind speed, wind direction, and relative humidity. Overall, temperature, wind speed, and humidity had the strongest influence on bat activity. Wind speed had the strongest effect on activity of all three species in the West, with activity of each species decreasing with increasing wind speed. In the Midwest, temperature had the strongest effect on bat activity, with activity of each species increasing with increasing temperature. Our results suggest that multiple environmental variables influence bat activity at potential WEFs across the United States, but that the influence of individual weather variables varies among geographic regions and species. These are important factors to consider for successful mortality mitigation at WEFs.

Monitoring Bat Species Communities by Operation Wallacea within the Iwokrama and Surama Forests in Guyana, South America
Thomas Horsley, Burton Lim, Jake Bicknell, and Loren Ammerman, Angelo State University, San Angelo, TX; Royal Ontario Museum, Toronto, Ontario, Canada; University of Kent, Kent, United Kingdom

The Iwokrama Forest in Guyana, South America is home to over eighty-six species of bats. This is one of the highest bat species diversity recorded for any protected area in the world. Establishing long-term annual monitoring based on standardized survey methods is an essential step in attaining a more complete understanding of this unique bat community. Operation Wallacea (OW) is a student-supported organization composed of participants from universities throughout Europe and North America that initiated a long-term vertebrate monitoring project within the Iwokrama and Surama forests beginning in summer 2011 to track changes in species diversity and relative abundance. Five sites were surveyed for bats using eighteen understory mist nets arranged in nine pairs positioned at 50-m intervals in a 100-m grid. Captured individuals were weighed, sexed, aged, and

marked by wing puncture for release. Overall, species richness decreased from 30 to 20 species from 2011 to 2012 and capture rates decreased by half (average capture rates 0.130 captures/net hour and .0649 captures/net hour, respectively). Five species were dominant (*Artibeus planirostris*, *A. obscurus*, *A. lituratus, Carollia perspicillata*, and *Lophostoma silvicolum*), and accounted for 68% and 59% of total captures in 2011 and 2012. In 2011, *Furipterus horrens* and *Mimon bennettii* were added to the list of known species of the Iwokrama Forest. Further monitoring is needed in order to ascertain whether the decrease in species diversity and relative abundance represent natural community and populational variation or a downward trend of potential conservation concern.

Relating Bat Fatalities to Bat Activity at Individual Wind Turbines

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Minimizing the impact of wind turbines on wildlife begins with proper siting in areas where risk is believed to be low. One indicator of risk to bats is pre-construction activity recorded within or below the rotor-swept-area (RSA). A direct concurrent relationship between bat activity in the RSA and fatality post-construction has not yet been shown, making an indirect relationship of pre-construction activity with post-construction fatality even more tenuous. In 2011, we conducted an 8-week study at Iberdrola Renewables' Casselman Wind Power Project, Pennsylvania to explore whether a direct relationship exists between acoustic activity measured within the RSA and fatality on a turbine-specific basis. We recorded bat passes using acoustic detectors secured to the nacelles of 15 turbines. We assigned each pass to the low- or high-frequency phonic group, and identified a subset of low-frequency passes as hoary bats (*Lasiurus cinereus*), a species particularly vulnerable to wind energy development. We conducted daily fatality searches and estimated turbine-level fatality. We fit turbine-scale models relating total estimated fatality to total activity throughout the study period at each turbine. We found little correlation for high-frequency bats. Although we found significant correlations for low-frequency and hoary bats, prediction intervals were imprecise, spanning an order of magnitude. The purpose of monitoring bat activity at wind power facilities is to provide input to predictive models of risk, yet our preliminary results relating fatality to concurrent activity within the RSA suggest that acoustic monitoring may be limited in its ability to precisely estimate risk of turbines to bats.

Assessing the Status of Philippine Cave Bats and Networking for their Conservation

Nina Ingle, Rai Gomez, and Dave Waldien, Wildlife Conservation Society of the Philippines, Davao City, Philippines; Bat Conservation International, Austin, TX

In the Philippines, caves are home to about 40 species of bats and laws are in place to protect both bats and caves. Unfortunately, reports have been coming in from throughout the country of hunting of cave bats, caves with extensive bat staining but very few bats, and high levels of human disturbance in bat caves. A collaborative effort to assess the status of Philippine cave bats and to work together for their conservation was launched in January 2011 at a 4-day meeting with 50 bat biologists, cavers, and staff of the Department of Environment and Natural Resources (DENR). Participants entered observations on cave bats into a geospatial database using the website, http://phcavebats.crowdmap.com. Data from over 70 roosts were entered into the database during the workshop and the total number of cave reports is now 342; additional data are being collated from 756 caves reported to have bats from DENR reports. The top three uses/threats to bats reported include illegal collection of bats for food (62 reported caves), guano harvesting (100 caves), and cave tourism (119 caves). A 30-minute educational video, *Saving Philippine Cave Bats*, was released in April 2012 and a print and web-based report is being compiled. The process of sharing data and collaborating on the report has stimulated a national movement for bat conservation and facilitated communication through the Philippine Bat Champions Facebook page— launched in April with over 450 members.

Roost Fidelity and Social Interactions among Multiple Colonies of the Little Brown Bat

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Research on the social behavior of the little brown bat (*Myotis lucifugus*) and details about factors that influence roost site selection is generally unknown. It is known that little brown bats are long-lived and are able to recognize individuals by call, and given that females live in large maternal colonies during the summer, it is

predicted that there are complex social interactions among colony members, although the nature of which is unknown. To characterize roost-site selection and make inference on sociality, bats at three maternity colonies were tagged with passive integrative transmitters (PIT) and then roosts were monitored remotely with PIT-readers. In Tatamagouche, Nova Scotia, we monitored ≈40 bats at 4 roosts. On the island of Newfoundland we monitored ≈100 bats at 4 roosts in Pynns Brook, and ≈500 bats at 11 roosts in Salmonier. Some bats exhibited a strong roost fidelity throughout the season, whereas some used a majority of the roosts, sometimes even within the same 24h period. Across all three sites, over 100,000 PIT-tag reads were recorded over four months, with some individuals recorded for 90+ days, while others were not recorded again after initial capture. Overall, roost fidelity seems to change as the season progresses as well as from one individual to the next.

Visual Detection and the Occurrence of Cryptic *Geomyces destructans* Infection

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White-nose syndrome is a large-scale epizootic in hibernating bats and the causal agent has been identified as the psychrophilic fungus, *Geomyces destructans*. Detection of *G. destructans* in the field is limited by the ability of researchers to visually document fungal growth on affected bats and submit these bats for laboratory testing. Because most major bat hibernacula are entered only once a year or less, the presence of *G. destructans* may be missed at the early stages. Swabbing bats for fungal DNA provides non-invasive sampling for *G. destructans* and also the opportunity to document the accuracy of visual observations for detecting the fungus. To determine the presence of *G. destructans*, bats were swabbed on their muzzle and forearm with polyester-tipped swabs dipped in sterile water. It was noted whether the individual bats being swabbed had visual fungus anywhere on the body. PCR was used to detect *G. destructans* DNA, if present. As part of a continent-wide study, bats ($n \cong 1{,}400$ bats of 10 species) were swabbed at approximately 85 hibernacula in 18 states during the winter of 2011-2012. Preliminary results suggest the occurrence of "cryptic" infections; *G. destructans* was detected on an *Eptesicus fuscus* in a new state, with no visual observation of fungus. These data should provide a sensitive analysis for geographic distribution of *G. destructans* where it may not otherwise be detected, and be useful for management purposes in documenting the presence of *G. destructans* in sampled hibernacula.

Preparing for Possible Arrival of White-nose Syndrome in the Western United States: an Example from Yellowstone National Park

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White-nose syndrome (WNS) continues to spread west and north across eastern North America, suggesting possible future expansion of the *Geomyces* fungus into western North America. Limited data are available on winter ecology of cave hibernating bats in some portions of western North America compared to the eastern half of the continent, making it unclear how WNS will impact western bat populations if it arrives there. Further, summer and winter assemblages of bats are poorly documented for many areas, confounding potential monitoring efforts. Yellowstone National Park initiated a bat monitoring program in 2010 to better understand seasonal distribution of local bat assemblages. Bats were radio-tagged during fall 2010 and 2011 to assess migratory patterns and potential winter residence, documenting presence of several *Myotis* species through late October. Acoustic detectors were deployed during the winter months to assess winter activity of bats, finding several species present and periodically active throughout the winter. Monitoring of summer activity of bats began in 2011, with placement of acoustic detectors and insect black-light traps in numerous habitats. Monitoring of summer maternity habitat of little brown bats (*Myotis lucifugus*) began in 2012, including use of temperature-sensitive radio-telemetry. Plans are in place to continue long-term monitoring efforts in an effort to acquire much needed baseline data on bat species composition, relative abundance, and habitat needs so that the Park will be ready to adequately address the needs of bats in future planning efforts, especially in response to the possible arrival of WNS into the Rocky Mountain west.

Population Genetic Structure of *Myotis septentrionalis* on Island and Mainland Areas of Atlantic Canada: a Proposal

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Defining the scale at which to manage a species of conservation concern is typically limited by our understanding of the degree of relatedness among groups or populations. Population structure is a function of the amount of gene flow between groups, as well as any underlying social structure influencing movement or reproduction (e.g., maternally-directed site fidelity). With this study we aim to characterize the population structure of northern long-eared bats (*Myotis septentrionalis*) across their range in Atlantic Canada, including mainland and island areas. We hypothesize that oceanic straits act as barriers to dispersal, limiting gene flow between mainland and island populations. We therefore predict to find low pairwise differentiation between mainland populations, and genetic isolation of island groups. Using a collection of tissue samples taken from over 800 individuals across Atlantic Canada, we will sequence approximately 300 bp of the HVII region of mtDNA and genotype samples at 11 nuclear microsatellite loci. These results will help us identify barriers to gene flow, reveal distinct populations for management priority, and determine the extent to which island populations may act as a refuge from the white-nose syndrome epidemic.

Variation in Fatality Risk to Mexican Free-tailed Bats versus Hoary Bats at Wind Energy Facilities

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Understanding bat activity patterns at wind facilities and determining correlates of fatality risk are important topics for the wind energy industry. Few detailed investigations have included free-tailed bats (Family Molossidae) in their analyses. During the fall of 2009 and 2010 at the Montezuma Hills Wind Energy Area in Central California, we conducted daily fatality searches to investigate the relationships between fatalities and environmental factors to understand mortality. We predicted that environmental factors would differentially affect fatality risks for the Mexican free-tailed bat and the hoary bat. Mexican free-tailed bats comprised 57% (n = 30) of total bat fatalities with multiple fatalities (2–4) observed on five of 78 nights. Poisson quasi-GLM modeling of unadjusted Mexican free-tailed bat fatality counts revealed positive relationships with wind speed. Contrary to previous studies for other species of bats, strong winds were associated with an increase in Mexican free-tailed bat fatalities, not a decrease in fatalities such as for hoary bats. The distance between foraging areas and potential roosts varies between the two species, which can account for the different responses to wind speed. As winds increase to speeds unfavorable to foraging success, hoary bats may find night roosting habitat in nearby trees whereas Mexican free-tailed bats, which usually roost much farther away, likely remain flying. Currently, wind turbines are sometimes shut down at low wind speeds (e.g., < 5 m/sec), which effectively reduces fatality rates for the hoary bat, but would not likely reduce fatalities for the Mexican free-tailed bat.

Stopover Behavior of Silver-haired Bats during Spring Migration

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Several temperate bat species undertake long-distance latitudinal migrations. Studies of migratory tree-roosting bats have increased in response to mortality at wind energy facilities during the fall migratory period, but much remains unknown about their ecology during the spring migratory period. In recent studies we found that fall-migrating silver-haired bats (*Lasionycteris noctivagans*) have brief 1–2 day stopovers, during which they do not appear to refuel and use torpor extensively in the non-active period to maintain nutrient stores for subsequent flight. We hypothesized that spring migrating bats use a similar migration strategy. We used radio-telemetry to quantify the stopover durations of 21 silver-haired bats captured between mid-April and late May at Long Point, Ontario, Canada. We measured fat stores using quantitative magnetic resonance. Similar to the pattern seen in the fall, 14 of the spring migrants departed the same evening they were captured, or the following evening if captured near dawn. Five bats had short stopovers ranging from three to six days, and two bats stopped over for two weeks. Bats that stopped over for several days had lower body fat percentages than those that resumed migration quickly. Multi-day stopovers were not associated with inclement weather and other individuals departed on these nights. Although most bats stopover briefly during their spring migration, some individuals appear to require longer refueling periods. Understanding the requirements of migratory tree bats during their spring migration is important for the conservation of these species as carry-over effects (i.e., energy reserves) have the potential to impact female reproductive success.

Bats of the Bars of Alaska

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Small insectivorous bats that spend summers at very high latitudes experience a suite of bioenergetic constraints including cool nighttime temperatures, long daylight periods that limit foraging, and a short summer. Thus, they are likely to display feeding and foraging patterns unlike those of congeners and conspecifics at lower latitudes. We evaluated the feeding patterns of small myotine bats roosting in buildings (mostly bars) in and around Wrangell-St. Elias National Park, Alaska (~62-63°N) during mid-summer 2012. During the sampling period, which included summer solstice, there was no true darkness and twilight lasted for approximately 2-3 hrs. We captured bats exiting buildings and held them to collect feces; diet was later determined through standard analytical techniques. We also collected free-flying insects, including mosquitoes, to analyze energetic content of the prey available to bats. Finally, we used ultrasonic detectors to determine activity patterns over a period of approximately three weeks. Nightly foraging bouts were confined to the twilight hours, but bats gained several grams during that period.

Differences in Data Acquisition with Paired Wildlife Acoustic SM2bat+ and Anabat SD2 Bat Detectors in Field Settings

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Manufacturers of acoustic bat detectors use proprietary microphones, each with different sensitivities, frequency responses, and directionality. Accordingly, it is likely that these microphones will have dissimilar data acquisition abilities. To test this hypothesis, Wildlife Acoustic SM2bat+ (SM2) and Titley Scientific Anabat SD2 (SD2) bat detectors were paired and deployed at 35 randomly selected points for 68 detector nights. Selected points encompassed wetlands, deciduous forests, pasture lands, and riparian corridors near Camby, Indiana. The SD2 microphones were weather-proofed with 45 degree-angle PVC housings. The SM2 microphones were weather-proofed with their stock foam coverings. Time between calls and maximum file duration parameters were adjusted making SM2 and SD2 zero-crossing data comparable. Files were identified to phonic group (low, midrange, and *Myotis*) using Bat Call ID automated software with ≥ 90% confidence level. Negative binomial count regression analyses for each phonic group demonstrated that SM2s and SD2s record significantly different file and pulse counts ($p < 0.022$). The SD2 recorded more low ($\bar{x} = 19.5 \pm 4.1$) and midrange ($\bar{x} = 15.5 \pm 3.9$) files per night than the SM2 (low: $\bar{x} = 10.6 \pm 3.5$, midrange: $\bar{x} = 6.2 \pm 1.5$). The SM2 recorded more *Myotis* ($\bar{x} = 2.4 \pm 0.5$) files per night than the SD2 ($\bar{x} = 1.1 \pm 0.2$). The results suggest that not all bat detectors are created equal. Weather-proofing may limit the ability of the SD2 to record *Myotis* bats. Microphone directionality may also be responsible for file and pulse counts differences. Consequently, variability between detector brands complicates comparisons across research studies.

Sociality, Density-Dependence, and Microclimates Determine the Persistence of Populations Suffering from a Novel Fungal Disease, White-nose Syndrome

Marm Kilpatrick, Kate Langwig, Jason Bried, Alan Hicks, Thomas Kunz, and Winifred Frick; University of California, Santa Cruz, CA; Boston, University, Boston, MA; Oklahoma State University, Stillwater, OK; New York State Department of Environmental Conservation, Albany, NY

Disease has caused striking declines in wildlife and threatens numerous species with extinction. Theory suggests that the ecology and density-dependence of transmission dynamics can determine the probability of disease-caused extinction, but few empirical studies have simultaneously examined multiple factors influencing disease impact. We show, in hibernating bats infected with *Geomyces destructans*, that impacts of disease on solitary species were lower in smaller populations, whereas in socially gregarious species declines were equally severe in populations spanning four orders of magnitude. However, as these gregarious species declined, we observed decreases in social group size that reduced the likelihood of extinction. In addition, disease impacts in these species increased with humidity and temperature such that the coldest and driest roosts provided initial refuge from disease. These results expand our theoretical framework and provide an empirical basis for determining which host species are likely to be driven extinct while management action is still possible.

The Role of Extreme Bandwidths in Frequency-modulated Echolocation Calls: a Tribute to Björn Siemers
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Bats that use echolocation to hunt for insects in densely-vegetated, or narrow-space, habitats face two major acoustic challenges. Not only do they need to minimize forward masking (overlap of the outgoing call with the returning echoes) but they must also distinguish prey echoes that may be embedded within a complex of echoes returning from the surrounding clutter (backward masking). Nonetheless, insectivorous bats of the rainforests of Southeast Asia have clearly overcome these challenges, as species of Hipposideridae, Rhinolophidae, Kerivoulinae, and Murininae can comprise ensembles of over 20 species. While the Rhinolophidae and Hipposideridae use CF calls to convey the distinct echo signature of fluttering insect wings, and separate pulse and echo in the frequency domain, the Kerivoulinae and Murininae use high frequency (max. 230 kHz), short duration, low intensity FM calls of extreme bandwidth (> 90 kHz). Here we trace the progression of our understanding of the role of these extreme FM sweeps, from first descriptions and characterizations through determination of the relationship between bandwidth and prey detection performance in European *Myotis*, and recent testing of this relationship in Malaysian *Kerivoula* and *Murina.* Björn Siemers played the central role in this story, and this paper is dedicated to his memory.

Rapid Ecological Assessments: Just How Rapidly Can They Identify Important Bat Habitats?
Susan Koenig, Windsor Research Centre, Trelawny, Jamaica

Rapid ecological assessments, such as those deployed in environmental impact assessments (EIAs), are thought to give a snapshot of species diversity in a localized area. However, for mobile species such as bats, it is recognized that temporal variation in food availability leads to significant seasonal shifts in spatial occupancy. In Jamaica, although EIA terms-of-reference (ToR) require a "detailed description of flora and fauna" and "an assessment of the ecological health and functions of the ecosystem," a comprehensive review of EIAs revealed that none fulfilled their ToR: not a single EIA included bat surveys, including the EIA for a 23-turbine wind farm located within 15 km of three roosting caves. In 2012 Government issued EIA-ToR for a proposed new wind farm, but it was unable to define the minimum survey requirements for bats. Since May 2011, I have conducted bi-weekly acoustic surveys using passive bat detectors to better understand habitat associations, nocturnal activity patterns, and seasonal variation in site use for a 13-species bat community in northern Cockpit Country. Within monthly recording sessions, species composition and relative abundances differ significantly amongst land-use categories defined by plant diversity and physiognomy. Corresponding to wet and dry season rainfall patterns, species' relative abundances and activity (e.g., detection of hunting buzzes) differ significantly within each land-use category. With two peaks in annual rainfall (October and May) and a prolonged dry season (January–March), survey results suggest that quarterly surveys for a minimum of one year are needed for a *rapid* assessment of Jamaican bat habitats.

A Genetic Method to Determine the Sex of *Lasiurus* Bat Carcasses Found at Wind Farms
Jennifer Korstian, Amanda Hale, Victoria Bennett and Dean Williams, Texas Christian University, Fort Worth, TX

Large numbers of migratory tree bats are being killed at wind facilities worldwide, and yet we know very little about the factors contributing to bat-turbine collisions. If we are to implement effective mitigation and minimization strategies, we need to understand which individuals (species, sex, age, etc.) are most vulnerable and why. Data collected from fatality searches can be used to test hypotheses about why bats are coming into contact with wind turbines; however, all too often carcasses are found scavenged and/or decayed making sex identification, in particular, difficult if not impossible. Since April 2009, we have collected more than 900 bat carcasses and DNA samples during fatality searches at a wind farm in north-central Texas. The majority of carcasses were *Lasiurus borealis* and *L. cinereus* bats, and in the field we identified the sex of approximately 50% of them. To acquire usable sex data from carcasses that would otherwise have been excluded from our analyses, we developed *Lasiurus* sex-specific genetic markers by modifying a marker that amplifies an intron in the zinc finger (*zf*) genes located on the X (*zfx*) and Y (*zfy*) chromosomes of mammals. These new markers successfully identified the sex of 15 known pregnant females and 15 breeding males. We will present results on the sex of all carcasses previously categorized as unknown. The application of these primer pairs will greatly improve the amount of data available to us and thus enhance our ability to test hypotheses about bat collisions with wind turbines.

Post-construction Mortality Monitoring: Study Design and Analysis Focused on Bats
Karl Kosciuch and Laura Nagy, Tetra Tech, Portland, Or

Bat fatalities have been documented at wind energy projects, and adaptive management triggers for bats are often based on the upper end of the confidence internal of these estimates. Thus, obtaining precise bat fatality estimates are important because of the implications regarding adaptive management of wind projects and for evaluating the effectiveness of mitigation. The challenge of post-construction mortality monitoring is finding the balance between costs/level of effort and the level of precision required. This challenge can be met by examining aspects of a fatality monitoring study can be controlled such as plot size, transect spacing, search interval, proportion of turbines sampled, and number of detection bias trial carcasses, and the recommendations for study designs can vary widely. We show that closely matching search interval to carcass persistence time and increasing the number of detection bias trial carcasses can reduce the variability in the fatality estimate. However, the spatial distribution of fatalities can have large effects on the variability of the estimate, but not necessarily on the estimate itself. Thus, fatality monitoring studies for bats can be designed to balance effort and precision, and can be optimized depending on the study objectives and the implications of the results.

The Moveable Feast: Linking Bat and Insect Migration
Jennifer Krauel and Gary McCracken, University of Tennessee, Knoxville, TN

Seasonal migrations of insects represent a moveable feast for insectivorous bats, some of which also migrate in turn. Northward spring migration of insects in North America, especially involving agricultural pests, has been relatively well studied because of the insects' agronomic importance, but less attention has been paid to the return migration of insects from high-production temperate areas in the fall. Migratory noctuid moths, in particular, make up a significant proportion of the diet of Brazilian free-tailed bats (*Tadarida brasiliensis*) in summer. These bats likely take advantage of the fall migration of noctuids, which may provide an important source of energy when the free-tailed bat population in the central United States is preparing to migrate to Mexico for winter. However, the implications of the fall insect migration for bat populations are unknown. We monitored fluctuations in common noctuid moth populations and changes in free-tailed bat body condition and behavior during three fall migration seasons, 2010-2012, near Uvalde, Uvalde County, Texas. Fluctuations in migrant moth populations were significantly related to cold front weather patterns, though responses varied among species. Both male and female bat mass increased over the course of the fall season, and that increase was greater directly after cold front passage than at other times. Foraging durations of bats decreased significantly in response to cold front passage. Our results indicate that bats use migrating insects to fuel their own seasonal migration.

Does Honeysuckle Invasion in Forests Affect Insect Availability and Bat Foraging Activity?
Vona Kuczynska, Kirk Barnett, and Robert Marquis, University of Missouri, Saint Louis, MO

Amur honeysuckle *(Lonicera maackii*) is an invasive understory shrub that displaces native vegetation and drastically alters forest structure in the eastern United States. Few studies investigate its effects on other trophic levels. Previous *L. maackii* research supports the Enemy-Release hypothesis, which states that generalist herbivores are not adapted to eating non-native plants, which experience little herbivory. Past studies also reveal that herbivorous insect richness and abundance is related to plant phylogenetic diversity. We seek to answer: 1) Do insect assemblages differ between native and *L. maackii* invaded forests? 2) If so, does the presence of *L. maackii* affect insects that are prey to bats? 3) How do bat species respond to varying levels of insect biomass and richness based on preferred prey availability? We are currently collecting preliminary data using Composite Insect Traps, passive acoustic surveys, and vegetation characterizations. Because *L. maackii* supports few herbivores and displaces native vegetation, we predict that invaded forests will have less insect biomass and biodiversity throughout the year, with the exception of times when *L. maackii* is in flower and likely attracts moths and other nocturnal pollinators. Therefore, we also predict that invaded forests will have less bat foraging activity than native forests (except when *L. maackii* is in flower). Plans for future work and this season's data will be presented.

Hibernating Bats in Michigan
Allen Kurta, Eastern Michigan University, Ypsilanti, MI

Michigan is one of the last great bastions of little brown bats (*Myotis lucifugus*) and northern bats (*Myotis septentrionalis*) on the continent that remains free of white-nose syndrome, due to the isolation of the hibernacula from major areas of karst and barriers provided by the Great Lakes. Since 1978, I have visited 179 potential hibernacula within the state, including caves, mines, and other manmade structures, and most sites have been examined or re-examined since 2005. The Lower Peninsula is geologically unsuitable for underground hibernators, although one significant colony (16,000–20,000 bats) occupies a hydroelectric dam. Most hibernacula are abandoned copper and iron mines in rugged areas of the western Upper Peninsula, where populations of up to 55,000 animals occur; number of bats in a mine is moderately correlated with length of passage and maximum ambient temperature. Total number of hibernating bats in the state is 267,000, although many hibernacula likely remain undiscovered. Knowledge of where and under what environmental conditions bats hibernate will provide resource agencies the opportunity to protect sites that seem desired by the bats and that may be less conducive to the growth of *Geomyces destructans*.

Bats of the U.S. Virgin Islands: Survey Results and Conservation and Management Plan
Gary Kwiecinski, Jean-Pierre Bacle, and Kevel Lindsay, University of Scranton, Scranton, PA; Island Resources Foundation, Washington, DC

The United States Virgin Islands (USVI), a territory of the United States purchased from Denmark in 1916, consists of three major islands with more than 50 offshore cays and minor islands. The USVI is part of an archipelago (Puerto Rican Bank) that includes the nearby Spanish and British Virgin Islands, except St. Croix, which has a unique geological origin and position amongst all the other Virgin Islands. During 2003 to 2011, mist-net surveys at 96 localities confirmed five species on St. Thomas, six species on St. John, and four species plus one new species for St. Croix. Of 2,542 bat captures, *Artibeus jamaicensis* represented 73.9%, *Molossus molossus* 11.1%, *Brachyphylla cavernarum* 9.8%, *Noctilio leporinus* 4.5%, *Stenoderma rufum* 0.6%, and *Tadarida brasiliensis* 0.1%. Three of these species are listed (*S. rufum, B. cavernarum,* and *N. leporinus*) as locally threatened and/or endangered (USVI Department of Planning and Natural Resources, Division of Fish and Wildlife, 2005). Roost surveys found artificial roosts and trees utilized most commonly. Karst/solution caves do not exist and the few crevice/fault caves found did not house nearly the number of bats found in abandoned buildings. Conservation and management issues include six key areas for action: roost sites (protection and development), habitats (interagency cooperation, protection, reforestation, enhancement), food (enrichment plantings), fresh water (protection, restoration, pollution control, infrastructural engineering), research and monitoring (establish protocols, training, reviews), and education and awareness (displays, kiosks, websites, outreach).

Seasonal Transmission of *Geomyces destructans*
Kate Langwig, Winifred Frick, Kevin Drees, Jeff Foster, Thomas Kunz, and Marm Kilpatrick; University of California Santa Cruz, Santa Cruz, CA; Northern Arizona University, Flagstaff, AZ; Boston University, Boston, MA

Understanding seasonal changes in *Geomyces destructans* transmission on multiple host species will allow for targeted disease management that may reduce the consequences of white-nose syndrome (WNS) on bat populations. Faster spatial spread of the pathogen will be observed if transmission occurs during fall swarm; however, this period may be the more tenable than winter to reduce disturbance of potential treatment strategies. If transmission and spatial spread occur only during the winter, it may be possible to seal uninfected sites once most bats have entered hibernation, thus preventing pathogen invasion to new hibernacula. We investigated seasonal transmission of the etiological agent of WNS, *G. destructans*. Swabs from exposed wing and muzzle tissue of bats were collected and analyzed using real-time quantitative PCR. We found strong evidence of intense transmission during the winter, and by late winter nearly all bats were infected. In contrast, there is no evidence of transmission occurring during fall swarm; in fact, no *G. destructans* was detected on any bat during this period. In summer, a small fraction of bats entered maternity colonies infected, but infections were cleared by late summer, and no juveniles were detected with infections. This suggests that protecting unaffected hibernacula against migrant infected bats during the winter may offer hope as a possible management strategy in reducing spatial spread of white-nose syndrome.

Development of a North American Bat Population Monitoring and Modeling Program
Susan Loeb, Jeremy Coleman, Laura Ellison, Paul Cryan, Cris Hein, Tom Rodhouse, Tom Ingersoll, and Rebecca Ewing; USDA Forest Service Southern Research Station, Clemson, SC; U.S. Fish and Wildlife Service, Hadley, MA; USGS Fort Collins Science Center, Fort Collins, CO; Bat Conservation International, Austin, TX; National Park Service, Bend, OR; National Institute of Mathematical and Biological Synthesis, Knoxville, TN; USDA Forest Service, Milwaukee, WI

Despite the importance of bats and the numerous threats facing their populations (white-nose syndrome—WNS, climate change, wind energy development, and habitat loss and fragmentation), there are no national or international programs to monitor their populations in North America. A statistically rigorous and nationally coordinated bat monitoring program is critical for determining the impacts of the many stressors on bat populations, as well as for evaluating the efficacy of management actions. Developing such a program was identified as a high priority in the National WNS Conservation and Recovery Working Group (CRWG) Implementation Plan. In April 2012, the CRWG convened a workshop on bat population monitoring and modeling attended by 26 participants from the United States, Canada, and United Kingdom. Recommendations were developed for conducting colony counts, collecting vital rates, conducting acoustic and mist-net monitoring, modeling spatial and temporal distributions, data management, and an overall sampling framework. Workshop participants also made four major recommendations: 1) a successful North American bat monitoring and modeling program will require centralized coordination; 2) there is strong need for coordination between site based monitoring programs and the continental program; 3) continuous monetary commitments from State, Federal, Provincial, and Tribal agencies is necessary to ensure consistent long-term data collection; and 4) a core group of statisticians and biologists should be convened for a series of workshops to design a general sampling frame for bat monitoring that can be scaled down for site-based monitoring. Workshops to develop the sampling frame are currently being planned and will be discussed.

Parasites Affecting Bats (Microchiroptera) on St. Kitts, Lesser Antilles
Amanda Loftis, Jason Beck, and Will Reeves,
Ross University, Basseterre, St. Kitts and Nevis; Idaho Department of Fish and Game, Pocatello, ID; Wright-Patterson Air Force Base, Dayton, OH

Bats are the only native mammals remaining on the island of St. Kitts, in the Eastern Caribbean. Previous work documented seven bat species on the island, predominantly species unique to the Lesser Antilles. The presence or impact of diseases on bat populations in this region is unknown. Mist nets were used to capture bats on St. Kitts between November 2010 and September 2011. Bats were identified to life stage and species; weight and forearm and tibia length were recorded; ectoparasites were collected; blood was sampled from representatives of each species; and bats were released. Blood films were examined for visible parasites and DNA was extracted; the cytochrome *b* oxidase gene sequence was used to confirm bat species identity. *Artibeus jamaicensis* were most frequently captured (n = 127) and were parasitized by two species of streblid bat flies (*Trichobius intermedius*, 39% and *Megistopoda aranea*, 35%), by *Periglishrus* mites (70%), and by microfilarial nematodes (11%, 10/59). No parasites were detected from *Molossus molossus* (n = 99). *Ardops nichollsi* (n = 57) were parasitized only by *Periglishrus* (79%). *Brachyphylla cavernarum* (n = 35) were parasitized by two species of streblid bat flies, *Trichobius frequens* (86%) and a new species *Nycterophilia* n. sp. (9%), and by *Periglishrus* (11%). Three species previously reported from St. Kitts were not captured, including *Noctilio leporinus*, which was last reported in 1934. Ectoparasites were frequently seen on the phyllostomid bats, especially those that roost in large colonies. These blood-feeding parasites can also transmit other pathogens, such as microfilaria, affecting bat health both directly and indirectly.

A Comparison of Bats and Rodents as Hosts of Zoonotic Viruses: Are Bats Special?
Angela Luis, Colorado State University, Fort Collins, CO and Fogarty International Center, National Institutes of Health, Bethesda, MD

Bats are now known to be the natural reservoirs of a number of high impact zoonotic viruses, such as SARS coronavirus, Ebola and Marburg filoviruses, Hendra virus, and Nipah virus. There has been consequent speculation that bats may be unique in their potential to harbor zoonotic viruses, yet there are no published quantitative comparative analyses to support these claims. Here, we compare bats (Order Chiroptera) and rodents (Order Rodentia) as reservoirs of zoonotic viruses using statistical and network analyses of published reports and show that bats do, indeed, host a greater number of zoonotic viruses per species than rodents. This leads us to ask,

why are bats special? We show that viruses may pass more easily between sympatric bat species than sympatric rodent species. Using a network approach, we detect distinct communities of bats and identify species and host traits that may be particularly important in spreading viruses between communities. Gaining understanding of actual mechanisms of such pathogen transfer should be an active area of research in order to develop evidence-based policies to minimize risks, while conserving bats and the irreplaceable ecosystem services they provide across a vast range of regions and habitats.

A Comparison of DNA Yields from Different Tissue Types and Storage Media

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Preserved tissues provide a wealth of genetic information that can be revisited by researchers, but the quality of the DNA in preserved tissue is affected by the method and conditions under which it is preserved. Because sampling location climate and logistics, tissue preservation methods are often limited. Although tissue and storage media type may impact the extent to which DNA degrades, the relative efficacy of commonly used storage media has never been directly tested. We analyzed differences in DNA yield for wing tissue preserved in three media: ethanol, dimethyl sulfoxide (DMSO), and silica gel desiccant. DNA extraction yield was also compared for different types of non-lethally sampled tissues: buccal swabs and wing punches. We found that wing tissues preserved in silica gel yield significantly more total DNA (μg/μL) than in DMSO ($p = 0.032$) or ethanol ($p = 0.029$), and wing punches yield more total DNA than buccal swabs ($p = 3.332 \times 10^{-7}$). Additionally, qPCR was used to determine which tissue type and preservation methods yielded the highest quality bat DNA. These results demonstrate that choices in sampled tissue and storage media type can have significant impacts on the quantity and quality of DNA obtained from genetic samples.

Torpor-assisted Migration in Bats

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In a recent study, we found that fall migrating silver-haired bats (*Lasionycteris noctivagans*) made only 1–2 day stopovers at a site where similar sized birds stayed for one week or longer. In migratory birds the cost of maintaining normothermic body temperature reduces the effective refueling rate, resulting in prolonged stopovers. We hypothesized that bats could use daily torpor to minimize energy expenditure, which may allow them to forego extended stopovers as required by birds. We conducted a follow-up study with silver-haired bats captured during autumn migration at Long Point, Ontario, Canada. We used temperature sensitive radio-telemetry to monitor torpor patterns in free-living bats. We also held bats in respirometry at a range of local daytime temperatures to estimate metabolic rates of the free-living bats. All bats used torpor, regardless of age or sex. When accounting for energy savings from torpor (including cooling and arousal costs), bats saved 12–90% of the energy requirement compared to maintaining euthermia. Bats spent more time in torpor on cooler days, but the total daytime energy expenditure was independent of ambient temperature. On cooler days, the energy saved would provide enough energy to fly an additional 24–90 km per night. Thus bats are able to use a torpor-assisted migration strategy to minimize energetic costs during non-flight periods, and maintain a predictable daily energy expenditure independent of ambient temperature. Consequently the need for refueling is reduced and migrating bats are able to minimize time spent migrating independent of energy minimization trade-offs.

The Recovery of a Threatened Species: the Lesser Long-nosed Bat

Rodrigo Medellin, A. de la Torre, R. Galicia, A. Ibarra, M. Rivero, L. Torres, and C. Vargas, UNAM

Delisting species should be the final goal of conservation professionals working on endangered species. Unfortunately, too often species enter endangered species lists only to remain there. The lesser long-nosed bat, *Leptonycteris yerbabuenae*, has been listed as threatened in Mexico and as endangered in the United States Endangered Species Act for at least 20 years. Mexico contains at least 80% of the species distributional range. The Program for Conservation of Mexican Bats decided to work on its recovery in 1993 through a three-pronged strategy including research, education, and conservation actions. At least 13 roosts have been monitored over the past 19 years. All roosts have shown stability or growth in their numbers and in addition we have found two new roosts. These caves did not have a *L. yerbabuenae* colony until 2009, so evidently the species is not only stable

but also increasing its populations. We have also been researching its ecology and links to the ecosystem, working with decision makers to increase their protection, and understanding its short- and long-distance movements. In May 2012 we demonstrated movements of at least 50 km from the largest maternity colony to the feeding grounds. Also, the first observations on mother-pup interactions have been conducted. All this information has led to submitting a proposal to the Mexican federal government to delist the species from its Endangered Species List and finally the species will be delisted in the next iteration of the Mexican List.

***Reproduction in Big Brown Bats: Fitness in a Post White-nose World**
Melissa Meierhofer, Madeline Pucciarello, Calvin Butchkoski, Gregory Turner, and DeeAnn Reeder, Bucknell University, Lewisburg, PA; Pennsylvania Game Commission, Harrisburg, PA
*** Melissa Meierhofer** received the **Organization for Bat Conservation Award**.

White-nose syndrome (WNS) has devastated bat populations since 2007, but not all species are equally affected. For example, big brown bats (*Eptesicus fuscus*) have experienced relatively low mortality rates compared to other species. However, infection with the fungal causative agent (*Geomyces destructans*), even in bats that have presumably survived WNS will have a lower fitness than documented for this species prior to the onset of WNS. To test this hypothesis, we captured big brown bats between May and July 2012 within a 100-mile radius of Bucknell University (where a number of maternity colonies were known). Bats were captured using harp traps, or by hand. Standard measurements, including reproductive status and wing-score (Reichard scale) were recorded for each animal. Historic data from the same region from 1986 to 2008 were compared to data from 2012. Of the 618 adult females captured in years prior, 84.56% were pregnant, lactating, or post-lactating whereas of the 42 adult females captured, 76.19% showed evidence of reproducing this year. There was further evidence of reproductive success in that 62.91%, or 95 of 151 total captures this year were juveniles, and of those individuals, average wing score was 1.21. These data indicate, at least in this region, big brown bats are successfully breeding and rearing pups, perhaps at a slightly reduced rate.

Heritability of Survival Traits in Big Brown Bats
Allyson Menzies, Chelsey Musante, Jeff Lane, DeeAnn Reeder, and Craig Willis; University of Winnipeg, Winnipeg, MB; Bucknell University, Lewisburg, PA; University of Alberta, Edmonton, AB

Consistent individual differences exist within species for a range of physiological and behavioral traits. This variation can lead to differences in survival and fitness and, if it has a strong genetic component, it is potentially subject to natural selection. However, only a few studies have addressed heritability of ecological traits in wild populations of mammals. Addressing heritability of survival traits in bats has important applied significance in light of the emergence of white-nose syndrome (WNS). To date, it is not known what differs between individuals that are "resistant" or "vulnerable" to WNS, but it is possible that individuals differ in energetic and behavioral strategies that affect WNS status. If these differences have a strong genetic component, traits that increase survival from WNS may be susceptible to natural selection. Our objective is to quantify the heritability of potential 'survival traits,' related to physiology, energetics and behavior, in big brown bats (*Eptesicus fuscus*). Using molecular markers and information about known parent-offspring relationships, we have begun to build a pedigree for a captive colony of bats. Once the pedigree is complete we will use a recently developed pedigree analysis to make inferences about the genetic basis of trait variance and predict the potential strength of selection on each trait. If heritable survival phenotypes exist, natural selection for "resistant" individuals may be the only reliable hope that affected populations can recover from current population declines. Thus, it is urgent that we understand more about heritability of physiological and behavioral traits of bats.

Evidence for Competitive and Predator Release Responses in Bat and Aquatic Communities in Two Connecticut Rivers
Kate E. Miller and Barry Chernoff, Wesleyan University, Middletown, CT

Bat, benthic macroinvertebrate (BMI), and fish communities were monitored at eight sites on two rivers from 2008 through 2011. The goals of this study were to: 1) document changes to the bat communities caused by white-nose syndrome (WNS); 2) look for evidence of competitive release given species-specific differences in disease mortality rates; and 3) look for evidence of prey community response. This last goal was in response to a previous study documenting significant associations between WNS vulnerable species and Diptera and Trichoptera. Results included total reductions in activity of 95.2% for *Myotis* spp. and 81.9% for *Perimyotis*

subflavus, and increases to activity levels of *Eptesicus fuscus* and *Lasiurus borealis* of more than 300%, with site-specific patterns of change to activity levels and community composition even when sites were close to each other. At sites with the most *Myotis* and/or *P. subflavus* activity in 2008, BMI abundances increased after bat activity declined (ANOVA $p < 0.05$). There was a weak but significant correlation between inter-annual change in total bat calls and abundance of Hydropsychidae (Spearman's rank correlation $p < 0.05$, $r = .31$). There was a significant trend for increases to fish abundance at the two sites with the highest *Myotis/P. subflavus* bat call activity in 2008 ($p < 0.05$, $r^2 = .56$ and .69). Environmental conditions including organic matter, discharge, and water temperature and chemistry explain some, but not all, of these increases. Results provide evidence for a competitive release response by *E. fuscus*, and suggest a potential predator release response by BMI and their fish predators.

Acoustic Behavior at Roosts of Two Distantly Related Disc-winged Bats
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Examining links between ecological specialization and specific behavioral strategies is valuable for understanding how species adapt to using highly ephemeral resources. Here, we study roost monitoring behavior of two distantly related disc-winged bats, the Neotropical *Thyroptera tricolor* and the Paleotropical *Myzopoda aurita.* Despite disparate distributions and large phylogenetic distance, both species have developed similar, highly specialized morphological adaptations that enable individuals to roost inside furled leaves. Use of such a specialized roosting resource presents major challenges, as leaves rapidly unfurl, forcing bats to locate new roosts every few days. The convergent roosting ecology and morphology of disc-winged bats provides an opportunity to examine if similar behavioral strategies have evolved for coping with the use of such highly ephemeral roosting resource. For this purpose we recorded night activity at known roosts and available leaves with synchronized video and acoustic monitoring. Preliminary results indicate that both species evaluate the availability of a potentially suitable leaf throughout the night. Furthermore, we report the presence of social signaling when bats emerge and return to potential roosts. We suggest that the use of furled leaves as a roosting resource may be associated with the evolution of convergent behavioral strategies. By examining whether morphological specializations have evolved concordantly with a specialized behavioral mechanism, we can gain a better understanding of the adaptive significance of social behavior, and its relevance in the evolution of ecological specialization.

Between a Rock and a Hot Place: Thermal Behavior of Eastern Small-footed Bats
Paul Moosman, Molly Western, Micah Hosler, and Zackary Hann, Virginia Military Institute, Lexington, VA

Ecology of the eastern small-footed bat (*Myotis leibii*) is poorly understood. Recent studies indicate *M. leibii* primarily roosts in rock-outcrops, a behavior that is relatively unique among species of bats in eastern North America. We studied roosting and thermoregulatory behavior of 17 *M. leibii* in the Appalachian Mountains of New Hampshire and Virginia to better understand the link between habitat selection and thermoregulation, an aspect of the ecology of *M. leibii* that has not been described. Bats roosted in crevices between boulders on natural talus slopes and dams that provided talus-like habitat. Physical and thermal characteristics of roosts were similar among sites despite site-specific differences in climate and habitat features such as size and type of rocks available to bats. Roosts were significantly warmer than outside air temperatures, reaching an average maximum of 30.8 ± 4.7°C (± sd) and dropping to an average minimum of 17.2 ± 3.5°C, or 4.7 and 3.1°C above ambient, respectively. Body temperature of seven bats from Virginia was 33.7 ± 4.6°C during the warmest part of the day and 22.0 ± 3.8°C during the coldest, or 8.9–6.4°C above ambient, respectively. Roosts maintained significantly higher minimum temperatures, and were significantly larger and had narrower openings than random crevices. Results suggest rock formations provide roosts with particularly warm microclimates and *M. leibii* maintains torpid body temperatures that are correspondingly high. Thermal characteristics of crevices may be as important as their structural properties to habitat selection by *M. leibii*.

Mites of the Genus *Periglischrus* Associated with Glossophagini Bats.
Juan B. Morales-Malacara and Gabriela Castaño-Meneses, UNAM, Juriquilla, Querétaro, México

The genus *Periglischrus* has 24 species associated with phyllostomid bats in the Americas. After new morphological analysis, it was recognized some patterns with different clades or species groups that reflects its evolutionary trends. Each clade showed a close relationship with their bats hosts. In particular the *vargasi* and

caligus species groups have five nominated species and two undescribed species, all associated with Glossophagini bats. All *Periglischrus* parasites from Glossophagini bats were obtained from different mite collections, Bishop Museum, Ohio State University, Instituto de Biología, UNAM, and field surveys. We have studied these parasites from hosts of the genera *Anoura*, *Leptonycteris*, *Monophyllus*, *Glossophaga*, and *Choeronycteris*. After a detailed morphological analysis, which included outline of dorsal and sternal plates, foveae patterns, setal sizes, and some morphometric analyses for one of the species studied, we concluded that *Periglischrus* mites associated with Glossophagini bats have two different morphological patterns, and these reflect different evolutionary trends within Glossophagini bats. (Financial assistance was provided by DGAPA, UNAM, Grant IN226010 to JBMM.)

Changes in Relative Bat Activity over Four Years at the Dunnville Bat Monitoring Station, near Lake Erie, Ontario
Derek Morningstar, Golder Associates Limited, Cambridge, ON

Nightly acoustic monitoring using a Binary Acoustics Technology (BAT) AR125 was implemented from May through October of 2009, 2010, 2011, and 2012 to quantify relative bat activity near Dunnville, Ontario Canada. White-nose syndrome (WNS) was first confirmed in Ontario in 2010, and confirmed near this site in 2011. One wind farm has been commissioned locally in 2008, and additional wind farms are proposed for development in 2012 through 2014. Three bats observed at Dunnville Bat Monitoring Station have recently undergone a status re-assessment by the Committee for the Status of Wildlife in Canada. These three plus an additional species have been re-assessed by the Committee on the Status of Species at Risk in Ontario. Although Dunnville is outside the known range, some acoustic recordings resemble *Myotis sodalis*, and have been classified as such by three automated bat identification software packages. Although a decline was anticipated in overall bat activity because of WNS, an increase in overall bat activity was observed in 2010 followed by a decline in 2011 and 2012. Changes in relative bat activity for some species were also observed, but were not consistent across species. This information represents a multi-year study that will be continued in the future where relative activity as a surrogate of population changes will continue to be assessed.

Some Like it Hot—Evolution and Ecology of Novel Endosymbionts in Bat Flies of Cave-roosting Bats (Hippoboscoidea, Nycterophiliinae)
Solon Morse, Carl Dick, Bruce Patterson, and Katharina Dittmar, SUNY at Buffalo, Buffalo, NY; Western Kentucky University, Bowling Green, KY; Field Museum of Natural History, Chicago, IL

We investigated previously unknown associations between bacterial endosymbionts and bat flies of the subfamily Nycterophiliinae (Diptera, Streblidae). Molecular analyses revealed a novel clade of Gammaproteobacteria in *Nycterophilia* bat flies. This clade was not closely related to *Arsenophonus*-like microbes found in its sister genus *Phalconomus* and other bat flies. High population infection rates across a wide geographic area, the presence of the symbionts in pupae, the co-divergence between hosts and symbionts, and high AT composition bias in symbiont genes together suggest that this host-symbiont association is obligate in nature and ancient in origin. Likelihood-based ancestral character mapping revealed that initially, obligate symbionts exhibited association to host specific *Nycterophilia* bat flies that use a broad temperature range of cave environments for pupal development. As this mutualism evolved, the host temperature range narrowed to an exclusive hot cave use, followed by a secondary broadening of parasite host associations. These results suggest an influence of symbiosis on the environmental tolerance of parasite life history stages. The contingent change to expanded host use of *Nycterophilia* bat flies, upon narrowing the ecological niche of their developmental stages, furthermore suggests that environmental tolerance across life history stages may be a crucial factor in shaping parasite-host relationships.

Fur versus Feathers: Why Do Bat-flowers Produce So Much Pollen?
Nathan Muchhala and James Thomson, University of Nebraska, Lincoln, NE; University of Toronto, Toronto, ON

One floral characteristic associated with bat pollination (chiropterophily) is copious pollen production, a pattern we confirmed in a local comparison of hummingbird- and bat-adapted flowers from a cloud forest site in Ecuador. Previous authors have suggested that wasteful pollen transfer by bats accounted for the pattern. Here we propose and test a new hypothesis: bats select for increased pollen production because they can efficiently transfer larger amounts of pollen, which leads to a more linear male fitness gain curve for bat-pollinated plants. Flight cage experiments with artificial flowers and flowers of *Aphelandra acanthus* provide support for this hypothesis; in both instances, the amount of pollen delivered to stigmas by birds is not related to the amount of

pollen removed from anthers on the previous visit, while the same function for bats increases linearly. Thus, increased pollen production will be linearly related to increased male reproductive success for bat flowers, while for bird flowers, increased pollen production leads to rapidly diminishing fitness returns. We speculate that fur takes up and holds more pollen than feathers, which seem to readily shed excess grains. Our gain-curve hypothesis may also explain why evolutionary shifts from bird to bat pollination seem more common than shifts in the opposite direction.

Foraging Ecology of North Dakota Bats
Josiah Nelson and Erin Gillam, North Dakota State University, Fargo, ND

Many habitat studies of temperate North American bats have focused on characterizing roosts and landscape-level foraging habitat use, while fewer have investigated foraging habitat use at a fine scale. The purpose of this study is to investigate micro-level foraging habitat use in multiple vespertilionid species found in the various habitats of North Dakota. The methods developed incorporate two approaches. The first approach involves documenting bat activity at different sites using passive acoustic monitoring, and coupling these data to detailed measurements that characterize the recording conditions and immediate surrounding habitat (temperature, moon phase, insect activity, elevation, tree species/size, vegetation density, canopy cover, ground cover, distance to, type, and dimensions of water sources). The other approach is an experimental method to track bats during nightly foraging bouts and then map flight paths in the vicinity of different foraging sites. Preliminary data were collected from May to August of 2012. Initial results are being analyzed and we are currently working to improve telemetry and insect monitoring methods. The results from this study will ultimately supplement ongoing work to develop a conservation plan for bat habitat in North Dakota.

Thermal Ecology and Roosting Behavior in *Eptesicus fuscus*
Christopher Nicolay and Rebecca Hoffman, University of North Carolina Asheville, Asheville, NC

This study examined the roosting behavior and thermal ecology of a summer colony of *Eptesicus fuscus* roosting inside a house's north-facing gable attic vent. A screen had been placed over the entrance to the attic, effectively creating a two-dimensional vertical surface upon which the colony roosted. This enabled documentation of positional and clustering behaviors (Sony SR12 video camera). Temperatures were recorded with Vernier sensors placed at the top and bottom of the roost surface, and outside the roost. Data collection began in mid-July and is ongoing (n = 44 days reported). The maximum daily temperatures in the upper part of the roost ($\bar{x}$ = 43.4°C, range: 25.6–52.5) were significantly greater than in the lower part (32.8°C, 24.9–43.4), and were much higher than simultaneous temperatures outside (28.3°C, 23.8–32.4). The minimum temperatures in the roost (upper: 20.2°C, 11.5–24.3; lower: 18.8°C, 11.8–23.8) were closer to outside measurements (17.7°C, 10.9–23.0). Clustering of individuals and position in the roost were clearly influenced by inside temperature. At low temperatures, bats aggregated into a tight cluster at the higher (warmer) part of the roost. The high temperatures in the roost were potentially deleterious to the bats. As temperature increased, individuals spread further apart, moved toward the lower parts of the roost, and aligned along slats, which maximized exposure to outside air. These behaviors became evident when roost temperatures exceeded ~30°C, and were exaggerated with increasing temperature. These results demonstrate that individuals alter roosting behavior in response to heat stress.

Distribution and Conservation of Cave Bats in Mindanao, Philippines
Olga Nuñeza, Rosellynn Enguito, Yunalyn Labajo, and Amy Ponce, Mindanao State University-Iligan Institute of Technology, Iligan, Phillipines; Misamis University, Ozamiz City, Phillipines

The Philippine bat fauna is well documented and several species of bats are known to roost in caves. However, in Mindanao, the second largest island in the Philippines, cave bat fauna is poorly known. In this study, 37 caves in Mindanao were surveyed from April–July, 2010. Bats were captured by mist nets to document the bat species present, giving particular attention to endemic, threatened, and socioeconomically important species. Eighteen species were recorded of which five (28%) are endemic. Only 72% are known cave dwellers. Bigger caves were observed to be more species-rich. Bats were totally absent in the Bluewaters Cave, which is a tourist destination, implying that this cave is already severely disturbed. Two species were found to be socioeconomically important and locally threatened primarily due to bat hunting for food. Threats to the cave biodiversity include guano harvesting and treasure hunting, which could greatly disturb the bat fauna. Bat nurseries were found in the inner zones in two caves indicating the conservation importance of these caves. Results indicate

the need to protect the caves through strict policy implementation. The total number of bat species recorded could increase with the assessment of more caves in Mindanao.

Roosting Ecology of Indiana Bats in Forested and Fragmented Landscapes
Joy O'Keefe, Scott Bergeson, Kristina Hammond, Susan Loeb, Brianne Walters, Joey Weber, and John Whitaker, Indiana State University, Terre Haute, IN; USDA Forest Service, Southern Research Station, Clemson, SC

The federally endangered Indiana bat forms summer maternity colonies in a variety of forested environments across its range. Our goal was to compare Indiana bat roosting ecology in regions with varying degrees of forest cover. In summers 2002–2012, we conducted telemetry studies and assessed day roosts for female Indiana bats in three different regions. In the densely forested southern Appalachian Mountains, Indiana bats were more selective, roosting primarily in ephemeral pine snags with high solar exposure surrounded by closed canopy forests. In southern Illinois, an area with more moderate forest density, Indiana bats mainly used exposed oak and maple snags in closed-canopy bottomland hardwood forests. However, in a highly fragmented landscape in central Indiana, bats used a wide variety of roosts including exposed hardwood snags in riparian buffers, live trees in a mature woodlot, and bat boxes under dense canopy. In central Indiana, we observed intra- and inter-annual fidelity to roosts, but we rarely observed bats using roosts for > 1 week/season or > 1 season in the southern Appalachians or southern Illinois. In all regions, bats typically switched roosts every 1–3 days and distance between roosts mainly ranged from 1–4 km. Colony sizes were larger in the Midwest (maximum of ~170–260 bats), whereas smaller colonies were observed in the southern Appalachians. Roosting ecology varies with availability of roosting habitat; therefore, best management practices for Indiana bat habitat may also vary regionally. Understanding how roosting ecology varies with forest density is important for effective management of this species.

***First Records of Fossil Bats from the Dominican Republic**
Hannah O'Neill, Paúl Velazco, Gregg Gunnell, Renato Rimoli, Alfred Rosenberger, and Nancy Simmons; Brown University, Providence, RI; American Museum of Natural History, New York, NY; Duke University, Durham, NC; Museo del Hombre Dominicano, Santo Domingo, PR; Brooklyn College (CUNY), New York, NY
*** Hannah O'Neill** received the **Karl F. Koopman Award**.

Fieldwork conducted in 2011 in two underwater cave systems in the Dominican Republic has produced the first evidence of fossil bats from the eastern part of Hispaniola. Divers associated with the Museeo del Hombre Dominicano collected bat fossils at a locality known as Oleg's Bat Cave near Bavaro in the eastern Dominican Republic, and also in the El Dudu cave system in the northern part of the country. The bat fossils recovered, which are thought to be Late Pleistocene to Early Holocene in age, consist of isolated elements including skulls, jaws, and limb bones. Eleven bat species have been identified thus far including five mormoopids (*Mormoops blainvillii*, *M. magna*, *Pteronotus parnellii*, *P. quadridens*, and *P. macleayii*), five phyllostomids (*Brachyphylla nana*, *Erophylla bombifrons*, *Monophyllus redmani*, *Phyllonycteris poeyi*, and *Phyllops falcatus*), and one natalid (*Chilonatalus micropus*). All of these species still inhabit Hispaniola today with the exception of *M. magna*, an extinct species previously known only from Cuba, and *P. macleayii*, previously known only from Cuba and Jamaica (extant populations) and the Bahamas (Quaternary fossils). The discovery of these fossils in the eastern Dominican Republic represents significant range extensions for both species, and indicates that local extinction events have occurred over the past few thousand years, either in response to climate change or due to anthropogenic factors. In addition, our records from the Dominican Republic represent the first fossils of *P. parnellii* and *P. quadridens* from the island of Hispaniola, and the first ever record of *E. bombifrons* as a fossil.

Lipid Profiles of Bat Integument: a Comparison of Glycerolipid Contents among Species and Tissues
Evan Pannkuk, Nathan Fuller, David Gilmore, Brett Savary, and Thomas Risch; Arkansas State University, Jonesboro, AR; Boston University, Boston, MA; Arkansas Biosciences Institute, Jonesboro, AR

White-nose syndrome is a cutaneous fungal disease caused by *Geomyces destructans* that has devastated North American bat populations. To initiate infection, a fungal propagule must contact and recognize host tissue. Host lipids secreted from sebaceous glands may affect recognition for fungal pathogenicity. We hypothesize the ratio of free vs. esterified acyl lipids may play important roles in recognition of a suitable host and may vary among species. We extracted lipid from hair and wing tissue from different bat genera to compare relative amounts of free acyl lipids and glycerolipids. Thin-layer chromatography and gas chromatography/ion trap mass spectrometry (GC-MS) indicated major lipid classes correlating to cholesterol, squalene, free fatty acids (FFAs),

monoacylglycerides (MAGs), triacylglycerides (TAGs), sterol esters (SEs), and wax esters (WEs). TAG profiles determined by matrix-assisted laser-desorption/ionization time-of-flight mass spectrometry indicated sodiated TAG ions representing variable fatty acid moieties that ranged from *m/z* 633.52–911.81. Intense ion peaks at *m/z* 879.74, 881.76, 905.76, and 907.77 correlate with 18:1 and 16:0 being the dominant moieties of TAGs. Four species of MAGs were identified, with 18:0 MAG in highest amounts. Higher proportions of TAGs were present in hair tissue than wing tissue. FFAs determined by GC-MS including 10:0, 12:0, 14:0, 16:1, 18:0, 18:2, 18:3, and 20:4 were present in lower proportions. Thus, we have identified primary lipid constituents of bat species that may serve as targets for host recognition for *G. destructans* propagules. These data hold promise for future experimental growth studies that seek to elucidate fungal responses to specific lipids in culture.

Signatures of Genome-wide Convergent Molecular Evolution among Echolocating Bats
Joe Parker, Georgia Tsagkogeorga, James Cotton, Elia Stupka, and Stephen Rossiter, Queen Mary University of London, UK; San Raffaele Scientific Institute, Italy; Wellcome Trust Sanger Institute, UK

Recent studies have reported convergent sequence evolution in a small number of hearing genes in lineages of echolocating bats, and also in bats and echolocating cetaceans. Using a statistically robust phylogenetic method that models parallel substitutions in genetic data, we have screened for signatures of convergence across more than 2,000 orthologous genes in 6 bats and 30 other mammals. Early results indicate that echolocating Yinpterochiroptera and Yangochiroptera have undergone convergent sequence evolution in genes implicated in a range of functions, including hearing, vision, and metabolism. These early findings suggest adaptive sequence convergence is more prevalent in vertebrate genomes than previously recognized.

Maximum Weight Capacity of Leaves Used by Tent-roosting Bats: Implications for Social Structure
Phoebe Parker-Shames and Bernal Rodríguez-Herrera; Colorado College, Colorado Springs, CO; Universidad de Costa Rica, San José, Costa Rica; Reserva Biológica Tirimbina, Sarapiquí, Costa Rica

Less than 2% of bats have the capacity to modify their environment to construct roosts, such as those made by cutting and folding leaves to form structures called “tents.” Some tent-roosting bats specialize in certain species of plants. Unlike the caves or hollow trees used by some bats, leaves possess an upper limit on their capacity to support weight. We tested the hypothesis that the maximum weight capacity that leaves can support limits the maximum social group size of bats that roost in them. We conducted research in the Tirimbina Biological Reserve (TBR), Sarapiquí, Costa Rica, between March and April 2012. To test the hypothesis, we added weight incrementally to new leaves of three plant species until the angle of the leaves fell below that which bats naturally use. We determined that *Philodendron fragrantissimum* and *Heliconia imbricada* support more weight (44.0 ± 13.8 g and 42.2 ± 16.4 g) than *Asterogyne martiana* (33.3 ± 10.5 g). This study demonstrates that the maximum weight that the leaves can support is similar to the mean social group weight of *Dermanura watsoni* and *Ectophylla alba* reported in literature for these plant species and lower than their maximum reported bat social group weight. Therefore, it is possible that the maximum weight capacity of the leaves used to construct roosts limits the maximum social group size.

Winter Bat Activity Near Hibernacula Entrances and at Nearby Foraging Areas
Josh Parris, Janelle Bowcock, and Lynn Robbins, Missouri State University, Springfield, MO

Acoustic monitoring outside hibernacula as an early warning system for the arrival of white-nose syndrome provides an excellent opportunity to assess the winter activity of hibernating bat species. Few studies have addressed winter activity away from hibernacula entrances. We placed Anabat II acoustic detectors outside seven caves in Carter, Shannon, and Washington counties Missouri during the winters of 2010-2011 and 2011-2012. Year-round detectors have been in place at nearby foraging areas at two caves in Shannon County and a single cave in Washington County. Two of the foraging area detectors were within 500 meters of the cave entrance. We analyzed calls to species group using Bat Call Identification software (BCID). We calculated activity indices for each of the detector locations. The indices represent the number of minutes with bat activity during a defined period, standardized by the number of detector nights. Five of six caves monitored during both winters had higher activity indices during the winter of 2011-2012. All detectors documented bat activity throughout the winter, and five cave detectors and one foraging area detector documented > 20 minutes of bat activity per night across the entire winter. At two sites with both cave entrance and foraging area detectors, peaks of activity at the foraging areas corresponded to peaks of activity at the cave entrance. These patterns of activity suggest that winter bat activity is

influenced by severity of winter and may be normal activity for some species.

Phylogenetic Community Structure of North American Desert Bats
Lorelei Patrick and Richard Stevens, Louisiana State University, Baton Rouge, LA

Ecologists have long sought to understand how evolutionary and ecological processes interact to determine local community structure. Phylogeny of the species pool can be used to compare patterns of relatedness within real local communities to a null distribution of randomly generated communities, thereby providing mechanistic insight into structure. Local communities composed of species less related to each other than expected by chance (phylogenetically overdispersed) are assumed to be structured by competition, whereby closely related species sharing similar ecological traits are excluded during community assembly. Conversely, local communities possessing species more related to each other than expected by chance (phylogenetically clustered) are assumed to be structured by habitat filtering, because species with similar ecological traits are able to use available resources or persist in particular environments. We examine phylogenetic community structure of bats from the four great desert regions of North America, using several community delimitation methods at different spatial and taxonomic scales to infer what ecological processes may structure local communities. Species lists for local communities from each desert were compiled from fieldwork, MaNIS specimen records, and published reports. We have also inferred a phylogeny of all species in the regional pool. At the largest scales, communities are significantly phylogenetically clustered suggesting habitat filtering has been important in community assembly. At the level of individual deserts and smaller taxonomic scales, communities run the gamut from phylogenetically clustered to overdispersed, suggesting that different processes are important in each desert and at different scales.

Diversification of the Neotropical Yellow-shouldered bats (Phyllostomidae: Sturnirini)
Bruce Patterson and Paúl Velazco, Field Museum of Natural History, Chicago, IL; American Museum of Natural History, New York, NY

The yellow-shouldered bats are widespread, diverse, and abundant throughout the Neotropical Region, but little is known of their phylogeny and biogeography. We collected 4409 bp from three mitochondrial (cyt-*b*, ND2, D-loop) and two nuclear (RAG1, RAG2) sequences from 138 individuals representing all but two species of *Sturnira* and five other phyllostomids used as outgroups. Results overwhelmingly support the monophyly of *Sturnira* but not the subgenus *Corvira*; *bidens* and *nana* constitute separate, basal branches on the phylogeny. We recovered 21 monophyletic species, separated by an average 7.09% distance in cyt-*b*; three of these are apparently unnamed. Several clades are apparent, including a complex of seven species formerly confused with *S. lilium*. We used four well-documented phyllostomid fossils to construct a time-tree, using BEAST. *Sturnira* diverged from stem Stenodermatinae in the mid-Miocene, but most speciation events date to the Pliocene. Dispersal-Vicariance (DIVA) and Dispersal-Extinction-Cladogenesis (DEC) reconstructions of ancestral ranges agree in rooting the radiation of *Sturnira* in the Central Andes, and all three basal lineages (in order, *bidens, nana*, and *aratathomasi*) have strictly Andean distributions. Subsequently, *Sturnira* colonized and then radiated in Central America prior to the formation of the Panamanian landbridge. Both clades later recolonized South America, one colonizing the Antilles while the other recolonized the Andes. Consequently, elevational replacements in the Andes include both basal and highly derived members of *Sturnira*.

Thermal Characteristics of Leaf Litter During Winter and Expected Metabolic Rates of *Lasiurus borealis*
Roger W. Perry, U.S. Forest Service, Southern Research Station, Hot Springs, AR

During winter, several species of tree bats, especially red bats (*Lasiurus borealis*) and Seminole bats (*L. seminolus*) use leaf litter for roosting during colder periods of winter. However, information is needed on how these roosts affect energy expenditures of bats during winter. Thus, I initiated a study examining thermal properties under litter during winter in forests of the Ouachita Mountains, Arkansas. Temperatures were measured every 15 minutes under 2 cm, 5 cm, and 8 cm of leaf litter and compared to ambient temperatures on 14 plots over 7 nights. In addition, temperatures 2 cm below the soil surface were measured. Expected metabolic rates of red bats in torpor at these roost temperatures were estimated. Average temperatures below leaf litter remained above ambient during both day and night. At night, average temperatures differed significantly among litter depths, with deeper litter maintaining higher temps. During daytime, no difference in temperature existed among litter depths. Expected red bat metabolic rates based on temperature were lowest under 8 cm of litter and greatest in ambient air during

nighttime. Eventually, models of litter thermal characteristics incorporating litter depth, aspect, litter moisture, weather, and forest structural characteristics such as hardwood and pine basal areas will be created.

Does *Geomyces destructans* Infection Reduce Female Fertility in *Myotis lucifugus*?
Lisa Powers, Elizabeth Pritchard, Kristy Lau, and Bettina Francis, University of Illinois, Urbana-Champaign, IL

Bat populations are experiencing devastating population declines due to white-nose syndrome (WNS). Since rates of decline at most sites are estimated by annual counts, it is uncertain whether declines are due entirely to increased mortality, or if reduced fecundity also occurs. Researchers within the WNS zone have reported record low fecundity after the arrival of WNS, but WNS has yet to be directly linked to reproductive capacity. We conducted a histological examination of the reproductive organs of 12 female *Myotis lucifugus*, including 6 *Geomyces destructans* (Gd)-positive and 6 Gd-negative individuals. We hypothesized that Gd-positive females would be less likely than Gd-negative females to maintain a mature ovarian follicle and stored sperm. All individuals had mature follicles and stored sperm, except for one Gd-positive female that did not have a mature follicle. The difference was not statistically significant (p = 0.15, Chi-square test). However, previous research on hibernating *M. lucifugus* found a mature follicle in nearly 100% of females collected. If our results accurately portray reduced fertility (Gd+ fertility is approximately 83% of Gd-fertility), a larger sample size will be needed to demonstrate statistical significance on such a modest difference. Future studies include increasing sample size, and assessment of reproduction in post-hibernation females to determine whether Gd+ females with reduced fertility survive until spring.

***Characterizing Population Structure of *Myotis lucifugus* in the Eastern United States to Predict Geographic Spread of White-nose Syndrome**
Joy Collins Poythress, Aryn Wilder, Thomas Kunz, and Michael Sorenson, Boston University, Boston, MA
*** Joy Collins Poythress** received the **Avinet Award**.

The little brown bat (*Myotis lucifugus*) has suffered severe population declines as a result of white-nose syndrome (WNS). The phylogeography of affected species provides information on historical gene flow, aiding in the prediction of geographic spread of the disease. Our objective was to determine regional genetic structure and historic patterns of dispersal in little brown bats across the eastern United States and Canada. Bats were sequenced at roughly 536 base pairs of the maternally-inherited, mitochondrial cytochrome *b* locus. Sequence data were used to estimate diversity and population genetic structure. Distinct lineages within the complex of *M. lucifugus* are considered to characterize the so-called subspecies. All *M. lucifugus* from the eastern U.S. fell exclusively within the highly diverse *M. lucifugus lucifugus* lineage. Weak spatial clustering of sublineages was found in the southeastern U.S. Furthermore, weak spatial structure may exist across the Appalachians, as the dominant lineage appears to transition across this mountain range. However, the absence of distinct population boundaries indicates a high rate of gene flow consistent with the rapid spread of WNS in the eastern U.S. The presence of geographically distinct mitochondrial lineages in the western U.S. may indicate dispersal barriers that could slow the westward spread of WNS. If biparentally-inherited, nuclear genetic data support significant regional genetic structure, historical patterns of gene flow among bat populations may predict future dispersal routes of WNS. This knowledge is crucial when considering conservation of distinct populations and management of this declining bat species.

Is *Eptesicus fuscus* the Super Bat? Understanding Species Differences in the Response to White-nose Syndrome
DeeAnn Reeder, Marianne Moore, Gregory Turner, Morgan Furze, Paul Allegra, Sarah Brownlee, Chelsey Musante, Megan Vodzak, Matthew Biron, Melissa Meierhofer, and Kenneth Field; Bucknell University, Lewisburg, PA; Pennsylvania Game Commission, Harrisburg, PA

White-nose syndrome is caused by the fungal pathogen *Geomyces destructans* (Gd) but does not affect all species or all populations equally. For example, big brown bats (*Eptesicus fuscus*) have significantly lower mortality than little brown myotis (*Myotis lucifugus*). From a bat's perspective, surviving infection with Gd is presumably influenced by a number of factors, including within- and between-species variation in thermoregulatory traits, life history and behavioral traits, and immunological responsiveness. Although a number of traits likely favor big brown bat survival in the face of Gd infection (including their larger body size and their preference for hibernating for shorter periods, at colder temperatures, and solitarily or in smaller clusters), their ability to withstand Gd infection is not truly known. We conducted captive experimental Gd infections of little brown

myotis and big brown bats, measuring multiple aspects of immune function at 3, 7, and 13 weeks post-infection. Housed in identical conditions, big brown bats developed much lower levels of infection than little brown myotis. Immunological data, including analyses of bactericidal and fungicidal activity of the bat complement system, suggest that big brown bats are generally less immunosuppressed during hibernation than little brown myotis. Their specific immunological response to Gd infection is still under investigation, but we hypothesize that big brown bats are mounting a response to Gd that is absent in little brown myotis. Understanding how and why bats differ in their response to Gd will allow us to predict which species will be susceptible and to target mitigation strategies appropriately.

***Foraging Behavior of Female Little Brown Bats at Northern Latitudes in Canada**
Jesika Reimer, University of Calgary, Calgary, AB
*** Jesika Reimer** received the ***Bat Research News*** **Award**.

As latitude increases, summer season and summer night-length decrease. A combination of winter hibernation and summer nocturnality north of 60°N should hinder the ability of bats to gather adequate resources for reproduction and survival. I assessed how reduced summer season and night length influenced the foraging behavior of female *Myotis lucifugus*. I used echolocation recordings and radio-transmitters to address the following: 1) Does night length influence foraging duration? 2) Does foraging behavior differ between pregnant, lactating, and post-lactating females? 3) Do pregnant and non-reproductive females use night roosts? 4) What environmental factors affect foraging behavior? Duration of nightly activity for individuals varied between 98 to 201 minutes, increasing with increased night length. Duration of nightly foraging activity also increased with greater sky cover (clouds and forest-fire smoke). There was a significant effect of reproductive status on duration of night roosting. In June, pregnant females used a uni-modal feeding pattern, did not return to day roosts, and rarely used night roosts. Night roosting duration peaked in July, coinciding with lactation. I conclude that the environmental constraints of northern latitudes reduce the foraging time available to *Myotis lucifugus*, and that females have adapted to these constraints by employing a uni-modal feeding pattern during pregnancy and a shorter night-roost period during lactation compared to southern populations. Northern individuals may be able to increase foraging efficiency due to increased prey abundance.

Temporal and Spatial Patterns of Bat Activity at a Large-scale Wind Energy Facility
Scott Reynolds, St. Paul's School, Concord, NH; Boston University, Boston, MA; North East Ecological Services, Bow, NH

We investigated the bat activity at the Maple Ridge Wind facility (New York) to validate the monitoring protocol of the New York Department of Environmental Conservation. We used multiple met towers throughout the site to investigate the temporal (nightly and seasonal) and spatial (horizontal and vertical) distribution of bat activity across the project site. Almost 20,000 bat calls were recorded at the project site over the two-year sampling period. Data collected at the project site show that bat activity is highly variable in the vertical axis, suggesting it is more important to sample at multiple heights than it is to sample at multiple towers. The data also show strong seasonal variation in bat activity and evidence for the impact of white-nose syndrome on local bats. Regression tree analysis revealed that ambient temperature and wind speed were the two most predictive meteorological variables. We focused our analysis on the hoary bat, the species most frequently killed at wind sites, to determine the conditions most likely to increase migratory activity of this species. In addition to the long-term monitoring of bat activity using stationary platforms, we deployed a mobile aerial sampling platform (tethered blimp) at the project site. Due to the differences in bat activity seen at ground-based monitors, our data suggest more effort needs to be made to sample within the rotor swept area, and that blimps may be a viable alternative when met towers were not available or unpractical (e.g., off-shore wind).

Why a Maximum Air Temperature of 35.3ºC in Cueva Cucaracha, Puerto Rico is Good News
Ronald Richards, Universidad del Turabo, Gurabo, Puerto Rico

Cueva Cucaracha in Aguadilla has the largest bat population in Puerto Rico and the cave is heated by the body heat of the resident bats. In April 1983, it was estimated that the four species of bats had a combined population of 700,000. The maximum temperature of the cave was 35ºC. The bat population has not been

measured again. In June 2012 the air temperature at the entrance to the bat roost was 35.3ºC. The maximum air temperature in the cave has not changed in 29 years, which suggests a stable bat population. The air temperature and relative humidity were measured in 33 caves in Puerto Rico. At multiple locations in the first 200 m and on 4 days, the average air temperature at Cueva Cucaracha is 30.7ºC, which is the warmest in this dataset. The average relative humidity is 97.6%. The coldest cave is Cueva Tunel #1 in Utuado at 19.5ºC and 100% relative humidity. This cave is cooled by the Río Tanamá, which flows through it. The cave with the lowest relative humidity is Cueva Ventana in Arecibo at 81.4% and 24.4ºC. This cave has the lowest relative humidity because it is the best ventilated. The cave has an east-west orientation and the wind can be felt blowing through the cave. The average air temperature of the 33 caves is 24.4ºC and the distribution is normal. The average relative humidity is 93.1% but the distribution is not normal. The humid tail is cutoff by saturation. The Puerto Rico boa (*Epicrates inornatus*) is commonly found in hot caves and is a bat predator. White-nose syndrome is not expected to reach Puerto Rico because the caves are too hot and the bats do not hibernate.

How Good are Mathematical Algorithms and Statistical Probabilities in the Identification of Species Specific Call Sequences?

Lynn Robbins, Missouri State University, Springfield, MO

Species identification software is now being tested and used to determine species and species groups using echolocation data. The results of these identifications are being used to answer a number of important biological questions relating to species richness, habitat use, and presence or absence, especially of endangered or threatened species. For this presentation I will limit my discussion to the identification results based on zero-crossing analyses. The program written by C. R. Allen (BCID) provides a probability that the sequence represents the call characteristics of a species based on the percentage of pulses identified to the dominant species whereas the program written by E. R. Britzke (EchoClass 1.0) identifies sequences to species based on the majority being the rule for species identification. It also provides a probability that a specific species is present at a site. In either case, the identifications are based on the number or percentage of pulses within a sequence that have the necessary known call parameters to be considered a certain species. Studies have shown that there is a high level of variation within individual call sequences. This can lead to misidentifications when only a subset or a set number of pulses are needed to make an identification. Using results from the two programs, and any other program available before the meeting, I will use a new algorithm called a Teacher's T-test to help confirm the species identifications, but if not, to determine what species it is not.

Bat Activity across an Arid Landscape: Assessing Potential Impacts to Bats from Solar and Geothermal Energy Developments

Roger Rodriguez, Amanda Accamando, and Joe Vieira, Zotz Ecological Solutions, LLC, Denver, CO; Bureau of Land Management, Monte Vista, CO

The impact on bats from wind energy development has been well documented from numerous turbine-related mortalities. Yet, little is known about potential impacts of other renewable energy developments on bats. The cumulative negative impact on bat populations from wind energy and the disease white-nose syndrome has become a major concern throughout North America. Currently, public lands within the San Luis Valley of Colorado are being considered for development of utility-scale solar and geothermal energy. These developments, particularly solar energy, have become a concern to wildlife in the southwestern United States because of potential habitat loss and fragmentation. The objectives of this study were: 1) to assess pre-construction bat activity via acoustic surveys at proposed solar energy zones (SEZs) throughout the San Luis Valley; 2) assess bat activity at non-SEZ suitable bat habitat areas (SBHs) within the region for comparison of bat activity at the SEZs; 3) determine whether bat activity is related to geothermal energy potential; and 4) determine environmental correlates of bat activity. Based on passive acoustic data, there was 38.6% more bat activity at SBHs compared to SEZs. The site with the highest geothermal energy potential had the greatest bat activity. Nightly average temperature was positively related to bat activity among the majority of SEZs and SBHs. Results from this study could help inform energy development decisions in the region to minimize impacts on bats.

***Artibeus jamaicensis* in Puerto Rico versus Costa Rica: Support for the Metabolically Conservative Species Hypothesis**

Armando Rodríguez-Durán, Jean M. Sandoval, Eugenia Cordero-Schmidt, and Bernal Rodríguez-Herrera, Universidad Interamericana, Bayamón, Puerto Rico; Reserva Biológica Tirimbina, Sarapiquí, Costa Rica

In 1977 Faaborg proposed a Metabolically Conservative Species Hypothesis to explain a proportionally higher abundance of non-passerine birds on islands. Further work by Brian McNab has provided support for this hypothesis for vertebrates in general, and for bats in particular. However, to our knowledge, this study is the first instance where the same species has been examined under exactly the same conditions on the continent and an island. We measured oxygen consumption of *Artibeus jamaicensis richardsoni* in La Tirimbina, Costa Rica (10° 30' N 84° 00'W), and *Artibeus jamaicensis jamaicensis* in Bayamón, Puerto Rico (18° 21'N 66° 10'W) at temperatures ranging from 20–35°C. The same numbers of individuals were measured at the same temperatures with the same equipment. Slight differences between the Puerto Rican and Costa Rican populations in body mass (46.5 vs. 48.9 g) and rectal temperature (32 vs. 34°C) did not contribute significantly to explain differences in oxygen consumption. However, metabolic rate measured as oxygen consumption was significantly higher in the Costa Rican subspecies as compared to the subspecies in Puerto Rico. These results provide strong support to the hypothesis that bats on islands have depressed metabolic rates as compared to mainland populations.

Central American Strategy for Bat Conservation

B. Rodríguez-Herrera, L.R.A. Sánchez, I. Acosta, Y. Aguirre, A. Arias, R. Barahona, S. Briones, J. Cajas, C. Carias, E. Cordero, J. Echeverría, L. Giron, J. Hernández, I. Herrera, I. Martínez, J. Martinez, R. Medellín, A. Medina, M. Mondragón, A. Paz, K. Perdomo, H. Portillo, J. Ramírez, M. Rodriguez, M. Romero, O. Saldaña, L. Trujillo, F. Valle, and D. Villalobos; Universidad de Costa Rica; Reserva Biológica Tirimbina; PCM Costa Rica; Asociación Theria; PCM Honduras; PCM Nicaragua; PCM Guatemala; PCM El Salvador; UNAM

The Central American region has the largest number of bat genera in the world. Habitat loss, direct roosting, and population destruction by human beings based on unfounded myths are the main threats faced by these taxa in the region. Bat Conservation Programs (BCP or PCM in Spanish) established in Latin America developed their model based on species biology and priority areas knowledge, enriched by other tools such as environmental educational programs and outreach activities, making all this information available to the public. Our objective is to decrease the extinction risk of Central American bat species by strengthening the BCPs in the region and by implementing a joint regional Conservation Strategy for Bat Conservation. We organized the first Central America workshop focusing on bat biology where 29 participants from Guatemala, Honduras, El Salvador, Nicaragua, and Costa Rica gathered and generated a list of 134 species for the region, identifying 38 species under risk based on the Method of Species Risk Extinction (MER). Also, 17 priority areas for bat conservation in the 5 countries were identified, and 4 of the areas are bi-national or tri-national areas such as Indio-Maíz (Costa Rica-Nicaragua) and Trifinio (Honduras-Guatemala-El Salvador). Our project is the product of a group of Central Americans, which have the knowledge and leadership skills to coordinate and make this effort a reality. The contribution is not only related with species conservation, but it is the first regional experience where the initiative, coordination, and execution of a conservation program are done by locals, enhancing professional skills.

The Use of Canonical Correspondence Analysis in Dietary Studies

Ashley Rolfe, Eastern Michigan University, Ypsilanti, MI

The overall structure of assemblages is influenced by both biotic and abiotic factors, and this pluralist concept is widely accepted among ecologists. However, to simplify statistical approaches, assemblages are often analyzed in a single-factored approach, in which biologists examine the effect of one variable at a time, assuming the interaction between environmental factors has a neutral effect on the structure of the assemblage. Through the use of multivariate methods, such as ordination, it is possible to analyze variation in the data by examining all independent variables in the study at once. Many studies use principle components analysis (PCA), a common ordination technique; however, this linear-based approach is unsuitable for analyzing the structure of assemblages because environmental variables are typically non-linear. Canonical correspondence analysis (CCA), however, is a non-linear, multivariate approach that analyzes the relationship among species abundance and numerous environmental variables, and builds on typical ordination techniques through the use of regression. This analysis is frequently used to group independent variables, which may have interactive effects and overlap in explanatory power. The techniques used in CCA can help interpret how a multitude of species, such as the

assemblage of insects found within the guano of a bat, simultaneously change with respect to a suite of abiotic and biotic factors. This study illustrates the use of CCA to analyze dietary differences among species of Mormoopidae (*Mormoops blainvillei*, *Pteronotus parnellii*, and *P. quadridens*) on Puerto Rico, with respect to species, sex, age, reproductive condition, season, and geographic location.

Phylogeographic Analyses Reveal Cryptic Subdivisions and Unexpected Connections among *Myotis lucifugus* Populations

Amy Russell, Maarten Vonhof, and Cassandra Miller-Butterworth, Grand Valley State University, Allendale, MI; Western Michigan University, Kalamazoo, MI; Pennsylvania State University, Beaver, PA

Until recently, the little brown bat (*Myotis lucifugus*) was one of the most common bat species in North America. However, this species faces a significant and immediate threat from white-nose syndrome (WNS), which will likely result in the listing of *M. lucifugus* as a priority species in eastern parts of its range. The aim of this study is to examine the population genetic structure of *M. lucifugus*, and thereby infer the impact that WNS is likely to have on *M. lucifugus* populations, both locally and on a landscape scale. Samples were collected from over 500 individuals from eastern hibernacula and from maternity colonies throughout the United States and Canada. Both mitochondrial (cytochrome oxidase I) and nuclear (14 microsatellites) loci were examined. Our data reveal restricted gene flow among females, but not males, from winter colonies. This mitochondrial genetic structure mirrors topographical variation across the region. Broader sampling of summer maternity colonies reveals a role for the Rocky Mountains as a historically significant, although not complete, barrier to gene flow among both males and females. Microsatellite data indicate that colonies in the Rockies provide opportunities for admixture between characteristically eastern and western lineages, suggesting that these mountains are unlikely to act as firm barriers to the westward spread of WNS across the continent. Our results will help us to place current patterns of mortality and disease spread in eastern North America in the broader context of population-level processes across the range of this species.

Being Hot is Not Enough: Microclimate and Physical Constraints Affecting Bat Occupancy in Houses in Sarapiquí, Costa Rica

Ragde Sánchez, Luis Víquez, Priscilla Alpízar, and Jean Arias, Asociación Theria para la Investigación y la Conservación; Universidad Nacional Autónoma de México; Universidad de Costa Rica; Universidad Técnica Nacional de Atenas

Bats spend more than half of their lives inside a day roost; the selection of this resource is one of the most important aspects for their reproduction and survival. It is generally considered that bats select roosts based on temperature, predation risk, and accessibility. The main objective of our research was to identify: 1) the bat species that live in residential houses in rural Costa Rica; 2) the microclimatic conditions (temperature and humidity) they select inside a roost; and 3) the perception people from the study area have about bats. We worked in the rural town La Virgen de Sarapiquí in the Costa Rican Caribbean lowlands. We conducted a census in this town to determine which houses were functioning as bats roosts. We identified the species using mist nests, harp traps, and direct capturing from the roost. We used I-buttons to record the microclimate conditions of the roosts and the control group. We found that 15.83% of the houses (21 out of 139) in this town were being selected by bats as a roosting site. We found five species from two families utilizing the houses as roosts. There were no conclusive data that supported a specific microclimate selection, although the temperature inside the roosts can reach up to 41ºC. We believe that probably what makes the difference is the diversity of microhabitats inside one same roost. This diversity bestows plasticity before external environmental changes and allows bats to move between microhabitats, according to the immediate requirements.

An Integrative and Comparative Approach to Detecting and Understanding Bat Fatalities at a Wind Energy Facility in Indiana

Michael Schirmacher, Blayne Gunderman, Manuela Huso, Paul Cryan, Marcos Gorresen, Robb Diehl, Kevin Heist, Frank Bonaccorso, and Cris Hein; Bat Conservation International, Austin, TX; BP Wind Energy, Houston, TX; U.S. Geological Survey (USGS) Forest and Rangeland Ecosystem Science Center, Corvallis, OR; USGS Fort Collins Science Center, Fort Collins, CO; University of Hawaii, Hilo, HI; USGS Northern Rocky Mountain Science Center, Bozeman, MT; University of Minnesota, St. Paul, MN; USGS Northern Prairie Wildlife Research Center, Jamestown, ND; USGS Pacific Island Ecosystems Research Center, Hawaii National Park, HI

Although wind-generated electricity is renewable and generally considered environmentally friendly, greater-than-anticipated bat fatalities have occurred at wind-energy facilities worldwide. Existing methods for monitoring bats at these sites include searching underneath turbines for carcasses, recording bat echolocation calls, following flight trajectories with radar, and watching behavior with video imaging. However, these techniques have not been fully optimized, validated, and/or combined and compared to find the most efficient and useful ways of both detecting fatalities and understanding the process of underlying bat/turbine interactions at multiple spatial and temporal scales. In summer 2012, we initiated a case study at the Fowler Ridge Wind Energy Facility in northwest Indiana to simultaneously monitor turbines under three different operational scenarios for activity and fatality of bats using ground searches, acoustic detectors, radar, and infrared and thermal videography. Our objectives were to: 1) determine the best combination of methods for detecting and observing bat interactions with operating turbines; 2) assess whether blade rotation influences activity; and 3) understand the environmental conditions under which fatalities are most likely to occur. We anticipate this research will result in new tools and techniques for efficiently monitoring and studying bat activity and fatality at wind-energy facilities. It also will advance the understanding of why certain bats are vulnerable to wind turbines.

"To the Batplane!"—Using Unmanned Aerial Vehicles to Track Bats

Kenneth Sebesta and Nathan Fuller, Boston University, Boston, MA

Current bat tracking techniques rely heavily on human intervention and labor. Bats are notoriously difficult to track, often making radio-telemetry projects impractical without a large team of people, a high level of organization, and generous funding. Additionally, the data quality may be compromised as workers fatigue after tracking bats for several hours on consecutive nights. Aerial telemetry has been used to avoid some of the limitations of tracking bats using radio-telemetry, but this is often prohibitively expensive. We propose the Automated Tracking and Localization Aerial System (ATLAS), a novel bat-tracking technique that uses a low-cost, lightweight, and compact unmanned aerial vehicle. ATLAS is an unmanned aerial vehicle (UAV) carrying two directional antennas that are coupled with a software defined radio (SDR). The UAV orbits the bat's position by using the azimuth data, given by the onboard radio equipment, with a potential field tracker. Conservative simulations show that combining GPS information with antenna readings locates the bat within a circle of approximately a 50-m radius. This compares favorably with current telemetry techniques, which struggle to maintain such accuracy for extended periods. Flight times in excess of two hours have been demonstrated in a sub-$500 package, opening the door to all-night tracking of bats by using multiple UAVs taking turns in a relay system. This tracking platform could provide an extraordinary opportunity to track organisms whose movement patterns are largely unknown, such as migratory bats, small birds, and even insects, at a far lower cost of manpower and equipment.

Summer distribution and Movement Patterns of *Myotis lucifugus* and *M. septentrionalis* at a Wind Farm in Nova Scotia

Jordi Segers and Hugh Broders, Saint Mary's University, Halifax, NS

The impact of wind energy facilities on the local movement patterns of short distance migratory bats is not well understood. The goal of this ongoing study is to characterize the distribution and behavior of the little brown bat (*Myotis lucifugus*) and the northern long-eared bat (*M. septentrionalis*) at a wind farm in Nova Scotia, Canada. Bats were systematically trapped within and around the facility to characterize distribution and estimate an index of abundance. Nineteen female bats (eight *M. lucifugus* and eleven *M. septentrionalis*) were radio-tracked to calculate minimum foraging area (MFA) and minimum roosting area (MRA) and to identify the location of these ranges relative to the wind facility. Bat detectors (Anabat) were systematically deployed at three site types (ponds, forest edges, and streams) to monitor for bat activity in (three sites; one per type) and outside (nine sites; three per type) of

the wind farm. Trap success was higher outside than inside the facility. Of 26 bats trapped (7 sites outside wind farm, 3 inside), fewer were trapped within the boundaries of the wind farm than outside. Preliminary data suggest that no bats roosted inside the wind farm but some individuals of each of *M. lucifugus* and *M. septentrionalis* had MFAs that extended into the wind facility. Overall, at stream sites activity was higher inside the wind facility than outside, but at ponds and forest edges activity was greater outside the wind facility.

New Insights on the Phylogenetic Diversity within the Genus *Micronycteris* (Chiroptera: Phyllostomidae)
Lizette Siles and Robert J. Baker, Texas Tech University, Lubbock, TX

The Neotropical bat genus *Micronycteris* comprises ten species, partitioned into four subgenera. Despite all the research effort devoted to this group in the past, its systematics is not yet resolved; the molecular data show evidence of paraphyletic relationships within several species, and authors have indicated that the genus probably contains a number of undescribed species. The first molecular analysis of the genus was performed five years ago and included 45 specimens of 8 species. The most recent analysis, based on previous work, focused only on the description of a new species. The aim of this project is to increase sample size, to include all species recognized, and to expand the geographic coverage. We extracted DNA and sequenced the entire cytochrome-*b* gene (1140 bp) for 70 individuals. Maximum likelihood and maximum parsimony analyses were performed and genetic distance values were estimated using the Kimura 2-parameter model. Our results support previous analyses and indicate that species-level clades are present within *M. hirsuta* (at least two clades), *M. minuta* (at least six clades), and *M. megalotis*. The latter presents the most complex tree topology, with at least seven clades, two of which include specimens identified as *M. microtis*. In most cases, there is phylogeographic structure, suggesting some level of geographic isolation. The level of complexity within the genus indicates the necessity to include samples from type localities and to include in the analysis nuclear genes.

What's New about Bat Research and Conservation in the Province of Québec, Canada
Anouk Simard, André Desrochers, Nathalie Desrosiers, François Fabianek, Julie Faure Lacroix, Ariane Massé, and Valérie Simard, Ministère des Ressources Naturelles et de la Faune (MRNF), Québec, QC; Université Laval, Québec, QC

As elsewhere in North America bats of the province of Québec, Canada are not doing great. As for now, seven of the eight species present in Québec are listed under some categories of species at risk. In order to improve their status, several actions—both in research and conservation—have been initiated. Since spring 2011 an important research project is being conducted in order to improve our knowledge of habitats used by bats in boreal forest ecosystems. This research proposes to evaluate feeding habitat using acoustic surveys and diurnal roosts using telemetry in two distinct regions of Québec. Preliminary results suggest a pattern of selection by *Myotis* species for large balsam fir in an advanced stage of decomposition. Theses results will be used to improve the new Québec program for ecosystem forest management and put forward protection measures for bats. Other actions put forward in Québec province for bat conservation involve 10-year acoustic surveys in different regions, monitoring of certain hibernacula, and a new census for maternity colonies. We are planning to initiate more research projects in the near future, hoping to improve tools for bat conservation in the province.

Comparison of Full-Spectrum and Zero-Crossing Automated Bat Call Classifiers
Donald Solick, Matthew Clement, Kevin Murray, Christopher Nations, and Jerrery Gruver, Western EcoSystems Technology, Inc., Cheyenne, WY

Identification of bat echolocation calls to species is becoming increasingly important, particularly for assessing the risk to bat species posed by wind-energy development and for monitoring the spread of white-nose syndrome. Calls recorded using full-spectrum detectors (e.g., Pettersson™) contain more acoustic information than calls recorded using zero-crossing detectors (e.g., Anabat™), and it is commonly assumed that this leads to better species discrimination. We tested this assumption using 650 full-spectrum reference calls for nine eastern bat species. Calls were analyzed using SonoBat™ 3.04 Northeast, and classified using three types of output: Consensus, By Vote, and Mean Classification. The full-spectrum calls were then converted to zero-crossing data using Anabat Converter 0.8. Call parameters were extracted using Analook and were analyzed using BCID software, EchoClass software, a DFA for New York, and a DFA developed by WEST, Inc. Average correct classification rates for all methods ranged from 14.3% (*Myotis leibii*) to 93.5% (*Perimyotis subflavus*). Incorrect classification rates were lower for SonoBat methods (range 4.4–12.9%) than for zero-crossing methods (36.4–45.9%). In general, zero-

crossing methods outperformed SonoBat for *Myotis* species, while SonoBat was better at classifying non-*Myotis* species. SonoBat did not identify any *M. sodalis* calls, while zero-crossing methods correctly classified 30.8–38.5%. Our results illustrate some of the limitations of automated classification, and suggest that the best approach for species surveys may be a combination of full-spectrum and zero-crossing methods.

Paleo-ecological Niche Models of *Macrotus waterhousii* in the Caribbean: Assessing Climate Change Impacts on an Insular Bat

J. Angel Soto-Centeno, Susan Cameron Devitt, and David Steadman, Florida Museum of Natural History and University of Florida, Gainesville, FL

Increasing interest in the impacts of climate change on biodiversity has lead phylogeographers to the use of Ecological Niche Modeling (ENM) to reconstruct species distributions under present and historical climate conditions. Paleo-ENM is produced using present-day locality records, which are projected onto Last Glacial Maximum climate (LGM, ca. 21 ky). Nevertheless, results of paleo-ENM are seldom validated to assess model performance. We used an ensemble approach of four modeling algorithms to develop present and paleo-ENM for the bat *Macrotus waterhousii* in the Caribbean Islands. Models using present *M. waterhousii* localities were projected onto LGM climate and we used a large fossil dataset of this species to validate the paleo-ENM by assessing the true positive fraction of fossil localities. Present and paleo-ENM overlapped in 60% of the distribution of *M. waterhousii* and estimates of relative range sizes between them show a reduction of 32% in available climate habitat from past to present. Paleo-ENM predictive performance was good and models correctly predicted 90% of fossil localities (AUC = 0.82). In contrast, present climate models showed false presence in areas where the species is locally extinct. Our model projections suggest that climate habitat requirements for *M. waterhousii* have changed little over time. Additionally, differences in distributions from past to present are likely influenced by the amount of habitat lost because of sea level change after the LGM. Our integrative approach allowed us to directly link fossil evidence of species occurrence with ENM predictions to refine and better understand niche dynamics across space and time.

Will the Evening Bat Become the Dominant Tree-roosting Bat of the Midwest Following White-nose Syndrome?

Dale Sparks, Virgil Brack, Jr., Karen Francl, and Justin Boyles, Environmental Solutions & Innovations, Cincinnati, OH; Radford University, Radford, VA; Southern Illinois University, Carbondale, IL

The evening bat (*Nycticeius humeralis*) is an abundant species across much of the southeastern United States. The species reaches its northern range limit in the Midwest where it is listed by several states. Despite its status as a protected species in multiple states, evening bats appear to be increasing in number throughout the region. In Indiana, all known colonies had disappeared by the early 1990s. However the species has not only been rediscovered but is now known to exist along every major river in the state. There is evidence that the species spread across the entire state of Kansas, and a colony is now known in Michigan. These increases have occurred despite the fact that the region is filled with other tree-roosting species that potentially compete for the same feeding and roosting locations. Unlike these potential competitors, however, evening bats hibernate primarily in trees and not caves. This behavior of hibernating in trees will likely protect the species from the scourge of white-nose syndrome, a fatal fungal disease that has decimated cave-hibernating bats in the eastern United States. If the cave-hibernating species are greatly reduced in the Midwest, the evening bat will have further opportunities to increase within the region.

Bat Occupancy of Forests and Managed Savanna and Woodland in the Missouri Ozark Region

Clarissa Starbuck, Sybill Amelon, and Frank Thompson, University of Missouri, Columbia, MO; U.S. Forest Service, Columbia, MO

Many Missouri agencies are restoring savanna and woodland ecosystems with prescribed fire and forest thinning. Our objective was to determine how occurrence of foraging bats varies with environmental variables across a gradient of savanna, woodland, and forest in the Missouri Ozark Region. We identified sites that are actively managed for savanna and woodland conditions and control areas on similar landforms with no recent management that had succeeded to more closed canopy forest. We used Anabat II and SD1 bat detectors (Titley Electronics) to survey bats at 23 points during August 2010, 150 points during May to July of 2011, and 173 points during May through June of 2012. We used occupancy modeling in an information theoretic approach to

evaluate *a priori* hypotheses concerning habitat and landscape factors affecting bat occupancy. The probability of detecting bat species varied by species and was affected by temperature, relative humidity, barometric pressure, tree density, Julian date, and distance to water. The probability a site was occupied by foraging bats varied among species and was affected by forest type (savanna/woodland/forest), tree density, distance to water, distance to roads, land cover (percent forest, urban, or open areas), canopy closure, tree diameter, vegetative composition, and road density. Vegetative structural conditions created by savanna and woodland restoration and management result in greater occupancy of *Myotis septentrionalis*, *Lasiurus borealis*, *Nycticeius humeralis*, *Eptesicus fuscus*, and *Perimyotis subflavus* than in mature, un-managed forest.

Dimensionality of Biodiversity of Phyllostomidae

Richard Stevens and Sebastian Tello, Louisiana State University, Baton Rouge, LA; Missouri Botanical Garden, St. Louis, MO

Billions of years of environmental dynamics and evolution have lead to unimaginable biological complexity. Despite centuries of documenting the biota, patterns of biodiversity and the mechanisms that generate such natural phenomena are still poorly understood. Nescience stems from uni-dimensional approaches, in particular a focus on species richness, that have traditionally been used to understand the multidimensional phenomenon of biodiversity. Indeed, patterns of taxonomic, phylogenetic, functional, and phenotypic diversity (TPFP diversity) exhibit complimentary yet different gradients. Still, even basic information of how these dimensions are related to each other is virtually unknown. Dimensions represent only complimentary facets of the same entities (i.e., species) and thus likely exhibit correlation to some degree. Moreover, strong richness gradients characterize variation in biodiversity in nature, further enhancing correlation among indices that are sensitive to variation in number of things. This research has three aims: 1) characterize correlations among indices of TPFP diversity; 2) examine if correlations are different than null model expectations; and 3) determine true dimensionality of this multivariate dataset and examine if dimensionality is different than null model expectations. Ten measures characterizing TPFP diversity exhibited high correlation with all but one different from null model expectations. Accordingly, dimensionality of was low (2) and lower than null model expectations. Most biodiversity measures are redundant and ecologists should strive to enhance the characterization of the complexity of life on earth.

Stable-isotope Analysis of Diet in Some Phyllostomid Bats

Erin Stukenholtz and Heather York, Doane College, Crete, NE; Buena Vista University, Storm Lake, IA

Family Phyllostomidae, the Neotropical leaf-nosed bats, is one of the most ecologically diverse of all mammal families. Having evolved from insectivorous ancestors, this speciose group now consists of frugivores, nectarivores, sanguinivores, and gleaning animalivores, and some level of omnivory is common in several phyllostomids. Nonetheless, dietary behavior is not well documented for many species, often being inferred from the diets of a handful of better known relatives. Subtle interspecific differences, which may be of use in understanding bat habitat preferences and roles in ecosystem function, are understood only after careful study of individual species. Here, we offer additional dietary details for a number of phyllostomid species through the analysis of the stable isotopes of carbon and nitrogen in hair samples taken from museum and living specimens. We confirmed that even with fairly conservative diets in a number of species, gleaning phyllostomids are more omnivorous than previously known.

Analysis of Captive Bat Management Strategies in Response to White-nose Syndrome

Robert Tawes and Mary Parkin, U.S. Fish and Wildlife Service, Atlanta, Georgia; U.S. Fish and Wildlife Service, Hadley, MA

In 2010, a U.S. Fish and Wildlife Service (FWS) team began investigating the efficacy of various *ex situ* captive management strategies in response to the white-nose syndrome (WNS) crisis. We identified 10 conservation objectives and 11 alternative management strategies, ranging from "no captive management" to intensive long-term breeding. We then employed a structured decision-making (SDM) process, involving experts inside and outside the agency, to evaluate how well the various alternatives address conservation objectives for eastern small-footed, gray, Indiana, little brown, northern long-eared, Ozark big-eared, and Virginia big-eared bats. Our results reflected substantial uncertainty surrounding the ability of captive management to meet the stated conservation objectives, especially for long-term scenarios. "No captive management" was preferred for gray, Ozark big-eared, Virginia big-eared, and northern long-eared bats, while short-term holding of hibernating bats was preferred for eastern small-footed, Indiana, and little brown bats. Overall, except for the northern long-eared

bat, individual species' susceptibility to WNS strongly influenced the predicted efficacy of short-term holding strategies. Based on SDM results, we recommend removing long-term captive strategies from consideration; deferring captive management for four of the seven species; and conducting a one-winter holding pilot project for eastern small-footed, Indiana, or little brown bats.

Large-Scale Climate Variation Modifies the Grouping Behavior of Wintering Endangered Indiana Bats
Wayne Thogmartin and Patrick McKann, U.S. Geological Survey, La Crosse, WI; IAP World Services, La Crosse, WI

When the frequency of an event *N* (such as a subpopulation) varies as the power of some attribute of that event (its size), it is said to follow a power law. We examined whether the size of wintering populations of endangered Indiana bats (*Myotis sodalis*) followed a power law, and then leveraged this relationship to predict the proportion of smaller wintering populations not known to exist. By regressing log frequency of hibernacula within histogram bins of 256–131,072 bats against the log count of hibernacula within those bins, we determined the power law distribution of wintering populations (scaling coefficient α = -0.44, 95% CI = -0.61–-0.28). We associated temporal patterns in these annual (1983–2011) scaling coefficients with the North Atlantic Oscillation index in August [$\beta_{\text{NAO August}}$ = -0.017 (95% CI = -0.037, 0.002)], when Indiana bats are deciding when and where to hibernate. These results suggest, after accounting for the inertia associated with philopatry to a habitual wintering location, that Indiana bats aggregate in larger wintering populations during periods of severe winter and among smaller populations in milder winters. Prior to the onset of white-nose syndrome, 813 hibernacula comprising 8,494 bats were missed by the survey protocol employed for this endangered species, more than three times the number of known hibernacula but only about 2% of the total population. We conclude current survey protocols are sufficiently representative for characterizing current status and trends of this species, but that climate warming may require future emphases on smaller wintering populations.

Does Forest Fragmentation Affect the Relationship Between Bat Pollinators and Floral Resources in the tree *Crescentia alata*?
Pamela Thompson and Victoria Sork, University of California – Los Angeles, Los Angeles, CA

Deforestation and fragmentation are threatening the survival of tropical forest tree species and the animals that depend on them. Highly mobile animals, such as bats, can transport pollen and seeds long distances, and may mitigate the impacts of fragmentation if these animals are not inhibited by landscape change. The goal of this study is to evaluate the impact of the landscape type (fragmented or intact forest) on bat pollinator abundance, and to evaluate whether bat pollinator presence enhances plant reproductive success in the tree species *Crescentia alata.* A total of 366 nectarivorous bats were mist-netted near flowering *C. alata* trees in different landscape types, over the flowering period. The number of nectarivorous bats caught was significantly and positively correlated with number of open flowers. Number of bats caught did not differ significantly between landscape types, except for the species *Choeroniscus godmani*, which was only found in intact forest. Reproductive success of *C. alata* was measured by ratio of fruit to flowers produced. Using a negative binomial regression, we found reproductive success was significantly higher in fragmented forest sites. The most abundant nectarivorous bat caught, *Glossophaga* sp., also had a significant effect on reproductive success. Based on pollen presence data, we found that the second most abundant nectarivore, *Leptonycteris yerbabuenae*, may be a more effective pollinator than the *Glossophaga* species. These findings highlight the complex species interactions at work in this pollination system, and suggest that bat pollinator behavior may exhibit some degree of resilience to forest fragmentation.

Annual Sex Ratio Fluctuation in *Myotis septentrionalis*
Brenna Tinsley, Janelle Bowcock, and Lynn Robbins, Missouri State University, Springfield, MO

Uneven sex ratios have been documented in several studies of megachiropteran species. For the species that inhabit the caves along the Ozark National Scenic Riverways (ONSR) in southern Missouri, no study examining skewed sex ratio has been conducted. *Myotis septentrionalis,* the northern myotis, has been documented to hibernate in caves with both sexes together. However, the sexes of this species are typically separated during the maternity season when the females leave the caves for snags and/or man-made structures. Capture data from two maternity seasons and two hibernation seasons were used for this study. Captures were all in mist nets at cave entrances or within 200 meters of them, or out in flyways away from the caves. I predicted a statistically significant fluctuation in sex ratio in *Myotis septentrionalis* populations, both at caves and in the landscape, during the maternity season of both years along the ONSR. I also predicted neither a significant difference in sex ratio

between years, nor a significant difference in sexes during the hibernation season at caves or on the landscape during both years. A three-way ANOVA was performed, using the MiniTab software, to determine the effects of season, year, and location on the sex ratio of this species. The main effects of year and season of capture, as well as the interaction effect of season and location, were shown to be statistically significant. A difference between years was not expected and future studies should examine this.

Two Decades of Working with Bats in the Megadiversity of Ecuador
Diego Tirira, Fundación Mamíferos y Conservación, Quito, Ecuador

Investigation of bats in Ecuador by a local scientist started recently at the end of the 1970s, and until 1990 this activity was relegated to only one person. Since that year, I started working with bats, traveling around the country, catching and researching hundreds of specimens as part of the Museum of Zoology at Catholic University (QCAZ), in Quito, Ecuador. Two decades later, there are ~20 new scientists working on bats in Ecuador, many of them conducting multiple investigations and providing multiple contributions on bats. In 1991, the number of species of bats recorded in Ecuador was 118; two decades later this number not only has increased to 167 but it represents one of the highest species richness numbers in the Neotropical region. In 1990, the QCAZ Museum had less than 200 specimens of bats; 22 years later, this number has increased to almost 10,000, becoming the largest collection of Ecuadorian bats in the World. This lecture summarizes two decades of work on the investigation and conservation of bats in Ecuador, one of the most megadiverse countries in the World.

***Ecoimmunology in Bats: Lessons from the Field and Laboratory**
Megan Vodzak, DeeAnn Reeder, and Kenneth Field, Bucknell University, Lewisburg, PA
*** Megan Vodzak** received the **Basically Bats Award**.

Bats represent critical species: in their physiology and ecology, in their ability to serve as reservoirs for zoonotic diseases, and in their susceptibility to white-nose syndrome (WNS). Yet, little is known about their immune responses and how they vary by sex, species, social processes, and environmental conditions. Differences in immune mechanisms between various species of bats may explain why some serve as carriers for zoonotic diseases such as those caused by rabies, Nipah, Hendra, and Ebola viruses, or why some species are susceptible to WNS while others appear resistant. In captive pteropodid bats (fruit bats) we have found significant seasonal, social, and sex differences in leucocyte counts that mirror glucocorticoid hormone levels (which reflect metabolic processes and the stress response) and that inversely relate to testosterone levels. Species differences in complement activity (an innate immune system component) have been documented both in captive pteropodids and in free-ranging African pteropodids and molossids (free-tailed bats). In response to a significant immune challenge that typically induces a fever response—injection of lipopolysaccharide (LPS), a component of the bacterial cell wall—free-ranging pteropodids and molossids decreased, rather than increased, their complement activity. This may be related to the fact that some of the bats exhibited shallow torpor (in relation to ambient temperature) rather than a fever. Analyses of additional immune components, including cytokine and antibody levels, are underway. Our findings contribute to the physiological and ecological knowledge base for this diverse taxonomic group and inform future studies of disease ecology in bats.

Relative Roles of Host Exposure and Parasite Establishment in Determining Helminth Burdens of *Eptesicus fuscus*
Elizabeth Warburton and Maarten Vonhof, Western Michigan University, Kalamazoo, MI

In most host-parasite systems, variation in parasite burden among hosts facilitates transmission dynamics. Heavily infected individuals introduce disproportionate numbers of infective stages into host populations and may cause sharp increases in frequency of infection. Heterogeneity in exposure and susceptibility can cause parasite burdens to vary widely within host populations; however, the unique contributions of each are unclear. This presents possible barriers to developing effective mitigation strategies in threatened human and wildlife populations. To understand why these hosts have heavy burdens, we used *Eptesicus fuscus* and its helminths as a model system. Exposure variables (capture location, capture date, water contact) and parasite establishment variables (sex, age, body condition, immune function) were used to determine which traits influence variation in parasite burden. We captured *E. fuscus* from colonies in Michigan and Indiana and assessed their sex, age class, body condition, functional immunocompetence, and helminth burden. Structural equation modeling revealed the best-fitting *a priori* model (*AIC* = 16.193) included year of capture and distance of colony to nearest body of water. Thus,

differential host exposure appears to play a more significant role than differential parasite establishment in creating heterogeneous helminth burdens. Future directions include assessing neutral genetic diversity by genotyping 18 autosomal microsatellites of each individual bat and extending the model to other parasites in other mammalian species. Evidence for similar patterns in different taxa would provide novel insight into modeling disease transmission and possible mitigation strategies.

Is Personality Correlated with Ectoparasite Load in Little Brown Bats?
Quinn Webber, Zenon Czenze, Dylan Baloun, Allyson Menzies, and Craig Willis, University of Winnipeg, Winnipeg, MB

Animal personality or temperament has been linked to variation in numerous physiological, behavioral, and energetic traits. Some aspects of personality, such as exploration, boldness, and activity, may be linked to an individual's propensity to disperse and interact with other individuals, and this propensity could increase an individual's risk of exposure to parasites or pathogens. Increased ectoparasite exposure is a cost of coloniality and may further be affected by age-related variation in grooming ability. We tested the hypotheses that individual personality, reproductive status, and age (juvenile or adult) correlate with ectoparasite load in little brown bats (*Myotis lucifugus*). We predicted that: 1) females would have greater ectoparasite loads than males because of colonial roosting; 2) juveniles would have greater ectoparasite load than adults because of their inexperience in grooming; and 3) individuals with bold, explorative, and active personalities would exhibit higher ectoparasite loads. We captured 171 little brown bats (53 adult males, 37 juvenile males, 37 adult females, and 44 juvenile females) from four sites in central and northern Manitoba, Canada, during July and August 2012. We used infrared video to record behavioral responses of individuals in a novel environment test during ten-minute trials and subsequently sampled each individual for ectoparasites. We quantified personality by scoring videos for a range of personality traits. Analyses are in progress. Understanding individual variation in personality has implications for understanding energetics, fitness, and disease ecology, and this study could help improve our knowledge of fitness costs of personality variation.

Benefits of Bats: Ecosystem Services Provided by Mexican Free-tailed Bats, *Tadarida brasiliensis mexicana*
Ruscena P. Wiederholt and Laura López-Hoffman, University of Arizona, Tucson, AZ

Mexican free-tailed bats (*Tadarida brasiliensis)* are an important asset in agricultural areas, especially those producing cotton. These migratory bats travel between southern Mexico and northern Mexico/southwestern United States each year, providing an essential ecosystem service, pest control. Mexican free-tailed bats—a general insectivore—lower costs in cotton fields by reducing damage caused by pests. By studying Mexican free-tail bats and their impacts on the economy of crop production, we estimated the ecosystem service value they provide to farmers across the United States and as well as studying trends over time. Using current and historical data for crop production, agricultural practices, pesticide use, bat populations, and crop damages, we determined a monetary value for Mexican free-tail bats. We applied this method to over 50 counties in the southwestern United States to determine the overall effects of reduced damages these bats can provide. The pest control value was estimated as the money saved by avoided crop damage and the avoided use of pesticides. We estimated the pest control value over multiple years to illustrate the dynamic nature of ecosystem service valuation. We determined that the worth these bats provide varies over time as a function of changes in land-use and socio-economic factors in the Southwest. This demonstrates that, along with environmental change, variation in social factors can also affect the value of ecosystem services. This is an area, in our opinion, that merits further study in the ecosystem service field and an increase in conservation of bat migration sites.

Use of Caves by Hibernating Townsend's Big-eared Bats in Sagebrush Steppe: Implications for Management and Conservation
Jericho Whiting, Bill Doering, and Bill Bosworth; Gonzales-Stoller Surveillance, Idaho Falls, ID; Power Engineers, Boise, ID; Idaho Department of Fish and Game, Boise, ID

The destruction and anthropogenic modification of roosting habitat is a primary threat to Townsend's big-eared bats (*Corynorhinus townsendii*) in the western United States. Certain caves in sagebrush-steppe habitat are important hibernacula for these mammals. Little is known, however, about the long-term use patterns of caves by this species during winter and the formation and termination of hibernating colonies. We compiled data regarding periodic mid-winter counts of Townsend's big-eared bats across 28 years to assess trends in the number of those bats hibernating

in two caves in Idaho. We also compiled information on the formation and termination of a hibernating colony of Townsend's big-eared bats. Surveys were conducted during six winters between 1985 to 2011 in Middle Butte and Rattlesnake caves, which are separated by 9.1 km. Across surveys, the number of bats increased substantially in Middle Butte Cave ($\bar{x}$ = 168, sd = 197, range = 15–464), whereas the number of bats remained relatively stable in Rattlesnake Cave ($\bar{x}$ =142, sd = 16, range = 127–175). Twenty-two surveys were conducted in Rattlesnake Cave, and Townsend's big-eared bats entered hibernation in early November 1992 and colony size remained stable ($\bar{x}$ = 141, sd = 5, range = 131–151) until early April 1993. Our results indicate that across decades, Middle Butte Cave became an important hibernaculum for Townsend's big-eared bats, whereas Rattlesnake Cave was utilized consistently across that time. We also provide biologists with an optimal range of dates to conduct winter counts for this species.

Impacts of White-nose Syndrome on *Myotis* Activity, Based on Long-term Acoustic Datasets

Lindsey Wight, Sarah Boyden, Trevor Peterson, Kristen Watrous, and Kristian Omland, Stantec Consulting, Topsham, ME

Populations of cave-roosting bats in the eastern United States have experienced unprecedented declines since the emergence of white-nose syndrome (WNS), as observed in both winter cave surveys and recent mist-netting capture results. In several affected states throughout the eastern United States, Stantec has conducted long-term passive acoustic bat monitoring, beginning in 2004 and continuing through the present. These data provide an opportunity to detect and assess any possible changes in acoustic activity patterns and species composition that are likely to have occurred since the appearance of WNS. We hypothesized that the activity level of *Myotis* species, as a percentage of total bat activity, declined on a regional level after WNS became established. Suitable acoustic datasets were categorized on a regional basis as pre- or post-exposure to WNS, and adjusted for survey effort, habitat characteristics, and time of year. We calculated the percentage of *Myotis* species activity relative to total bat activity for each dataset and tested whether the change in percent of *Myotis* activity could be attributed to WNS. Preliminary observations suggest a marked decrease in the percentage of *Myotis* calls relative to overall activity levels; final results of our analysis will provide an opportunity to compare observed reductions from cave surveys, mist-netting capture results, and acoustic data, helping understand how survey methods and biases of each technique may affect assessments of the extent and severity of WNS.

The Effect of *Geomyces destructans* on the Behavior of Hibernating Little Brown Bats

Alana Wilcox, Lisa Warnecke, James Turner, Liam McGuire, Joel Jameson, Trent Bollinger, Vikram Misra, and Craig Willis, University of Winnipeg, Winnipeg, MB; University of Saskatchewan, Saskatoon, SK

Bats with white-nose syndrome (WNS) arouse from torpor more frequently during hibernation than healthy bats, which could lead to starvation, but a mechanism underlying increased arousal frequency remains unknown. Three non-mutually exclusive hypotheses are that bats infected with *Geomyces destructans* (Gd) arouse more frequently to: 1) groom in response to skin irritation; 2) drink to offset increased water loss from cutaneous infection; or 3) escape the hibernaculum to access water or food and/or avoid other infected individuals. To test these hypotheses we analyzed the behavior of little brown bats (*Myotis lucifugus*) inoculated with either a North American or European isolate of Gd, and a sham-inoculated control group (n = 18 bats per group). Each group was housed in an environmental chamber at 7°C and 97% relative humidity from November 2010 to March 2011. We quantified grooming, visits to the water dish at the bottom of each enclosure, and overall activity of individuals during arousals by monitoring behaviors via infrared security cameras. We also quantified clustering behavior throughout hibernation. Inoculated bats did not increase duration of grooming or duration of visits to the water dish but did spend more time active during arousals relative to controls ($F_{2,38}$ = 4.5, p = 0.017). Inoculated bats also occupied more space in their enclosures ($F_{1,27}$ = 40.2, p < 0.001) and divided into more clusters ($F_{1,27}$ = 25.3, p < 0.001) as infection progressed. These findings could reflect attempts by bats to find alternative microclimates or leave hibernacula prematurely perhaps attempting to access resources or avoid infected bats or substrates.

Phylogeography of *Myotis lucifugus* using High Throughput Sequencing: Implications for Disease Spread and Conservation of Diversity

Aryn Wilder, Thomas Kunz, and Michael Sorenson, Boston University, Boston, MA

The little brown myotis (*Myotis lucifugus*) is a common, broadly distributed bat species; however, in the eastern portion of its range it has suffered severe declines from white-nose syndrome (WNS). The use of genetic data collected over the range of this species will increase our understanding of the distribution and boundaries of distinct populations, patterns of gene flow and dispersal, and the potential loss of diversity posed by declines from WNS. We sequenced the mitochondrial cytochrome-*b* locus and restriction site-associated DNA (RAD-tags) from individuals sampled throughout their range. RAD-tag sequence data were run through a computational pipeline that filters out low quality sequences, aligns loci, and identifies and calls single nucleotide polymorphisms (SNPs) for each individual. Thus far we have generated and analyzed data from over 3,400 loci, from which over 19,000 SNPs were identified. Analysis is preliminary and ongoing; however, using principle components analysis, bats sampled throughout eastern North America form a dense, overlapping cluster without separation, indicating frequent gene exchange and dispersal over this region. By contrast, samples from western localities show a clear separation from eastern bats, and suggest substructure reflecting their geographic localities within the west. Frequent dispersal of little brown myotis throughout eastern North America is consistent with the rapid spread of WNS, and dispersal of the WNS pathogen by this species may slow across the eastern population boundary. These data are critical to future management of little brown myotis and our understanding of the potential for dispersal of the causative agent of WNS.

***Geomyces destructans*, Environmental Conditions, and the Physiology and Behavior of Little Brown Bats**

Craig Willis, Lisa Warnecke, James Turner, Alana Wilcox, Shauna Baillie, Liam McGuire, Trent Bollinger, and Vikram Misra, University of Winnipeg, Winnipeg, MB; University of Saskatchewan, Saskatoon, SK

Understanding factors influencing survival of bats following infection with *Geomyces destructans* (Gd) is critical for understanding the disease and potentially informing management. Field observations suggest that more bats persist in relatively dry, Gd-infected hibernacula and that a smaller proportion of bats cluster in affected sites but experimental evidence of these patterns is lacking. We conducted an inoculation experiment using little brown bats to test the hypotheses that high relative humidity increases the pathogenicity of Gd and leads to a greater reduction in clustering by infected individuals. We housed paired groups of 10 experimentally inoculated and 10 sham-inoculated control bats in four different incubators maintained at 7°C and one of four levels of relative humidity (85%, 90%, 95%, and 99%). Infected and control bats were isolated from each other but maintained in the same incubator to help control for possible cage effects. We recorded skin temperature using temperature data-loggers and behavior using motion-sensitive infrared security cameras. Necropsy, histopathology, and hematology were conducted at the end of the experiment. Differences in arousal frequency and other clinical signs were more pronounced for high humidity treatments and clustering by infected bats declined as infection progressed. Our experimental results are, therefore, consistent with recent field observations and suggest that relatively dry hibernacula may be especially important sites to consider for protection.

Insects and Indiana Bats

Kathryn Womack, Sybill Amelon, and Frank Thompson III, University of Missouri, Columbia, MO; U.S. Forest Service, Columbia, MO

Indiana bats use fragmented forests in largely agricultural landscapes during the maternity season. Understanding how land use and land management affect bat activity and insect prey availability would provide insight into resource needs of Indiana bats. Our objectives were to determine what habitat, climatic, and temporal variables predict potential prey availability and to determine whether we could predict Indiana bat activity using prey biomass, climatic, and habitat covariates. We collected insects using both active and passive traps. We monitored Indiana bat activity with Anabat acoustic detector systems in summers 2009 and 2010 in northeastern Missouri. We used an information theoretic approach to evaluate *a priori* hypotheses concerning factors affecting insect prey biomass and Indiana bat activity. We evaluated generalized linear models with a negative binomial distribution and model averaged model coefficients and predictions. We found support for effects of average barometric pressure, average temperature and month on dry insect biomass collected in both trap types. The top model for predicting Indiana bat activity included percent canopy cover, management status, maximum temperature, maximum humidity, and average barometric pressure. Indiana bat activity was higher in areas

managed by prescribed fire and with high percent canopy cover, and at sites with higher dry insect biomass collected in passive traps. Insect biomass was lower in burned areas; therefore, we believe prescribed fire in our study benefitted bats by reducing understory clutter.

***The Use of Temperature Gradients as a Possible Mechanism for Energy Conservation in Hibernating Tri-colored Bats**

Risa Wright and Thomas Tomasi, Missouri State University, Springfield, MO

*** Risa Wright** received the **Titley Electronics Award**.

Hibernation is used by many bats in temperate environments to cope with seasonal fluctuations in temperature and food availability. Arousals during hibernation are energetically costly, and optimal ambient temperatures are different for aroused vs. torpid bats. It is hypothesized that individuals hibernating with a range of temperatures available will choose relatively cooler temperatures while torpid and move into warmer areas while aroused in order to reduce the total energetic costs of hibernation. In this study, 16 tri-colored bats (*Perimyotis subflavus*) were divided into two treatment groups (n = 8). Bats in the experimental group were housed individually in hibernation chambers with a thermal gradient (8–17ºC), and bats in the control group were similarly housed but at a uniform temperature (8ºC). Movement within chambers while aroused, frequency and duration of torpor and arousals, activity budget while aroused, and mass lost over the winter were compared between treatments. Bats in the experimental group did not appear to conserve more mass than bats in the control group. The data suggest that bats in the experimental group experienced more frequent but shorter arousals than bats housed at a uniform temperature, but the total amount of time spent aroused was not significantly different between the two groups. Only two of the five bats in the experimental group demonstrated a preference for the warmer areas of the chamber while aroused. A greater understanding of temperature effects on hibernation behavior is important for the conservation of bats and their existing hibernacula, as well as for the construction of artificial roosts.

***Frugivorous Bat Ensemble in Riparian Habitat in Tropical Dry Forest: Effect of Vegetation Structure and Seasonality**

Mariana Zarazúa-Carbajal, Luis Daniel Avila-Cabadilla, Mariana Yólotl Álvarez-Añorve, Julieta Benítez-Malvido, Hector Arita, Luis Gerardo Herrera, and Kathryn Stoner; UNAM, Morelia, Michoacán, México; UNAM, D.F., México; Texas A&M University-Kingsville, Kingsville, TX

*** Mariana Zarazúa-Carbajal** received the **Bernardo Villa Award**.

The unique vegetation structure and composition of riparian habitat, as well as its distribution within the landscape, provide fauna with shelter, feeding resources, and commuting areas. Few studies have addressed the importance of riparian habitat for bats in the tropics, especially in dry forests where riparian forest likely is the main source of food, water, and shelter for fauna during long drought periods. This study documented frugivorous bat abundance and species richness in riparian forest and upland dry forest during the dry and rainy season, and evaluated how vegetation structure and composition in each habitat determine bat ensemble attributes. We sampled bats and vegetation in three upland dry forest and three riparian forest sites in the Chamela-Cuixmala Biosphere Reserve in Jalisco, Mexico. Bat ensembles and populations were analyzed with generalized linear models, including as independent factors: 1) habitat and season; 2) vegetation structure and species composition; and 3) vegetation structure, vegetation species composition, and canopy cover. In 72 nights we captured 840 bats of 7 species of Stenodermatinae. Total abundance of frugivorous bats including *Artibeus jamaicensis* was higher in riparian forest than in upland dry forest. Abundance was also higher in the rainy season and positively correlated to vegetation structure and canopy cover. Species composition of the frugivorous bat ensemble was positively related to vegetation structure during the dry season. There were no differences in bat species richness or diversity between habitat or seasons. The results highlight the importance of riparian forest for frugivorous bats, especially during the dry season.

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ANNOUNCEMENTS

The State of the United Kingdom's Bats—Latest Edition

The latest edition of the State of the United Kingdom's Bats is now available to download at http://www.bats.org.uk/pages/results_and_reports.html. This publication highlights the most up-to-date population trends of all species currently surveyed for the National Bat Monitoring Programme (NBMP)—a partnership between BCT, the Joint Nature Conservation Committee, Countryside Council for Wales, and Defra, with additional funding from Natural England. It is the longest running purpose-built monitoring program for mammals in the United Kingdom. More detailed trend data can be found in the *2011 National Bat Monitoring Programme Annual Report*, which can also be found at the above link**.**

Basically Bats Student Research Scholarship for 2013-2014

Basically Bats Wildlife Conservation Society announces a $5,000 student research scholarship. The scholarship will be awarded for research directly related to white-nose syndrome in North American bats. **Deadline** for receipt of applications is **June 30th, 2013**. For more information please contact Dr. Steve Burnett at sburnett@clayton.edu.

Request for Manuscripts — *Bat Research News*

Original research/speculative review articles, short to moderate length, on a bat-related topic would be most welcomed. Please submit manuscripts as MSWord documents to Allen Kurta, Editor for Feature Articles (akurta@emich.edu). If you have questions, contact either Al (akurta@emich.edu) or Margaret Griffiths (margaret.griffiths01@gmail.com). Thank you for considering submitting some of your work to *BRN*.

Change of Address Requested

Will you be moving in the near future? If so, please **send** your **new postal and e-mail addresses** to Margaret Griffiths (margaret.griffiths01@gmail.com), and include the date on which the change will become effective. Thank you in advance for helping us out!

FUTURE MEETINGS and EVENTS

11–13 January 2013

Bat Conservation and Management, Inc. and SonoBat are hosting a SonoBat Software Training Workshop at the Airport Best Western in Albany, New York, from 11–13 January 2013. The course will highlight current acoustic inventory techniques with a focus on the use of the latest full-spectrum bat detectors and echolocation call analysis. More information can be found at:
http://www.batmanagement.com/Programs/2013AlbanySBS/2013AlbanySBS.html.

11–15 August 2013

The 16th International Bat Research Conference and the 43rd Annual NASBR will be held at the Hotel Herradura in San Jose, Costa Rica, August 11th–15th, 2013. See http://www.ibrc2013.com/index.php for more information about the meeting.

2014

The 44th Annual NASBR will be held in Albany, New York, in October 2014, dates TBA. See the NASBR website for future updates — http://www.nasbr.org/.

2015

The 45th Annual NASBR will be held in Monterey, California, in October 2015, dates TBA. See the NASBR website for future updates — http://www.nasbr.org/.