BAT RESEARCH NEWS

VOLUME 52: NO. 1 SPRING 2011

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Front Cover

Uroderma bilobatum (the common tent-making bat) in Costa Rica, by Jason Collins. Many thanks to Jason for sharing the 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 Al Kurta, recent literature items to Jacques Veilleux, and conservation items and all other correspondence to Margaret Griffiths. (Contact information is listed above.)

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BOOK REVIEW

Bats of Ohio. Virgil Brack, Jr., Dale W. Sparks, John O. Whitaker, Jr., Brianne L. Walters, and Angela Boyer. Indiana State University Center for North American Bat Research and Conservation, Terre Haute, Indiana. 92 pp., 2010. Softcover: ISBN: 978-0-9817096-3-5 ($10 U.S.)

Bats of Ohio is a long overdue and much needed synthesis of the ecology, distribution, and conservation needs of bats in Ohio. Considerable research and survey efforts have been completed in the state during the past two decades and the information available on these bats has grown accordingly. The last effort to describe the bats in the state was in Gotttschang's (1981) *A Guide to the Mammals of Ohio*. This current volume provides an excellent and up-to-date overview of the assemblage of bats in Ohio, placing a strong and much needed emphasis on conservation issues. The five authors bring considerable years of experience working with bats in Ohio and are experts on these species in the state.

The layout of the book is similar to recent publications from the Indiana State University Center for North American Bat Research and Conservation, such as *Bats of Indiana* by Whitaker et al. (2007) and *Bats of Michigan* by Kurta (2008). Included are county-based distribution maps of the nine most common species, one table comparing morphological characteristics of the different species of *Myotis*, and 59 figures, mostly in color, that cover all species of bats in Ohio, some of their common insect prey, and parasites for which these bats are hosts. The latter two sets of figures are an interesting addition to the volume for scientists, managers, and laypersons alike. The book is organized into seven chapters, including an introduction, a description of the annual cycle of bats in the state, methods for studying bats, threats to bats, the interplay of bats and humans, and conservation of bats. The final section includes 11 species accounts, preceded by an easy-to-follow dichotomous key to the bats of Ohio. After the species accounts, a glossary of terms is provided for those less familiar with bats. The book ends with a bibliography that includes two sections: literature relevant to bats in Ohio and a lengthy listing of recent, unpublished studies by environmental consultants, which is helpful to those interested in studying bats in the state.

The introduction sets the tone of the book with folklore, taxonomy, and some of the basics of bat biology, such as echolocation, feeding ecology, and reproduction. The section on parasites of bats in Ohio is a nice addition not regularly found in similar publications. The chapter titled "A Year in the Life of a Bat in Ohio" describes the staging, maternity, swarming, and hibernation seasons of bats. The section on hibernation is especially well done. In this section and elsewhere in the volume, the authors periodically raise questions about bats and their ecology, facilitating the reader to think more in depth about the subject. The next chapter briefly explains field methods for studying bats, emphasizing capture, radio-tracking, ultrasonic detection, and dietary analyses. The chapter "Threats and Causes of Decline" describes primary threats to bats and stresses habitat fragmentation, pesticides, wind power, and white-nose syndrome. The chapter "Bats and Humans" indicates both positive and negative aspects of bat/human interactions and contains a 'how to' description of bat houses and their use. The discussion of rabies in bats is very informative. The subsequent chapter "Bat Conservation" is a bit dry to read, emphasizing codes and listings of non-governmental organizations that target bat conservation.

The final chapter provides accounts for all 11 species of bats currently or formerly

known to occur in Ohio. The accounts are well written and use the authors own examples of work or observations of bats in the state that add context and make the book more interesting and relevant to Ohio. The accounts are organized according to the perceived abundance of each species in the state and vary in length, likely based on existing knowledge and the authors own experiences with each species. Each account contains four sections: description, similar species, distribution, and habits. However, the writing emphasizes varying content across species within sections, making the book, in my opinion, more attractive to the reader. The distribution maps that accompany species accounts are based upon 175 studies completed in Ohio from 2005 to 2009. Thus, the maps provide the current distribution for each species, but lack historic information available in earlier published works and records available in collections at the Ohio State University. The duplication of species names on each map and in the legend for each map seems unnecessary.

The book is laid out in an attractive manner, but I found several formatting errors, the most glaring of which is the heading in the species account for Rafinesque's big-eared bat. The far right column in Table 1 incorrectly indicates that toe hairs are shorter than the claws for little brown bats, although the text on pages 48 and 52 describe that character correctly. The heading for Figure 35 is incorrect, describing the relationship between the length of toe hairs and claws differently from that presented in the image. There are a few misstatements of fact, such as equating the terms poikilotherm and ectotherm, describing triangulation as the crossing of three bearings instead of two, and stating that *Lasiurus cinereus* is the second largest bat in the United States even though there are multiple species in the Southwest that exceed the hoary bat in mass and dimensions. The authors mix the use of old and new common names for *Perimyotis subflavus* throughout the text and even within the same image (Map 5); the book would have been better served if one of the two had been chosen and used throughout. Regardless, I found this volume to be informative, very readable, and a good source of information on bats in Ohio. The book will make an excellent addition to the working libraries of scientists, managers, and consultants interested in the bats of Ohio and surrounding states, and serves as a helpful introduction to bats for interested laypersons living in the midwestern United States.

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From the Editor

Greetings!

I hope that 2011 finds you well. To our new subscribers, welcome and thank you for subscribing to *Bat Research News*! To our returning subscribers, thank you for renewing your subscription to *Bat Research News*! I appreciate and value your continued support.

As hard as it to believe, I am beginning my eighth year as publisher and managing editor of *Bat Research News* (*BRN*). One of the most common requests I have received over the years is to have a complete listing of contents for *BRN*, and indeed developing that 50-year list has been one of my top goals as well. Thanks to several people—especially Roy Horst and Tom Griffiths—I now have a complete set of back issues of *BRN* and am in the process of doing just that. On *BRN*'s Web site, you will find a complete listing of the table of contents for Volumes 1–30 and Volumes 41–51. The lists are available by decade (Vol. 1–10, Vol. 11–20, etc.) as downloadable PDFs. To find the lists, go to *BRN*'s homepage, and click on the "Back Issues/Table of Contents" link, which will take you to the page with links to the table of contents documents. Over the next few months, I plan to finish the list for Volumes 31–40 and will post it when it is finished. I hope you find these listings helpful.

One thing that struck me as I went through the first 30+ years of journals/newsletters was how grateful we all should be to those who have worked diligently to produce *Bat Research News* over the years. The next time you see the following individuals, thank them for their time, efforts, and selfless sacrifices to produce *Bat Research News* over the past 50 years—Wayne Davis (Founder and Managing Editor, 1960–1970); Robert L. Martin (1970–1975); Stephen R. Humphrey (1973–1974); M. Brock Fenton (1977–1981); Kunwar Bhatnagar (1982–1986); Tom Griffiths (1987–2001); and G. Roy Horst (1977–2004). As someone who followed in their footsteps, I am deeply grateful to each of them for what they did.

Al, Jacques, and I hope to bring you some interesting articles and news this year, but we need your help too. Please consider submitting short-to-moderate length, bat-related research or review articles to *Bat Research News*. We'd be happy to receive non-technical articles as well, describing your research or updates in your area of expertise, or some bat educational or conservation projects you are doing. Also send us news from your lab, field work, sabbatical experience, etc.

Finally I'm always glad to hear from you and any comments you have, so please consider sending us something. (Both positive and negative comments are welcome, although I must admit the former usually make my day!)

Best wishes,

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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ANNOUNCEMENTS

Bat Conservation International's 2011 Workshops

Bat Conservation International has announced the dates and locations for their 2011 workshops. Two different **Bat Conservation and Management Workshops** will be offered this year. One session will be held in Portal, Arizona, May 8–13, 2011, and will emphasize bats of the western U.S. The other will be held in Olive Hill, Kentucky, September 12–17, 2011, with emphasis on bats of the eastern U.S. The **Acoustic Monitoring Workshop** will be held May 19–24, 2011, in Portal, Arizona. Plus BCI is offering a brand **new Advanced Capture Techniques Workshop** this year. It will be held in Portal, Arizona, May 14–18, 2011. Information and registration forms for all workshops can be found under the "Get Involved" link on BCI's website: http://www.batcon.org/.

2011 SonoBat Training Courses

Bat Conservation and Management, Inc., and SonoBat will host three SonoBat training courses, which will introduce participants to noninvasive acoustic monitoring and species identification of bats. The Software Training Course will be held in Gettysburg, PA, March 19–20, 2011. The Western Field Techniques Course will be held in Tucson, AZ, April 15–18, 2011. The Eastern Field Techniques Course will be held in Uniontown, PA, September 28–October 1, 2011. Detailed information about these workshops and contact information can be found at: http://www.batmanagement.com/Programs/programcentral.html.

Bat Course 2012 on Taxonomy, Ecology and Conservation (Peru)

Valeria Tavares has announced that the Bat Course 2012 on Taxonomy, Ecology and Conservation will be conducted in the Jenaro Herrera Research Center, IIAP, Loreto, Peru, 14–24 January 2012. The application deadline is 1 August 2011. Additional information may be found at the course's webpage: http://cebioperu.org/courses/bat.html.

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 (griffm@lycoming.edu). 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 (griffm@lycoming.edu), and include the date on which the change will become effective. Thank you in advance for helping us out!

FUTURE MEETINGS and EVENTS

2–5 May 2011
The Conference on Wind Energy and Wildlife Impacts will be held in Trondheim, Norway, May 2–5, 2011. For information please see: http://www.cww2011.nina.no/.

22–26 August 2011
The XIIth European Bat Research Symposium will be held in Vilnius, Lithuania, August 22–26, 2011. Information can be found at: http://www.chiroptera.lt/symposium/index1.php?do=1.

26–29 October 2011
The 41st Annual NASBR will be held in Toronto, Ontario, Canada, October 26–29, 2011. Please check the NASBR Web site at http://www.nasbr.org/ for upcoming information.

2012
The 15th Australasian Bat Society Conference will be held in Melbourne, Australia, dates TBA. Check http://ausbats.org.au/ for any updates.

The 42nd Annual NASBR will be held in San Juan, Puerto Rico, dates TBA.

2013
The 43rd Annual NASBR and the 15th International Bat Research Conference will be held in Costa Rica, dates and city TBA.

BAT RESEARCH NEWS

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Front Cover

The characteristic white fungus (*Geomyces destructans*) associated with white-nose syndrome covering the nose, ears, and wings of a *Myotis septentrionalis* (northern long-eared myotis) in Durham Mine, Bucks County, Pennsylvania, on March 2011. Photo taken by Greg Turner. Please see article about the state of bats and white-nose syndrome in this issue.

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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 Al Kurta, recent literature items to Jacques Veilleux, and conservation/education items and all other correspondence to Margaret Griffiths. (Contact information is listed above.)

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

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A Five-year Assessment of Mortality and Geographic Spread of White-nose Syndrome in North American Bats and a Look to the Future

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Overview

The presence of an unusual fungal infection and aberrant behavior in hibernating bats was first described in New York during winter 2006–2007. The disease was dubbed white-nose syndrome (WNS) after the most prominent field sign—white fungus on the muzzle and other areas of exposed skin. The fungus, newly described as *Geomyces destructans*, also produces characteristic skin lesions on the wing and other membranes of bats (Blehert et al., 2009; Courtin et al., 2010; Meteyer et al., 2009) and probably is the causative agent of the disease (Blehert et al., 2009; Gargas et al., 2009). In this review, we briefly summarize the current state of knowledge, including estimates of mortality for a five-state region, and describe a national plan for managing WNS. Our report is not meant to be a comprehensive review of the ever-expanding literature, but we do include a bibliography of peer-reviewed publications concerning WNS.

Geographic and Taxonomic Spread

White-nose syndrome was first noticed at Howe's Cave, near Albany, New York, in February 2006 (Blehert et al., 2009; Turner and Reeder, 2009). Currently, the presence of WNS in hibernating bats has been confirmed using histopathological criteria (Meteyer et al., 2009) at more than 190 sites in 16 states and 4 Canadian provinces (Fig. 1). Three additional states are considered suspect for the disease. Evidence of *G. destructans* has been obtained from bats not associated with any hibernaculum in Delaware, and *G. destructans* also has been identified on bats from three hibernacula in Missouri and Oklahoma through polymerase-chain-reaction (PCR) techniques, although infection in each of the three states could not be confirmed by histopathology. The detection of *G. destructans* on a bat in western Oklahoma indicates that the fungus has spread ca. 2,200 km from the original site in New York.

Infection with *G. destructans* and significant mortality associated with WNS has been documented in six species: big brown bat (*Eptesicus fuscus*), small-footed bat (*Myotis leibii*), little brown bat (*M. lucifugus*), northern long-eared bat (*M. septentrionalis*), Indiana bat (*M. sodalis*), and tricolored bat (*Perimyotis subflavus*). Rates of mortality vary among species (Table 1), although reasons for the variation are unknown. *G. destructans* also has been isolated from three additional species—southeastern bat (*M. austroriparius*), gray bat (*M. grisescens*), and cave bat (*M. velifer*)—but without histological evidence of tissue damage or reports of mortality. In summer 2009, researchers convening at a WNS Science Strategy Meeting in Austin, Texas, estimated that at least one million bats had died from WNS (Kunz and Tuttle, 2009). Given the spread to new hibernacula and significant mortality noted across the region since this estimate (Fig. 1; Table 1), we believe that the number of bats that have died from WNS is surely much greater.

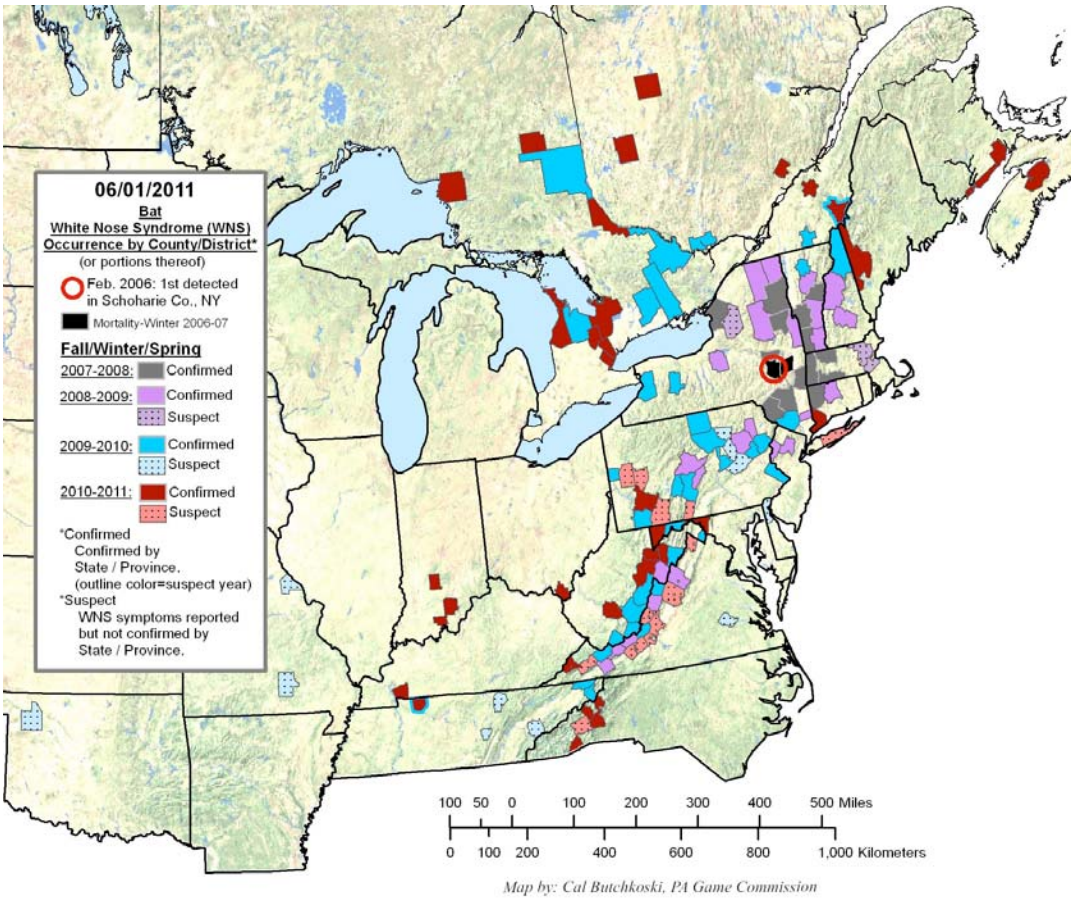

Figure 1. Current distribution of WNS in North America, showing progression of the disease over time and status ("confirmed" or "suspect") of each region as of 23 May 2011 (map may be viewed in color at http://www.fws.gov/WhiteNoseSyndrome; map by C. Butchkoski). A site (cave, county, state, etc.) is labeled as confirmed only if histopathological examination of a bat from a hibernaculum documents "a specific pattern of fungal colonization in the epidermis, which may extend to invasion of the dermis and connective tissue" (http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/wns_definitions.jsp; see details in Meteyer et al., 2009). Simple presence of hyphae or conidia, a positive fungal culture, or PCR-positive results, without fulfillment of the histopathological criteria, result in a site being categorized as suspect. In this report, a bat with simple evidence of *G. destructans* or even with histopathological signs of WNS that is found away from any hibernaculum also results in that geographic area being labeled as suspect (e.g., Delaware).

Epizootiology of WNS

Causation.—Geomyces destructans is the causative agent of the characteristic skin lesions seen on the exposed skin and in the hair follicles of affected bats (Blehert et al., 2009; Courtin et al., 2010; Meteyer et al., 2009). Although experiments are underway to determine whether *G. destructans* is the causal agent underlying WNS, the results are not yet available, and the mechanism by which an infection of the skin with *G. destructans* kills bats is unclear. In addition to studies examining the relationship between *G. destructans* and mortality, other projects that are underway include investigation of the microfauna of wing membranes and the potential roles they may play in differential survival among species or sites; exploration of various treatments for clearing fungal

infection in hibernating bats; molecular studies of the transcriptome of infected and healthy individuals, which will reveal patterns of up- and down-regulated genes, thus providing insight into responses to WNS and other potential pathogens; investigations of physiological and behavioral responses/ symptoms, including water/electrolyte balance and function of the immune system; determination of variations in species susceptibility, including non-volant mammals; and examination of the relationship between microclimate of the hibernacula and progression of the disease. Although some of this research does not require definitive identification of the causative agent, the operating assumption of most biologists within the WNS-research community is that *G. destructans* is responsible for the disease.

Anecdotal observations of bats infected by *G. destructans* may shed light on the mechanisms underlying mortality. For example, affected bats exhibit aberrant behavior including altered sensory thresholds; tremors of the forearms as they crawl; flying in daylight and collisions with large stationary objects, such as the side of a building; and excessive thirst, as evidenced by licking snow or flying for prolonged periods over small areas of open water (Hendricks and Hendricks, 2010). Either starvation and/or loss of electrolytic homeostasis could potentially explain these symptoms. Courtin et al. (2010) noted reduced (but varied) fat reserves in affected bats, which is likely due to shifts in arousal patterns during hibernation (D. M. Reeder, unpublished data), whereas Cryan et al. (2010) hypothesized that fungal attacks are disrupting physiological functions of the wing, particularly the bat's ability to maintain water balance. These are areas that hopefully will receive more attention in the near future.

Geographic origin.—Infection of bats by *G. destructans* without subsequent mass mortality has been recorded widely across Europe (Martinkova et al., 2010; Puechmaille et al., 2010, 2011; Šimonovičov et al., 2011; Wibbelt et al., 2010). For example, Martinkova et al. (2010) examined archived photographs taken since 1994 of greater than 6,000 bats in the Czech Republic and Slovakia, and their findings indicated the presence of *G. destructans* in those countries since at least 1995. These authors also noted that the incidence of visible fungus on the greater mouse-eared bat (*M. myotis*) increased from 2% in 2007 to 14% in 2010, but despite that increase, the population of bats actually grew. This inter-year variation could represent natural fluctuation in abundance of *G. destructans* or differential detection, but the lack of significant mortality and widespread geographic occurrence of the fungus suggest that *G. destructans* has been present in Europe for at least a decade (and likely longer) and that once the fungus becomes established in hibernacula, it persists. The lack of substantial mortality in European bats indicates that they are likely resistant to *G. destructans* and that *G. destructans* represents a novel pathogen for North American species.

Factors influencing transmission and spread.—Two modes of transmission of *G. destructans* have been proposed: bat-to-bat, via direct contact between animals, and hibernaculum-to-bat, via exposure to spores of *G. destructans* that were present on a roosting substrate, whether they were brought their by other bats or by humans. Bat-to-bat transmission is especially likely for those species that typically cluster during hibernation, such as little brown bats and Indiana bats. Given the temporal and geographical distribution of WNS, the scientific community investigating the disease generally agrees that bats can spread the fungus from site to site and to one another. The strongest evidence for interbat transmission comes from the infection of animals at numerous sites that were secured

Table 1. WNS-induced mortality of six species of hibernating bats from 42 sites in New York, Pennsylvania, Vermont,

		Species								
		Myotis lucifugus			*Myotis sodalis*			*Myotis septentrionalis*		
Site Name (Year WNS confirmed)	Pre-/Post-WNS Count Year	Pre-WNS Count[a]	Post-WNS Count	% Change	Pre-WNS Count (Year)[b]	Post-WNS Count	% Change	Pre-WNS Count	Post-WNS Count	% Change
New York										
Barton Hill Mine (2008)	2007/2011				9,393	7,398	-21%			
Baryte 'Garden of Dina' Mine (2007)	2006/2010	1	3	200%				6	0	-100%
Bartyes Cave (2009)	1986/2011	24	1	-96%				12	0	-100%
Bennett Hill Hitchcock Mine (2009)	2003/2011	17,399	1,669	-90%				26	11	-58%
Clarksville Cave (2008)	2006/2010	21	0	-100%				2	0	-100%
Eagle Cave (2009)[c]	1985/2011	2,587	4,324	67%				7	0	-100%
Gage's Cave (2007)	1985/2011	940	40	-96%				1	0	-100%
Glen Park Cave (2008)	2003/2011	151	10	-93%	1,908 (2007)	433	-77%			
Hailes Cave (2007)	2005/2011	15,374	1,496	-90%	685	0	-100%	14	4	-71%
Hasbrouck Mine (2009)	2006/2011	2,922	1,218	-58%						
Howe Cave (2006)	2005/2011	1,213	29	-98%				5	0	-100%
Howes Quarry Mine (2008)	1995/2010	42	1	-98%				6	0	-100%
Jamesville Quarry Cave (2009)	2003/2011	1,346	573	-57%	4,171 (2005)	251	-94%	2	1	-50%
Knox Cave (2007)	2001/2011	1,820	354	-81%				5	0	-100%
Lawrenceville Mine (2009)	2004/2011	293	6	-98%	57	71	25%	25	0	-100%
Main Graphite Mine (2008)	2000/2010	183,542	2,049	-99%	109 (2007)	0	-100%	440	0	-100%
Martin Mine (2008)	2004/2010	720	6	-99%				44	0	-100%
Schoharie Cavern (2007)	1999/2010	953	22	-98%				18	0	-100%
South Bethlehem Cave (2008)	2005/2011	100	0	-100%						
Walter Williams Preserve (2008)	1999/2010	87,401	16,673	-81%	13,014 (2007)	122	-99%	1	1	0%
Williams Fire Pit Mine (2008)	2002/2011	0	323	32,300%	0	718	71,800%	3	0	-100%
Williams Hotel Mine (2008)[d]	2003/2011				24,317 (2007)	6,389	-74%			
Williams Lake Mine (2008)	2003/2011	9,432	24	-100%	1,003 (2007)	11	-99%			

Virginia, and West Virginia, that have had WNS for at least 2 years.

Species											
Myotis leibii			*Perimyotis subflavus*			*Eptesicus fuscus*					
Pre-WNS Count	Post-WNS Count	% Change	Pre-WNS Count	Post-WNS Count	% Change	Pre-WNS Count	Post-WNS Count	% Change	**Pre-WNS Grand Total**	**Post-WNS Grand Total**	**% Change**
									9,393	**7,398**	**-21%**
			1	3	200%	7	15	114%	**15**	**21**	**40%**
			1	0	-100%	1	16	1,500%	**38**	**17**	**-55%**
183	398	117%	9	6	-33%	51	51	0%	**17,668**	**2,135**	**-88%**
			59	4	-93%				**82**	**4**	**-95%**
53	43	-19%				0	1	100%	**2,647**	**4,368**	**65%**
			27	0	-100%				**968**	**40**	**-96%**
			1	2	100%	14	3	-79%	**2,074**	**448**	**-78%**
15	1	-93%	45	9	-80%	1	0	-100%	**16,134**	**1,510**	**-91%**
						1,659	729	-56%	**4,581**	**1,947**	**-57%**
88	29	-67%	42	4	-90%	13	10	-23%	**1,361**	**72**	**-95%**
			47	0	-100%	0	1	100%	**95**	**2**	**-98%**
			0	2	200%				**5,519**	**827**	**-85%**
11	5	-55%	57	0	-100%				**1,893**	**359**	**-81%**
15	4	-73%	288	6	-98%	72	37	-49%	**750**	**124**	**-83%**
721	485	-33%	194	2	-99%	18	9	-50%	**185,024**	**2,545**	**-99%**
7	9	29%	112	4	-96%	135	31	-77%	**1,018**	**50**	**-95%**
0	1	100%	55	0	-100%	0	1	100%	**1,026**	**24**	**-98%**
17	26	53%	26	5	-81%	41	20	-51%	**184**	**51**	**-72%**
34	9	-74%	13	0	-100%	220	84	-62%	**100,683**	**16,889**	**-83%**
0	2	200%	1	0	-100%	5	71	1,320%	**9**	**1,114**	**1,2278%**
3	0	-100%				131	50	-62%	**24,451**	**6,439**	**-74%**
11	7	-36%	30	0	-100%	120	270	125%	**10,596**	**312**	**-97%**

Table 1 (cont.)

Site Name (Year WNS confirmed)	Pre-/Post-WNS Count Year	*Myotis lucifugus* Pre-WNS Count	*Myotis lucifugus* Post-WNS Count	*Myotis lucifugus* % Change	*Myotis sodalis* Pre-WNS Count (Year)[a]	*Myotis sodalis* Post-WNS Count	*Myotis sodalis* % Change	*Myotis septentrionalis* Pre-WNS Count	*Myotis septentrionalis* Post-WNS Count	*Myotis septentrionalis* % Change
New York (cont.)										
Williams Mine #7-8 (2008)	2002/2011	531	33	-94%	0	18	1,800%	2	0	-100%
Williams Mine #9-10 (2008)	2002/2011	1	35	3,400%						
Williams Mine #11 (2008)	2007/2011	54	1	-98%						
New York Totals and % Difference		**326,867**	**28,890**	**-91%**	**54,657**	**15,411**	**-72%**	**619**	**17**	**-97%**
Pennsylvania										
Alexander (2008)	2006/2010	1,604	8	-100%				30	0	-100%
Durham (2009)	2004/2011	7,356	161	-98%				881	2	-100%
Mt Rock (2009)	2005/2011	20	6	-70%						
Nuangola (2008)	2008/2011	224	0	-100%				6	0	-100%
Shindle (2008)[e]	2008/2010	2,276	3	-100%				19	0	
Woodward (2009)	2010/2011	2,749	20	-99%	3	0	-100%	4	0	-100%
Pennsylvania Totals and % Difference		**14,229**	**198**	**-99%**	**3**	**0**	**-100%**	**940**	**2**	**-100%**
Vermont										
Brandon Silver Mine (2009)	2009/2011	86	4	-95%	2	3	50%	27	0	-100%
Camp Brook Mine (2009)	2009/2011	40	0	-100%				21	0	-100%
Dover Iron Mine (2009)	2009/2011	518	22	-96%				12	0	-100%
E. Magnesia Talc Mine (2009)	2009/2011	768	84	-86%				35	3	-91%
Ely Copper Mine (2009)	2004/2011	531	4	-99%				41	0	-100%
Vermont Totals and % Difference		**1,943**	**114**	**-94%**	**2**	**3**	**50%**	**136**	**3**	**-98%**
Virginia										
Breathing Cave (2009)	2001/2011	701	475	-32%				7	9	29%
Newberry-Bane (2009)	2009/2011	4,143	557	-87%	208	146	-30%			
Virginia Totals and % Difference		**4,844**	**1,032**	**-79%**	**208**	**146**	**-30%**	**7**	**9**	**29%**
West Virginia										
Cave Mountain (2009)	2007/2011	209	17	-92%						
Hamilton (2008)	2007/2011	43	1	-98%						
Trout (2009)	2007/2011	142	8	-94%	158	90	-43%	4	0	-100%
West Virginia Totals and % Difference		**394**	**26**	**-93%**	**158**	**90**	**-43%**	**4**	**0**	**-100%**
All States Combined Totals and % Difference		**348,277**	**30,260**	**-91%**	**55,028**	**15,650**	**-72%**	**1,706**	**31**	**-98%**

[a] A blank indicates that no data on that species were provided by the state agency.
[b] Some sites in New York had visits to survey specifically for Indiana bats (*Myotis sodalis*) on dates more recent than the full site survey presented; in these
[c] Eagle Cave represents a significant increase, but this anomaly is likely due to the 25 years since the previous survey.
[d] The survey of the Williams Hotel Mine does not include counts for little brown bats (*Myotis lucifugus*), because the state biologist omitted them for
[e] Shindle Iron Mine was confirmed in December 2008, and although it qualified as 2 years, the site should be considered one full season of mortality; it

Myotis leibii			*Perimyotis subflavus*			*Eptesicus fuscus*					
Pre-WNS Count	Post-WNS Count	% Change	Pre-WNS Count	Post-WNS Count	% Change	Pre-WNS Count	Post-WNS Count	% Change	**Pre-WNS Grand Total**	**Post-WNS Grand Total**	**% Change**
0	2	200%	34	0	-100%	17	12	-29%	**584**	**65**	**-89%**
0	12	1200%				7	61	771%	**8**	**108**	**1,250%**
						61	6	-90%	**115**	**7**	**-94%**
1158	**1033**	**-11%**	**1042**	**47**	**-95%**	**2573**	**1478**	**-43%**	**386,916**	**46,876**	**-88%**
0	1	100%	16	1	-94%	0	1	100%	**1,650**	**11**	**-99%**
2	0	-100%	167	16	-90%	1	1	0%	**8,407**	**180**	**-98%**
1	1	0%	20	2	-90%	79	54	-32%	**120**	**63**	**-48%**
			12	9	-25%	36	2	-94%	**278**	**11**	**-96%**
			39	0	-100%				**2,334**	**3**	**-100%**
3	4	33%	30	0	-100%	17	4	-76%	**2,806**	**28**	**-99%**
6	**6**	**0%**	**284**	**28**	**-90%**	**133**	**62**	**-53%**	**15,595**	**296**	**-98%**
9	1	-89%	4	1	-75%	9	3	-67%	**137**	**12**	**-91%**
			0	1					**61**	**1**	**-98%**
			6	0	-100%				**536**	**22**	**-96%**
			0	0		8	5	-38%	**811**	**92**	**-89%**
122	90	-26%	5	6	20%	146	126	-14%	**845**	**226**	**-73%**
131	**91**	**-31%**	**15**	**8**	**-47%**	**163**	**134**	**-18%**	**2,390**	**353**	**-85%**
0	8	800%	513	408	-20%	12	21	75%	**1,233**	**921**	**-25%**
4	1	-75%	233	219	-6%	7	4	-43%	**4,595**	**927**	**-80%**
4	**9**	**125%**	**746**	**627**	**-16%**	**19**	**25**	**32%**	**5,828**	**1,848**	**-68%**
			151	8	-95%	6	2	-67%	**366**	**27**	**-93%**
			437	2	-100%				**480**	**3**	**-99%**
4	3	-25%	432	63	-85%	25	12	-52%	**765**	**176**	**-77%**
4	**3**	**-25%**	**1020**	**73**	**-93%**	**31**	**14**	**-55%**	**1,611**	**206**	**-87%**
1303	**1142**	**-12%**	**3107**	**783**	**-75%**	**2919**	**1713**	**-41%**	**412,340**	**49,579**	**-88%**

instances the year of the survey for Indiana bats follows the number of Indiana bats.

potential inaccuracies.
only was included because the mortality could not increase significantly with another year.

from human visitation and where no management or handling of bats occurred prior to arrival of WNS, such as the Shindle Iron Mine in Mifflin County, Pennsylvania (G. Turner, unpublished data).

The responses of a bat to WNS are surely contributing to the spread of the disease. Severely infected bats emerge prematurely from hibernation, and if they survive long enough and enter a different hibernaculum, the likelihood of transmission is probably high, because they presumably carry a large load of fungal spores. Many bats swarm at one site, yet hibernate at another (Humphrey and Cope, 1976), suggesting that infected bats know the location of other hibernacula. If infected bats survive the winter, their ability to retain viable spores and transmit *G. destructans* to healthy colony members in summer is unknown. Likewise, male bats that use hibernacula throughout summer may transmit *G. destructans* to other bats or sites during fall swarming.

Although bats are surely transmitting *G. destructans* to one another, more controversial is the occurrence of inadvertent human-assisted spread of the disease. Fungal spores are durable and easily can become attached to clothing or gear. Caving equipment used at a confirmed site did carry fungal spores having the distinctive shape of those of *G. destructans* (J. Okoniewski, unpublished data), and further research on this mode of transmission is ongoing. If in fact *G. destructans* was transported to North America from Europe, anthropogenic transmission via contaminated gear or clothing (and not bat-to-bat transmission) is the most parsimonious scenario for the initial infection. Furthermore, movement of the fungus to clean sites, hundreds or thousands of kilometers beyond the original epicenter in New York, might explain the rapid spread of WNS. To date, evidence for the anthropogenic spread of *G. destructans* remains largely anecdotal, but this fact does not diminish the very real risks posed by human action. Unintentional, human-assisted movement of pathogens is certainly not without historical precedent (e.g., the chytrid fungal disease in amphibians—Rosenblum et al., 2010) and is a grave concern to managers of animal health worldwide.

Significant variation exists in the time between detection of visible fungus and mass mortality. At some sites, we have observed the appearance of visible fungus on only a few animals during a particular winter, with further development of the disease and deaths not occurring until the next year or even later (e.g., Layton Fire Clay Mine, Fayette County, Pennsylvania). In other cases (e.g., Shindle Iron Mine), the progression from detection of a single bat with visible fungus to large-scale mortality has happened in a matter of weeks.

Once a bat is exposed to *G. destructans* at a particular location, a myriad of factors could influence progression of WNS. Understanding these factors is facilitated by considering the disease triangle (Fig. 2), which relates the potential dynamics of the host (bats of potentially multiple species), the pathogen (presumably *G. destructans*), and the environment (the hibernacula, but possibly active-season environments), as well as interactions between these variables. For example, questions such as how many spores are needed to establish infection (the loading dose) are best studied by considering the species of bat (different species and perhaps different sexes may vary in susceptibility), the time of year, and the nature of the hibernaculum (e.g., infections in sites with ambient temperature below the optimal growth temperature of *G. destructans* may progress more slowly). Likewise, understanding the timing of spread within a site and the rate of death once the fungus is visible will require analyses of these same variables.

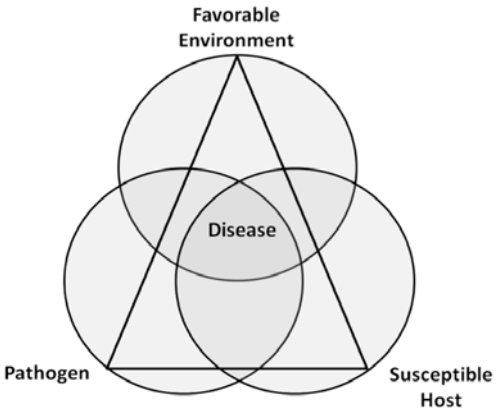

Figure 2. The disease triangle, showing the interrelationships between hosts, pathogens, and environment. A disease (WNS) occurs when a specific pathogen (presumably *Geomyces destructans*) infects susceptible hosts (hibernating bats) under certain environmental conditions (cold damp hibernacula, in which bats use torpor and effectively suppress their immune systems, allowing relatively unchecked fungal growth).

Patterns of Mortality

What is the overall decline of hibernating bats? Are there differences in mortality among species? Are there changes in mortality as the disease progresses across a region? These are some of the most frequently asked questions regarding the impacts of WNS, and biologists are just now starting to examine such issues. Unfortunately, answering these questions relies on accurately estimating/counting the number of bats in hibernacula, and multiple confounding variables make this a difficult task.

Difficulties encountered during winter surveys.—One variable affecting the accuracy of winter surveys is behavioral differences among species. For example, some species, such as big brown bats and small-footed bats are tolerant of low ambient temperatures and hibernate in highly variable conditions. They are often the last bats to enter and the first to leave a hibernaculum. Counts of these species, even those made in midwinter, often vary tremendously. This is likely due to variation in average ambient temperatures during a particular winter, which in turn affects whether the bats are in a particular cave or mine.

Timing of surveys may also play a significant role in differences among bat counts. Because winter surveys of some WNS-affected sites have been pushed from the typical mid-winter period to a time closer to natural emergence (to reduce potential stress on bats), early emerging species, such as big brown bats, and/or individuals affected with WNS may have already left, thus biasing these censuses. Finally, species preferences in roosting location during hibernation (e.g., northern long-eared bats prefer deep cracks) can result in significant underestimates of some species.

Even though most state agencies that perform the counts attempt to assign the same experienced surveyors to the same sites, misidentification of species is possible, especially for those bats that cluster in mixed-species groups and for those that are structurally similar. The physical size of the site, number of bats present, number of passages that surveyors cannot access, and amount of disturbance during the hibernating period can undermine accurate censuses.

The arrival of WNS in a site further affects the accuracy of counts. One of the hallmark signs that a site is affected is the shifting of roost sites within the hibernaculum and the premature exit of affected bats in winter, often months before food is available. Depending upon the time of the survey, this phenomenon may result in underestimates of winter abundance, whereas in other sites, numbers may initially increase during the first year of infection. For example, at Hall's Cave in Huntingdon County, Pennsylvania, total population size jumped from 75 bats before

WNS to 1,800 bats during the winter that WNS arrived, with a drop to 31 bats in the following year; surveys of surrounding sites did not detect similar changes in numbers. It is difficult to draw conclusions from the small number of these occurrences, but the increases may be due either to movement of bats away from nearby, high-mortality sites or to movement of bats within the site from hidden passages to areas closer to the entrance where they are more easily counted. The more pertinent question regarding the derivation of mortality numbers is whether or not to use these peaks in any estimate.

Prior to the arrival of WNS in new geographic areas, the collection of accurate population counts will allow a better understanding of WNS-related declines than may currently be possible in affected areas of the East. In addition, inclusion of data from the active season (e.g., counts at maternity colonies, acoustic surveys, and trapping during fall swarming—Brooks, 2011; Dzal et al., 2010) ultimately may help achieve a more accurate picture of total declines.

Current status of bat populations.—For the analysis presented herein, we utilized data for 42 sites from five states—New York, Pennsylvania, Vermont, Virginia, and West Virginia (Table 1). We limited our analysis to sites with confirmed mortality for at least 2 years, to control for some of the variation described earlier and have focused on counts derived from a consistent level of effort across years. Although some sites have many historical counts where numbers could have been averaged, many others do not, so for consistency, we present only data from the most recent census conducted prior to WNS and the latest count following confirmation of the disease. To reduce stochastic variation and/or issues relating to small samples, we added the count for each species at each site within a state to obtain average mortality estimates per species per state. We then combined data from all states to obtain an estimate of regional change in species composition and abundance. Finally, we aggregated all counted bats, regardless of species, to report the overall change in the total hibernating population for each state and the region. Note that the important number is the percent change in species by state, not absolute numbers, because our 42 sites represent only a fraction of known hibernacula in the region.

At our 42 sites, we saw a precipitous decline in the number of hibernating bats after WNS, from 412,340 to 49,579 animals, for an overall decrease of 88% (Table 1). All six species declined, but there were notable differences among species. Northern long-eared bats decreased by 98% (1,706 to 31 bats); little brown bats, 91% (348,277 to 30,260); tricolored bats, 75% (3,107 to 783); Indiana bats, 72% (55,028 to 15,650); big brown bats, 41% (2,919 to 1,713), and small-footed bats, 12% (1,303 to 1,142). The species with smaller reductions are hopefully less susceptible or more resistant to *G. destructans*, but it is possible that they are just declining at a slower rate, with total mortality rates eventually reaching those of the other species.

When examined by state, we see an overall decline of 98% in Pennsylvania, 88% in New York, 87% in West Virginia, 85% in Vermont, and 69% in Virginia. Although differences among states in overall mortality may be real, undersampling of sites and biased sampling of certain species (e.g., Indiana bats) also may contribute. As previously mentioned, increased accuracy of surveys and eventual inclusion of active-season data will improve our understanding of mortality by species and region. Unfortunately, our mortality estimates are in line with the mathematical models of Frick et al. (2010), who predict that the once-abundant and ubiquitous little brown bat has the potential to become extinct in the Northeast in only 7–30 years; a similar fate may await

Indiana, northern long-eared, and tricolored bats.

The differences in mortality among species also have affected composition of the hibernating assemblage (Fig. 3). For example, prior to WNS, little brown bats comprised 84.5% of all hibernating bats at the 42 sites used in this analysis, with Indiana bats at 13.4%. After WNS, little brown bats now represent only 61% of all bats, and Indiana bats have increased to 31.6% of the overall population.

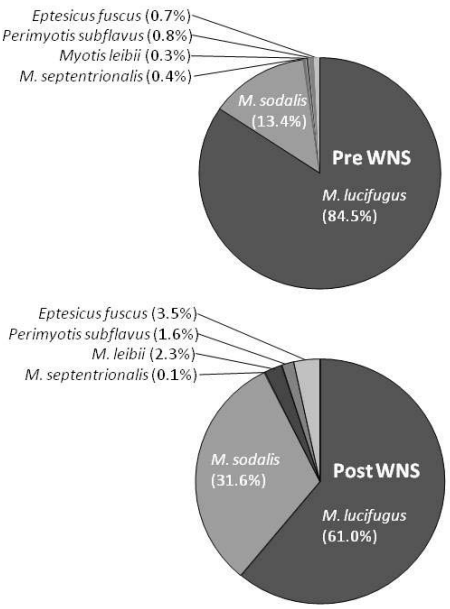

Figure 3. Changes in overall species composition for the six affected species of bats after 2 years of WNS-associated mortality (Table 1).

The National Plan

A final version of a national response plan, *A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats*, was released in May 2011 (http://www.fws.gov/WhiteNoseSyndrome/). The purpose of the national plan is to guide the reactions of federal, state, and tribal agencies and their partners to WNS. The plan has been developed with input from multiple agencies and establishes an organizational structure for the national response, with defined roles for agencies, stakeholders, and the research community. Oversight of implementation of the plan is provided by two committees—an executive committee and a steering committee—both of which were formally established during winter 2010–2011. The plan also officially institutes seven working groups to address the myriad needs of a national response: communications and outreach, conservation and recovery, data and technical information management, diagnostics, disease management, disease surveillance, and epidemiological and ecological research. The national plan will integrate and support state and regional response plans for WNS and is not intended to replace planning at the local/regional level.

The national plan for WNS is based on similar disease-response plans that have been implemented in the past (e.g., chronic wasting disease in cervids—http://www.cwd-info.org/index.php/fuseaction/policy.policy), and is essentially a formalization of coordinated efforts that were initiated in 2008. The final version of the plan is intended to be static, although implementation of the plan will be an adaptive process, allowing incorporation of new information and guidance, as they become available and/or necessary. The individual working groups will be responsible for developing and maintaining the various components of the action items identified for each element of the plan. The implementation of national strategies will help standardize management practices, including disease surveillance and population monitoring, to ensure consistency in data collection and to facilitate

interpretation of results at the continental scale. Because the national plan incorporates a number of actions and efforts that have been used to address WNS over the past 3 years, many elements of the plan are already in service. Existing and future guidance will continually be improved upon so that the WNS implementation plan will be an evolving system rather than a static document.

The Future of White-nose Syndrome?

While WNS continues to spread, not all news is bad news and several surprising findings offer rays of hope. For example, WNS has been confirmed in two hibernacula in West Virginia that harbor nearly 50% of the entire population of the endangered Virginia big-eared bat (*Corynorhinus townsendii virginianus*). Despite mortality of other species in those sites, no fungal infection has been found in the Virginia big-eared bat. Likewise, although *G. destructans* was detected in Oklahoma and Missouri in 2009–2010, histological examination showed that the infected bats were not suffering from WNS, and no new cases were detected in 2010–2011 in either state. Only one of four sites in Tennessee in which *G. destructans* was detected in 2009–2010 was confirmed by histology in 2010–2011, and despite an active surveillance program in Kentucky, WNS was not detected in that state until late spring 2011. Finally, limited evidence from the Northeast, mainly in the form of consistent annual counts at a few locations, suggests that some populations may have stabilized, albeit at much smaller sizes than before WNS. For example, surveys that occurred at Hailes Cave in New York before WNS estimated a hibernating population of 15,374 bats. Following the advent of WNS, annual surveys from winter 2007–2008 to 2010–2011, recorded 7,258; 1,443; 1,000; 1,198; and 1,496 bats.

Despite these few sources of optimism, the overall predictions for WNS are dire and researchers have really just begun to understand how the putative pathogen affects bats and spreads between individuals and populations. As many as 25 species of hibernating bats in North America may be susceptible to *G. destructans*, representing millions of individuals. To succeed in combating this threat, the size of the research community that is involved must increase significantly, with concomitant increases in funding. Efforts must be made not only to study the basic biology of this newly emerging disease, but also to generate a toolkit of mitigation strategies. Only when armed with more information and with mechanisms for fighting WNS can we truly have hope for the bats that hibernate in North America's mines and caves.

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Observations of Eastern Red Bats (*Lasiurus borealis*) 160 Kilometers from the Coast of Nova Scotia

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The eastern red bat (*Lasiurus borealis*) is a migratory species found throughout much of North America, except west of the Rocky Mountains (Cryan, 2003). In the East, these bats occasionally cross large expanses of open ocean during migration, as evidenced by their landing aboard ships off the coast of Nova Scotia (Fig. 1). On 7 October 1952, for example, Brown (1953) reported sighting red bats ca. 240 km SSE of Liverpool (42° 42′ N, 62° 58′ W), and on 17 August 1929, Norton (1930) mentioned a red bat ca. 210 km from Cape Sable (42°N, 66°W). Peterson (1970) provided another report of a red bat off Nova Scotia, ca. 145 km from Yarmouth (42° 30′ N, 66° 10′ W), in mid-October 1969. In addition to waters near Nova Scotia, red bats have been observed flying off Cape Cod, Massachusetts (Miller, 1897), as well as farther south (Carter, 1950; Mackiewicz and Backus, 1956). Nevertheless, despite these records, little is known about the frequency of long-distance, open-ocean flights in migratory bats, and additional observations are potentially useful.

During summer and fall, the distribution of eastern red bats spans most of eastern North America, but after fall migration, which occurs between August and November, their wintering range contracts primarily to areas near the Gulf of Mexico and the mid-Atlantic coast of the United States (Cryan, 2003). Interestingly, all records of red bats landing on ships occur during fall, and there are no such records during spring migration. Bats may routinely cross the Gulf of Maine to arrive at their overwintering grounds or may occasionally get blown out to sea during migration. In fall, westerly winds predominate in this region, which also may explain the occurrence of vagrant land birds on islands off Nova Scotia (McLaren, 1981). Migratory bats appear to be attracted to visually conspicuous tall structures on the landscape (Cryan and Brown, 2007), and if bats are blown off course during migration, it seems likely they would also be attracted to ships.

We report a new sighting of eastern red bats off the coast of Nova Scotia, near Sable Island, at ca. 43° 53.4' N and 60° 12.0' W (Fig. 1). The sighting was made by the officers and crew of a supply ship near an offshore natural-gas production platform, situated ca. 160 km from the coast of Nova Scotia and 8 km SW of Sable Island, a small island with no resident population of bats. The supply ship is 81 m in length and 16 m in width, with its bridge located 15 m above the waterline. For two-to-three consecutive evenings, up to three bats were observed at dusk. The sightings were not recorded in the log, and the crew could not remember the precise dates, although they did recall their position relative to the offshore platform at the time of the sightings. Therefore, we provide a range of potential dates for the sightings, 27 November–2 December 2010, based on the ship's activity and location

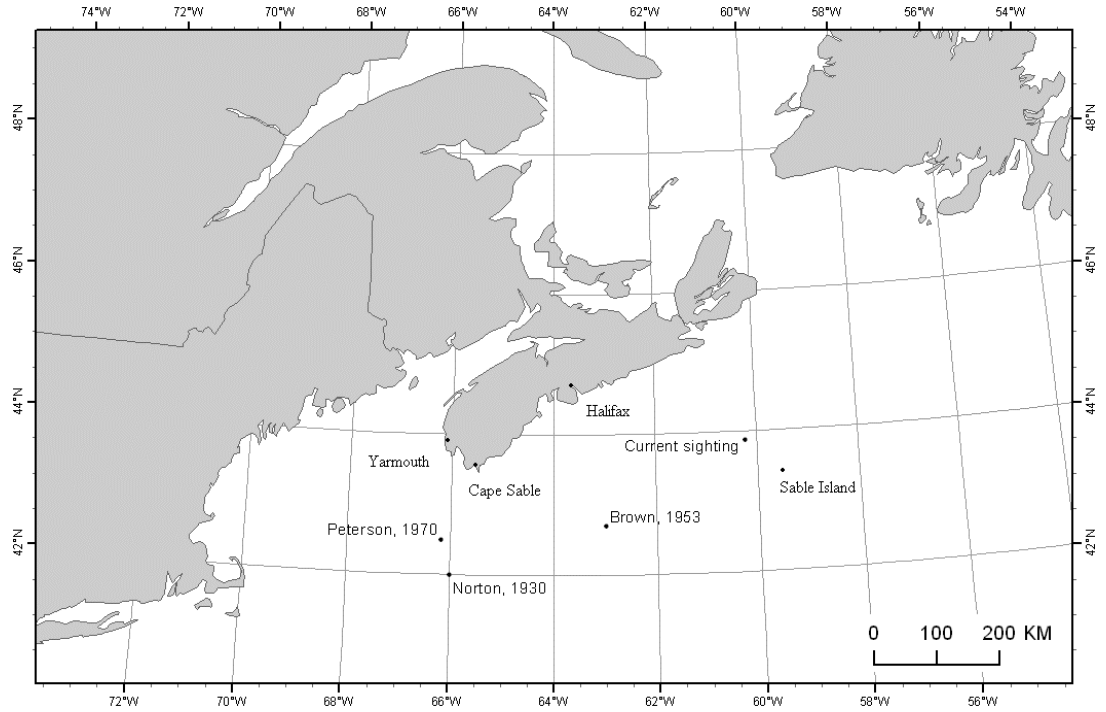

Figure 1. Map showing geographic sites on mainland Nova Scotia and approximate location of previous records of eastern red bats off the coast of Nova Scotia, along with the current sighting.

during that time.

An officer captured one of the bats when it roosted on a railing of the ship. When later asked about its appearance, the officer reported that the bat was clearly "red in color" with "very small ears." Photographs and descriptions of possible species—red bat, hoary bat (*Lasiurus cinereus*), little brown bat (*Myotis lucifugus*), and northern long-eared bat (*Myotis septentrionalis*)—were presented to the officer, who immediately identified the bat that he had captured as a red bat.

It is possible that the bat(s) stowed away on the ship, possibly roosting on railings, antennas, or under the lids of containers on the deck, during the three nights (23–25 November 2010) that the vessel was last in port, in the city of Dartmouth, Nova Scotia. However, this seems unlikely because eastern red bats typically roost in forest (Menzel et al., 1998), and the port area of Dartmouth is highly industrialized.

Aboard the ship, an officer recorded weather conditions on an hourly basis and recorded the information in a logbook aboard the vessel. Conditions at dusk during 27 November–2 December 2010 were mainly overcast, with good visibility (18 km), air temperature ranging from 5 to 8 °C, and predominately northwest winds, with Beaufort force of 2–6. Winds during the day and night were similar to those at dusk. Daytime temperatures during this period rose to as high as 13 °C, with nighttime temperatures as low as 2 °C. One week prior to the sightings, weather conditions were similar except that strong northwest winds (Beaufort force 6–10) were recorded on 21 November 2010. These relatively strong winds may be related to the occurrence of the bat(s) this far offshore. The 30-year-average wind speed for Sable Island at this time of year is 28.9 km/h (Beaufort force 4—Environment Canada, 2011).

These observations provide additional information on the fall migratory behavior of

eastern red bats and potentially other migrants who travel over the Gulf of Maine. The sightings were made in the open sea aboard a ship, which would have represented a visually conspicuous object for bats, and are consistent with the hypothesized attraction of migratory tree bats to tall structures (Cryan and Brown, 2007).

Oceanic records of bats rely on opportunistic sightings by crew and officers of offshore vessels, but there is currently no system in place to report these observations. Launching a "bat sighting" program would allow more rigorous documentation of the offshore occurrence of bats. Information regarding the importance of recording bats at sea, resources (e.g., photographs and descriptions of different species), and instructions (including datasheets) could be distributed to the crew and officers. Consistent recording of such observations could add insight into a poorly understood aspect of the migratory behavior of bats.

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ANNOUNCEMENTS

Basically Bats Wildlife Conservation Society, Inc. Student Research Award

Basically Bats Wildlife Conservation Society, Inc. announces a student research award for the 2011-2012 academic year. A $3,000 research scholarship will be awarded to a qualified student during the Fall of 2011. The scholarship 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 2011-2012 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 the field. **Deadline** for receipt of applications is **August 31st, 2011**. Applications should be submitted electronically (in .PDF format) to: Dr. Steve Burnett; sburnett@clayton.edu.

Neotropical Bat Project's Acoustic Data Services

Neotropical Bat Project is launching acoustic data services and provided Interactive ID keys for vocal signatures and distribution maps by U.S. counties for bats in the U.S. as well as data management services. For more information please see: https://sites.google.com/site/batsoundservices/

Bat Conservation International's 2011 Workshop

Bat Conservation International will hold their remaining workshop, "Bat Conservation and Management Workshop," in Olive Hill, Kentucky, September 12–17, 2011, with emphasis on bats of the eastern U.S. Information and registration forms can be found under the "Get Involved" link on BCI's website: http://www.batcon.org/.

2011 SonoBat Training Course

Bat Conservation and Management, Inc., and SonoBat will host the Eastern Field Techniques Course in Uniontown, PA, September 28–October 1, 2011. This training course will introduce participants to noninvasive acoustic monitoring and species identification of bats. Detailed information about these workshops and contact information can be found at: http://www.batmanagement.com/Programs/programcentral.html.

Bat Course 2012 on Taxonomy, Ecology and Conservation (Peru)

Valeria Tavares has announced that the Bat Course 2012 on Taxonomy, Ecology and Conservation will be conducted in the Jenaro Herrera Research Center, IIAP, Loreto, Peru, 14–24 January 2012. The application deadline is 1 August 2011. Additional information may be found at the course's webpage:
http://cebioperu.org/courses/bat.html.

U.S. Fish and Wildlife Service's White-nose Syndrome Plan

The Department of the Interior's U.S. Fish and Wildlife Service has unveiled a national management plan to address the threat posed by white-nose syndrome (WNS). The final document and additional information about WNS are available online at: http://www.fws.gov/WhiteNoseSyndrome/.

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 (mgriff@illinoisalumni.org). 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 (mgriff@illinoisalumni.org), and include the date on which the change will become effective. Thank you in advance for helping us out!

FUTURE MEETINGS and EVENTS

4–8 July 2011
The VIII International Convention on Environment and Development, III Congress on Biodiversity and Ecosystem Management will be July 4–8, 2011, at the Palace of the Conventions. (This is a rough translation of the announcement which follows. My apologies for any inaccuracies in the translation to English. Margaret Griffiths, Managing Editor.) VIII Convención Internacional Sobre Medio Ambiente y Desarrollo III Congreso Sobre Manejo de Ecosistemas y Biodiversidad, 4 al 8 de Julio del 2011, Palacio de Las Convenciones.

9 July 2011
The 10th Annual Great Lakes Bat Festival, presented by the Organization for Bat Conservation, will be held at Cranbrook Institute of Science, Bloomfield Hills, MI. The festival will feature activities for children, families, educators, and conservation professionals. Presentations by North American bat experts, live animals programs, hands-on activities, crafts for kids, and exhibits will provide a full day of fun and environmental education. Janell Cannon, award-winning author of "Stellaluna," is one of many featured speakers. For all ages and free with museum admission. More information available at: http://www.batconservation.org and http://science.cranbrook.edu/.

22–26 August 2011
The XIIth European Bat Research Symposium will be held in Vilnius, Lithuania, August 22–26, 2011. Information can be found at: http://www.chiroptera.lt/symposium/index1.php?do=1.

26–29 October 2011
The 41st Annual NASBR will be held in Toronto, Ontario, Canada, October 26–29, 2011. Please check the NASBR Web site at http://www.nasbr.org/ for upcoming information.

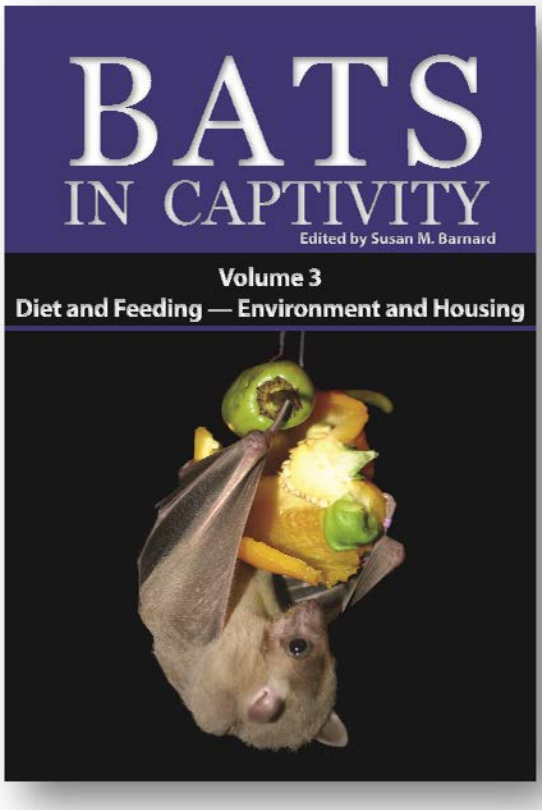
2012
The 15th Australasian Bat Society Conference will be held in Melbourne, Australia, dates TBA. Check http://ausbats.org.au/ for any updates.

The 42nd Annual NASBR will be held in San Juan, Puerto Rico, dates TBA.

2013
The 43rd Annual NASBR and the 15th International Bat Research Conference will be held in Costa Rica, dates and city TBA.

BATS IN CAPTIVITY

Volume 3: Diet and Feeding — Environment and Housing



Susan M. Barnard, Editor

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About the Editor

Susan M. Barnard holds a Bachelor of Science degree from the University of the State of New York. She founded Basically Bats – Wildlife Conservation Society, Inc. in 1993, and served as Executive Director until 2008. Currently retired from her position as Assistant Curator of Herpetology at Zoo Atlanta, Ms. Barnard has authored over 25 scientific papers in refereed journals and 2 book chapters. She also co-authored books on reptilian parasites and reptilian husbandry, and has appeared in numerous magazines and on television, including the National Geographic special, "Keepers of the Wild."

A comprehensive work intended for anyone maintaining captive bats. Bats in Captivity is the only multi-volume series of its kind, detailing the captive care of bats worldwide. This volume comprises 26 papers by 22 contributing authors. It contains a comprehensive discussion on nutrition, as well as dietary information for bats that eat insects, fruit, nectar, blood, fish and other vertebrates. Other subjects include methods for rearing insects, methods for collecting wild insects, environmental enrichment, roosting ecology, and environment and housing considerations for all bat groups, plus much more.

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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 Al Kurta, recent literature items to Jacques Veilleux, and conservation/education items and all other correspondence to Margaret Griffiths. (Contact information is listed above.)

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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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BAT RESEARCH NEWS

VOLUME 52: NUMBER 3 **FALL 2011**

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Front Cover

The cover photograph was captured by a night camera in Clay County, Indiana. The deer most likely triggered the camera, but a hoary bat (*Lasiurus cinereus*) flying just over the deer also can be seen. Many thanks to the photographer Devin Cress (Brazil, Indiana) and also to Dr. John Whitaker (Indiana State University, Terre Haute, Indiana) for submitting it.

From the Editor

Greetings!

I hope the beginning of fall finds you well. I have several items to report to you. First, please note the change of my postal and e-mail addresses. For those of you who do not already know, Tom and I moved to Illinois this summer. So kindly update your records with the correct contact information as listed on the inside front cover of this issue. Thanks!

There are several good things about moving back to Illinois but one of the best things to report is I once again saw numerous bats flying in the evening skies during the summer months, something I had not seen for the past two spring and summer seasons in Pennsylvania. Although there are still areas in Pennsylvania and other parts of the Northeast that continue to support healthy bat colonies (e.g., the library at Lycoming College), there was a definite change in the number and frequency of bats that we saw flying in Montoursville during summer 2010 and 2011. So it was especially nice to see bats flying around us here in Bloomington this summer, something I hope we continue to see in future years as well.

Right now *Bat Research News* is facing several challenges. One is the continually increasing production costs associated with our little journal/newsletter. As the end of the subscription year draws near, please know I am doing my best to keep these costs at a minimum, and I hoping not to increase subscription fees for 2012—but right now I cannot promise that.

The other challenge we have is soliciting bat-related papers and other items for publishing in *BRN*. As 2012 rolls around, please consider sending us short reviews, original technical papers, notes, letters, or news items about what's happening in your lab, in the field, etc. We look forward to hearing from you and to your continued support.

Have a safe and productive Fall 2011.

Best wishes,

Opportunistic Consumption of Blood from Pallas's Long-tongued Bat, *Glossophaga soricina*, by the Common Vampire, *Desmodus rotundus*, in Brazil

Renan de França Souza[1,2], Camila Sant'Anna[3], Mariana V.P. Aguiar[1], André C. Siqueira[1], Davi C. Tavares[1], Rafael S. Laurindo[1], and Roberto Leonan M. Novaes[1,3]

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E-mail: ismecn@gmail.com

Bats frequently are used as food by birds of prey (Twente, 1954; Escarlate-Tavares and Pessôa, 2005) and snakes (Martins and Oliveira, 1998; Esbérard and Vrcibradic, 2007) and occasionally consumed by felids, opossums, primates, rodents, and other bats (Wroe and Wroe, 1982; Gardner et al., 1991; Fischer et al., 1997; Souza et al., 1997; Fellers, 2000). The opportunistic consumption of bats that are entangled in mist nets has been reported for many non-volant mammals, including canids, felids, and marsupials (Breviglieri and Pedro, 2010; Gazarini et al., 2008; Novaes et al., 2011; Patrício-Costa et al., 2010; Rocha-Mendes and Bianconi, 2009), and for other bats (Oprea et al., 2006). However, there are no published observations of attacks by the common vampire, *Desmodus rotundus*, on another bat caught in a mist net.

Between 17 and 21 July 2010, a survey of bats was carried out at Reserva Particular do Patrimônio Natural Fazenda Lagoa (21°24'41.8"S and 46°15'53.7"W), a preserve containing ca. 300 ha of Atlantic Forest, in southern Minas Gerais, Brazil. On 20 July 2010, at 2036 hours, we observed a female Pallas's long-tongued bat, *Glossophaga soricina*, in a mist net being attacked by a common vampire that was caught in the same net. The attack produced an open wound on the rostrum of the long-tongued bat, from which the vampire licked the blood. We also found puncture wounds in the left wing of the long-tongued bat, between the second and third digits.

The common vampire consumes the blood of warm-blooded animals, especially medium- and large-sized mammals (Aguiar, 2007; Greenhall et al., 1983). However, our observation is the first record of a vampire bat attacking another bat tangled in a mist net. It is doubtful, though, whether vampires commonly attack other bats under natural conditions, because most bats, especially small-bodied bats like the long-tongued bat, probably do not provide a useful volume of blood.

Acknowledgments.—We thank Maria Cristina Weyland Vieira and the team at Reserva Particular do Patrimônio Natural Fazenda Lagoa, for technical and logistical support; Mariana Pacheco Gomes dos Santos, for helping with the translation; and Zootech, for sponsoring our research.

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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 generally should be no longer than two manuscript pages and sent to the Feature Editor.

Substitutability of Bats in Agricultural Systems: Why Ecosystem Valuation Is Not Likely to Sway Agricultural Interests

Wayne E. Thogmartin

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The economic utility of bats has been of interest of late as a fungal disease, white-nose syndrome, spreads through hibernating populations in eastern North America and wind-energy development threatens many migratory species (Boyles et al., 2011; Kunz et al., 2011). Bats play an important agricultural role, primarily by suppressing insects potentially harmful to crops but also by providing guano as a natural source of fertilizer, in dispersing seeds in tropical forests, and in pollinating some plants. As Kunz et al. (2011) emphasized, economic valuation is conducted by measuring gains or losses in human welfare resulting from changes in the provision of ecosystem services, and Boyles et al. (2011) argued that the agricultural benefit of bats in the United States was between $3.7 and $53 billion annually.

Proper valuation of bats, however, requires recognizing the economic system in which these species are evaluated. The dominant economic philosophy in western economies is neo-classical. Neo-classical economics focuses on supply-and-demand determination of prices, output, and market distributions, typically mediated through maximization of income-constrained individual utility or corporate profit. An important characteristic of neo-classical economics, possibly the most important characteristic in relation to the conservation of bats (or any wildlife species), is that neo-classical economists assume there are no limits to economic growth (Czech, 2000). Growth, for all intents and purposes according to this philosophy, can continue forever. Neo-classicists support their arguments of perpetual growth through two important principles—substitutability and efficiency (for brevity, I ignore a third principle related to human capital). Substitutability suggests that goods, as a result of a change in conditions, may be replaced by others (e.g., margarine substituted for butter). Efficiency is achieved through increased welfare or gain in output per unit of material input (e.g., robotic manufacturing decreases costs through reduction in human capital).

If we place bats in an economic system of valuation, then in western economies bats are, by definition, substitutable by other goods and services as elasticity of demand allows (Fig. 1). To their credit, the current economic argument in favor of bats is that they provide a free service to farmers. This free service is an externality, an unintended benefit provided

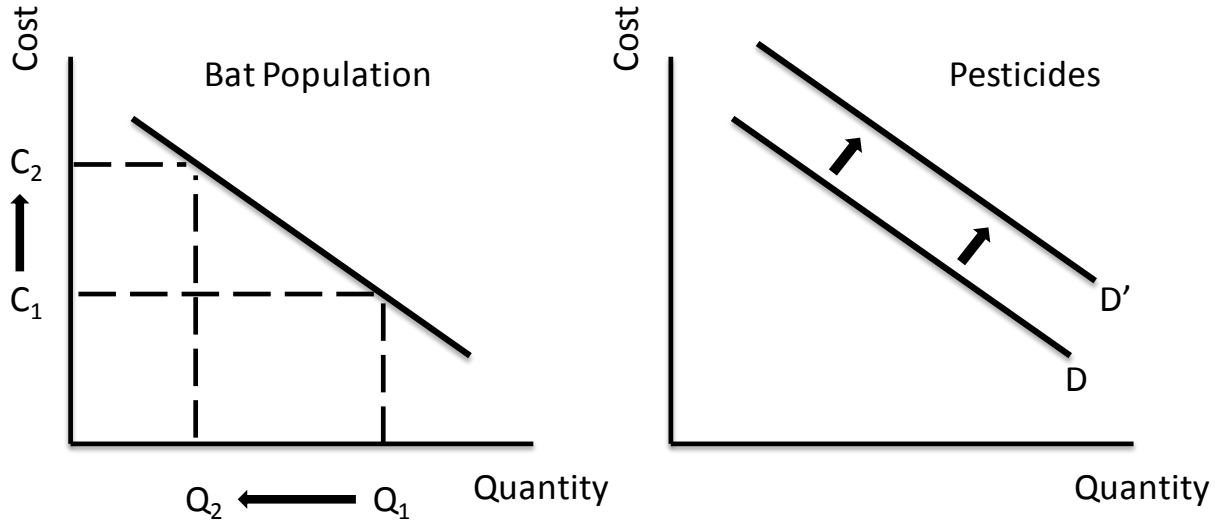

Figure 1. As populations of bats decline (from Q_1 to Q_2), the cost of missing services to farmers rises, requiring added inputs. This directly increases demand for pesticides (from D to D') and places added costs on the farmer (from C_1 to C_2), reducing efficiency.

to farmers by a party (bats) not directly involved in a market exchange. In the absence of this free service, farmers would need to invest in substitutable inputs of pesticides and fertilizers. Unfortunately, because bats are not an efficient mechanism for suppressing insects or delivering nitrogen at the exact time and place of a farmer's choosing, farmers are already versed in these inputs and will likely increase their participation in them as populations of bats wane (probably without any notion that the decline of bats has played any substantial role in their farming economy). Increased application of pesticides likely will occur because farmers have no compelling economic incentive to decrease use of pesticides, despite the possibility of major reductions in their use through implementation of available pest-control methods (NRC 1989, 1993). The cost of conserving bats will, in a strictly neo-classical economic evaluation, always be tempered by gains made available through relatively inexpensive substitutable inputs.

Additionally, the input cost borne by a farmer (for pesticides, currently 2–5% of the crop value—NRC 1989, 1993) can only marginally increase the value of bats, in part, because efforts at conserving bats are borne by a society larger than the segment of the economy most afflicted by their loss. This disconnect requires embedding an economic argument for conserving bats in a complex socio-political context. In a pluralistic society, the most economically afflicted population, farmers in this case, may not have the political clout to influence larger societal decisions regarding conservation of bats, regardless of the efficiencies farmers may gain from such actions—this alone may dissuade farmers from participating in advancing conservation of bats on economic grounds. Further, seeking a political solution to an economic issue in such an inequitable setting, as we have done here, creates what is known as the "other people's money problem" (OPM problem). As anyone in the United States who has followed the national debate about federal debt and taxation

understands, the OPM problem hinders development of economic solutions.

If the cost of conservation is relatively too high or the gains relatively insufficient, agricultural entities will be disinclined (from a strictly economic perspective) from participating; this is a standard cost-benefit analysis. Thus, rather than elevating free-market economic arguments for conserving bats, we may do better to renounce laissez-faire principles and consider instead the governance of commons (Kenward et al., 2011; Ostrom, 1999). As with most wildlife in North America, bats exist as a commons, a set of natural resources held in possession not by individuals or corporations but by society at large. To some extent, we may think of bats as a cryptic commons because of the general lack of acknowledgment of the role they play in our economy and the unknown extent to which our actions (e.g., conversion of land, application of pesticides) harm the commons. Successful governance of a commons, however, requires clear delineation of the resource (Ostrom, 1999); Boyles et al. (2011) and Kunz et al. (2011) provide steps in that direction. Importantly, delineation of the commons also requires establishing duties or obligations to the maintenance of the commons for the betterment of those who hold it.

It seems, currently, most species-related obligations to maintaining the commons in the United States are derived through considerations of the Endangered Species Act; fortunately, few species are as yet subject to this act, but in the absence of this authority, there is little law motivating the preservation of abundant populations of bats. Despite the lack of robust law motivating conservation of bats, there are established precedents for keeping species off the list of threatened and endangered species. For example, the cerulean warbler (*Setophaga cerulea*) was considered for listing as threatened, but the decision not to list this fast-declining species was possible because the U.S. Fish and Wildlife Service identified the warbler as a species of conservation concern, increased focus on long-term monitoring and conservation, provided assistance to the Cerulean Warbler Technical Group (a body of state, federal, commercial, academic, and non-governmental entities focusing research and management on this species), and increased support for international conservation efforts in places where this species overwinters (U.S. Department of the Interior, 2006). Similar means of avoiding listing may be a reasonable course of action for bats, thus increasing governance of the commons without burdensome and tedious establishment of law, or, as Ophuls (1973:220) suggested, "the tragic necessity of Leviathan." Further means of internalizing environmental services for what is now an externality are, for instance, establishment of environmental markets; the U.S. Department of Agriculture's Office of Environmental Markets exists for just this purpose (http://www.fs.fed.us/ecosystemservices/OEM/index.shtml).

It is a trick of neoclassical economists to assume away things inconvenient to their argument (such as natural limits to economies). I have done so here as well, glossing over many potentially important details relating to the economic context and valuation of bats; bats are not, among other things, exact substitutes for pesticides and fertilizers and no amount of chemical application can replace them. It seems clear, however, that economic arguments alone are insufficient motivation for the conservation of bats for the reasons outlined here. Instead, developing more robust governance rules have been shown to work for other taxa and may prove useful in bat conservation.

I acknowledge the helpful comments of K.

Kenow and K. Bagstad, both of the United States Geological Survey, in preparing this letter.

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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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NEWS and other FUN STUFF

Kunwar and Indu Bhatnagar have shared photographs of bat replicas they've seen during some of their travels. A replica of a bat, perhaps *Vespertilio*, was observed mounted atop a commemorative column erected in the city square, Plaza Rei San Carlos I, Palma de Mallorca, Spain. The next day, another bat was serendipitously spotted, mounted on a wrought iron gate in Barcelona on Passeig de Grasia. Miragall and Bhatnagar previously reported on a bat in the blazon of the City of Valencia, Spain (*Bat Research News*, 1983, 24:4–5), and commented on bats in the blazons of Barcelona and Palma de Mallorca heraldic shields since the times of old Aragonese monarchy. Many similar displays of bats may exist in Spain and elsewhere in Europe.

Photographs by Indu Bhatnagar.

ANNOUNCEMENTS

2012 Bat Conservation International Student Research Scholarships

Bat Conservation International is accepting applications for its 2012 BCI Student Research Scholarships. Grants of up to $5,000 each will be awarded for the 2012–2013 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 2012 scholarships is **15 December 2011**. Information and the online application form are available at http://www.batcon.org/scholarships.

Bat Course 2012 on Taxonomy, Ecology and Conservation (Peru)

Valeria Tavares has announced that the Bat Course 2012 on Taxonomy, Ecology and Conservation will be conducted in the Jenaro Herrera Research Center, IIAP, Loreto, Peru, 14–24 January 2012. The application deadline is 1 August 2011. Additional information may be found at the course's webpage:
http://cebioperu.org/courses/bat.html.

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 (mgriff@illinoisalumni.org). 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 (mgriff@illinoisalumni.org), and include the date on which the change will become effective. Thank you in advance for helping us out!

FUTURE MEETINGS and EVENTS

26–29 October 2011
The 41st Annual NASBR will be held in Toronto, Ontario, Canada, October 26–29, 2011. Please check the NASBR Web site at http://www.nasbr.org/ for upcoming information.

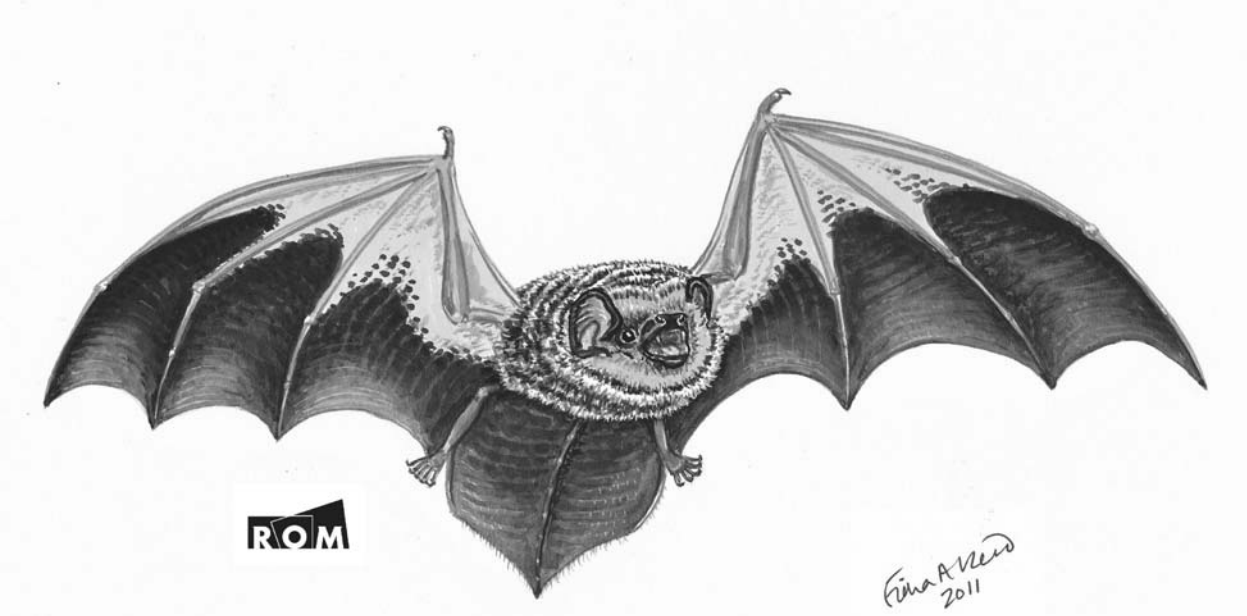
29 October 2011
The 7th Annual Florida Bat Festival will be held at the Lubee Bat Conservancy (1309 NW 192nd Ave., Gainesville, FL 32609) on October 29th. Activities will include viewing of bats at the Conservancy, educational talks about bats, local food and music, a children's costume contest, and a raffle featuring a Disney World Park and Resort Package. If you want to volunteer your help at the event, please email: batfest@lubee.org.

2012
The 15th Australasian Bat Society Conference will be held in Melbourne, Australia, dates TBA. Check http://ausbats.org.au/ for any updates.

The 42nd Annual NASBR will be held in San Juan, Puerto Rico, dates TBA.

2013
The 43rd Annual NASBR and the 15th International Bat Research Conference will be held in Costa Rica, dates and city TBA.

BAT RESEARCH NEWS



41st Annual Meeting North American Society for Bat Research
Royal Ontario Museum, Toronto, Canada, 26-29 October 2011

VOLUME 52: NO. 4 WINTER 2011

BAT RESEARCH NEWS

VOLUME 52: NUMBER 4 **WINTER 2011**

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Front Cover

The logo from the 41st Annual North American Symposium on Bat Research is shown on the cover of this issue. Hoary Bat (*Lasiurus cinereus*). The largest bat in the northeast and much of Canada, this species is a fast and high flier. It inhabits a range of forest types and has successfully colonized distant islands including Hawaii and the Galapagos.

Fiona Reid is author and illustrator of the Peterson Guide to Mammals of North America and a Field Guide to Mammals of Central America and Southeast Mexico. She has drawn more bat species direct from life than any other artist (http://www.fionareid.ca/). Thank you, Fiona, for sharing your artwork with us once again!

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 Al Kurta, recent literature items to Jacques Veilleux, and conservation/education items and all other correspondence to Margaret Griffiths. (Contact information is listed above.)

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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.

Retention of the Common Name Eastern Pipistrelle for *Perimyotis subflavus*

John O. Whitaker, Jr. [1], Allen Kurta[2], and Timothy C. Carter[3]

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Cuvier (1832) first described the bat *Vespertilio subflavus*, although the species later was placed in the genus *Pipistrellus* (Miller, 1897). The original specimens came from the eastern United States, and the type locality was restricted by Davis (1959) to the LeConte Plantation, 3 miles S of Riceboro, Liberty County, Georgia. During the first half of the 20th century, *P. subflavus* most commonly was called either the Georgian bat (e.g., Brimley, 1923; Goslin, 1947; Hahn, 1908; Sherman, 1939) or a name involving some form of the word pipistrelle (e.g., A. A. Allen, 1921; Saunders, 1920; Swanson and Evans, 1936), which simply is an anglicized version of the Italian word for bat, *pipistrello*. The name eastern pipistrelle appeared by 1939 (G. M. Allen, 1939), and it became the most widely used common name by the 1950s (e.g., Davis, 1959; Findley, 1954; Schwartz and Schwartz, 1959) and the only one applied in the latter half of the 20th century.

Recently, taxonomists (Menu, 1984; Hoofer and Van Den Bussche, 2003; Hoofer et al., 2006) have provided compelling evidence that neither the eastern or western pipistrelle (*Pipistrellus hesperus*) share a common ancestor with the Old World genus *Pipistrellus* nor with each other. Consequently, the accepted scientific name for the western pipistrelle is now *Parastrellus hesperus*, and for the eastern pipistrelle, the binomen is *Perimyotis subflavus*. Because the eastern pipistrelle is no longer in the genus *Pipistrellus*, other common names have been proposed (Naish, 2011). Manning et al. (2008) suggested that this bat be called the American perimyotis, whereas a number of biologists have started using the name tri-colored or tricolored bat, which apparently is a reference to the three distinct bands of color appearing in each dorsal hair. We can find no published proposal to use this particular common name, and a quick search of the Internet with googlescholar.com indicates no mention of the name tricolor in the scientific literature before 2009 (Geluso and Mink, 2009; Reichard and Kunz, 2009).

We suggest, though, that changing a scientific name is not a sufficient reason to abandon a long-existing common name (since at least 1939 in this case) and replace it with a newly coined one. Such a change adds no further specificity for trained biologists over the information contained in the binomen and only confuses members of the general public who do not use scientific names. Also use of the name tricolored bat to refer to the eastern pipistrelle is potentially misleading because there already is a mammal called the tricolored bat—the phyllostomid *Glyphonycteris sylvestris*—a species that is found from Peru and southeastern Brazil north to Nayarit and Veracruz, Mexico, as

well as on Trinidad (Wilson and Reeder, 2005). The name eastern pipistrelle has been in use for over 70 years, and worldwide, it is only applied to *P. subflavus*. Consequently, we suggest that use of the name eastern pipistrelle be continued and use of tricolored bat in relation to *P. subflavus* be discontinued.

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Abstracts of Papers Presented at the 41st Annual Symposium of the North American Society for Bat Research Toronto, Ontario 26–29 October 2011

The following abstracts are from papers presented at the 41st Annual North American Society for Bat Research (NASBR). Local hosts for the Symposium were Judith Eger and Burton Lim, Royal Ontario Museum and the University of Toronto. Meeting abstracts were compiled by Gary Kwiecinski 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 41st Annual NASBR are available in the list following the abstracts.

Bat Detector Comparison with Synthetic Playback and Free-flying Bats
Amanda M. Adams, Meredith K. Jantzen, and Rachel M. Hamilton, University of Western Ontario, London, ON

How do you begin to choose which bat detector is best suited for your needs? While budget is a major factor for many, there are numerous other features that contribute to a final decision (e.g., battery life, storage capacity, weatherproofing, etc.). The purpose of this study was to compare ultrasonic call detection in five different bat detectors: Anabat SD2 (Titley Scientific), Avisoft UltraSoundGate 116Hme CM16/CMPA (Avisoft Bioacoustics), Batcorder 2.0 (ecoObs), Batlogger (Elekon AG), and Songmeter SM2 BAT (Wildlife Acoustics). We used playback of synthetic calls to optimize detection settings for each detector. We played synthetic constant-frequency calls at four frequencies (25, 55, 85, 115 kHz) at five-meter intervals (5–40 m) and three angles (0°, 45°, 90°) from the detectors. Detection was most affected by call frequency and distance, while the effect of angle was less apparent. Avisoft and Batlogger outperformed other detectors, while Batcorder and Songmeter performed similarly. Batlogger performed better than the other detectors at angles off-center (45° and 90°). Anabat detected the fewest calls, none at the higher frequencies (85 kHz and 115 kHz). We also compared recordings made in the presence of free-flying bats, comparing the number of calls detected by each detector in 27 passes. On average, Batlogger recorded 93% relative to Avisoft, while Anabat, Batcorder, and Songmeter recorded 40–50% of the calls. These results suggest that detector performance differs among brands. This factor should be taken into account both when making purchasing decisions, as well as considering bat activity levels reported in studies using different detectors.

Year of the Bat: Estimates of Urban and Rural Bat Species Presence and Educational Outreach in Sichuan Province, China
Rick A. Adams and Sarah M. Bexell, University of Northern Colorado, Greeley, CO; University of Denver, Denver, CO; Chengdu Research Base of Giant Panda Breeding, China

In celebration of the UNEP 2011 Year of the Bat, we conducted comparative sonar sampling from 20 May to 3 June 2011 using a hand-held Pettersson D240x sonar detector attached to a Samson Zoom digital recorder at two urban and two rural sites in and around Chengdu, China. We also conducted educational outreach by giving talks to school, professional, and public groups. A total of 387 calls were recorded across the 4 sites (Fu River = 74 calls; Jiulidi Park = 100; Panda Base = 189; Longxi Hongkou = 24). Although there are limited records for species-specific echolocation calls for China's bats, we were able to decipher some species designations. Of interest: for Longxi Hongkou Nature Reserve, we isolated a previously undocumented family and species, *Chaerephon plicata* (Molossidae); at the Chengdu Research Base of Giant Panda Breeding, we isolated new distribution records for *Miniopterus fuliginosus* and *C. plicata* and for *Rhinolophus macrotis* at the Fu River in Chengdu. We gave talks and played bat games at Qi Zhong Middle School (200 students), Bei Xin Shi Yao Primary School (> 100 students), gave a lecture to the professional staff of the Chengdu Zoo, and a public lecture at Chengdu's largest shopping mall sponsored by Jane Goodall Institute's Roots and Shoots (> 150 people attended). In addition, we were interviewed about the importance of bats by the Chengdu Times, the largest newspaper in Chengdu (population 13 million). These projects are intended to continue and expand over the next several years.

A New Handheld Bat Detector with the Capability to Simultaneously Display a Real-time Spectrogram while Monitoring and Recording

Ian Agranat and Sherwood Snyder, Wildlife Acoustics, Concord, MA

Although Wildlife Acoustics SM2BAT recorder has quickly become a standard solution for long-term passive monitoring of bats, we wanted to also address the active side of the bat monitoring market. We present the new Echo Meter EM3, designed from the ground up specifically for active handheld monitoring. It includes every existing technology for monitoring bats in real time as well as our own Real Time Expansion. While monitoring, the EM3 has the ability to simultaneously make full spectrum recordings to an SD card. Additionally, the Echo Meter incorporates a real-time FFT, allowing the user to see frequency and amplitude information right in the field while monitoring and/or recording. We consider this to be an invaluable aid in recognizing species in the field. The microphone circuit was also designed from the ground up. The microphone is slightly directional to improve signal to noise ratio for active monitoring and has a flat frequency response (± 10 dB) up to 192 kHz. The EM3 is set up to be used "out of the box." It includes batteries and flash card and default settings such that the end user can be monitoring bats without significant effort. As per our design philosophy of creating fully featured products at a value price, the EM3 includes all the features of other professional detectors on the market as well as several available nowhere else, all at a fraction of the cost of competitive devices.

Genetic Structure and Relatedness of Indiana Bat (*Myotis sodalis*) Maternity Colonies in Missouri

Sybill K. Amelon and Abby E. Isabelle, USFS Northern Research Station, Columbia, MO; University of Missouri, Columbia, MO

We used DNA microsatellites (10 polymorphic loci) to investigate temporal and spatial patterns of genetic differentiation and relatedness in summer maternity colonies and individual male Indiana bats (*Myotis sodalis*; n = 40) in Missouri. Patterns of genetic variation were measured relative to spatial location of colonies (or individual male capture sites). Our preliminary findings detected significant genetic differentiation among colonies but less support for non-random patterns of colony genetic relatedness. We found some support for matrilineal genetic structure within colonies but lower than has previously been hypothesized for summer colonies of this species. We confirmed recapture of individuals between years by genetic analysis (identical genotype) indicating tissue DNA serves as a means for mark-recapture without the need of wing bands. Analysis with additional microsatellite loci and mitochondrial DNA as well as comparisons of space use among related individuals will provide additional insight into the genetic composition of summer Indiana bat colonies.

Monitoring the Colony Size of the Mexican Long-nosed Bat (*Leptonycteris nivalis*) in Texas Using Thermal Imaging

Loren K. Ammerman and Michael T. Dixon, Angelo State University, San Angelo, TX

The Mexican long-nosed bat, *Leptonycteris nivalis*, is an endangered, migratory species that occurs throughout much of Mexico, and is known from only two colonies in the United States. We used a FLIR P65 infrared thermal imaging camera to record the emergence of *L. nivalis* from a cave roost in Big Bend National Park (BBNP), Texas. Digital recordings were manually analyzed to determine the number of *Leptonycteris* and other species leaving the cave. Censuses were conducted annually from 2008 through 2011 on one night during the period of 2–5 July. The total number of *Leptonycteris* counted each year ranged from a low of 294 to as high as 2535. On average, emergences began 23 minutes after sunset (range = 12–36) and peaked an average of 49 minutes after sunset (range = 42–61). The maximum rate of emergence from the cave for *L. nivalis* was 129 bats/min observed in 2011. Environmental conditions during each census varied among years and might have influenced the pattern of emergence rates (bats/minute) that also varied among years. Counts of *Agave havardiana* (the primary food source for *L. nivalis*) during these same years in BBNP ranged from 92–533 blooming plants. Published data suggest that population size of *L. nivalis* is correlated with the number of *Agave* blooms in Mexico. The variation in numbers of *Leptonycteris* and *Agave* blooms in BBNP however, were not significantly correlated.

Designing Monitoring Networks for Bats in Northern Portugal Able to Detect Range Shifts Derived from Climate Change

Francisco Amorim, Sílvia Carvalho, João Honrado, and Hugo Rebelo; CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Vairão, Portugal; Faculdade de Ciências da Universidade do Porto, Porto, Portugal; University of Bristol, Bristol, United Kingdom

Monitoring is an essential part of environmental management programs, since it provides valuable information on the status of the ecosystems and their diversity. When designing monitoring networks, researchers should consider climate change as a probable long-term key factor influencing biodiversity, since it has the potential to drive shifts in the range of many species. Monitoring bats that roost in trees and crevices present a number of unique challenges, since it is often difficult to identify entrance and exit points of such roosts. For such species, using echolocation monitoring is one of the best available alternatives. We used Species Distribution Models to identify current patterns of species richness for seven bat species in northern Portugal and to identify areas where those patterns may be most prone to shift due to climate change. Two IPCC storylines (A2a and B2a) were used to predict species distributions for the year 2080. According to our results, three monitoring classes were determined: stable (no predicted variation in species number); decline (predicted decrease in species number); and increase (predicted raise in species number). A monitoring network was designed by distributing 40 acoustic monitoring stations along these three classes, while avoiding geographical bias. To date, we are working with state agencies and NGOs in order to implement this monitoring network in the field.

Phylogeography and Species-level Diversity within *Hipposideros bicolor* Complex Based on Genetics, Morphology, and Echolocation Call Frequencies

Faisal Ali Anwarali Khan, M. T. Abdullah, Ibnu Maryanto, Fahma Wijaya, and Robert J. Baker, Texas Tech University, Lubbock, TX; Universiti Malaysia Sarawak, Sarawak, Malaysia; Museum Zoologicum Bogoriense, Indonesian Institute of Sciences, Indonesia; Islamic University of Syarif Hidayatullah, Jakarta, Indonesia

Hipposideros bicolor Temminck, 1834 is a member of the *bicolor* species group, which encloses half of all named species in the genus *Hipposideros*, including representatives from Africa and Madagascar across southern Asia to Japan, and northern Australia. Taxonomy of *H. bicolor* is convoluted mainly due to cryptic diversity within the *bicolor* species group that was further complicated with poor description of the type specimen. We examined the genetics, morphology, and acoustic variations within currently recognized *H. bicolor* and some other morphologically similar species from Southeast Asia. We sequenced 1140 base pairs (bp) of cytochrome-*b* and 509 bp of NADH dehydrogenase subunit 2 genes for *H. ater*, *H. atrox*, *H. bicolor*, *H. cineraceus*, *H. doriae*, and *H. dyacorum*. Our analyses recovered three phylogroups within *H. bicolor* (Kimura 2 parameter distance value [K2P] = 3–7%), three phylogroups within *H. ater* (K2P = 8–17%), three phylogroups within *H. cineraceus* (K2P = 5–7%), and a single phylogroup for *H. atrox*, *H. doriae*, and *H. dyacorum*, respectively. Discriminant function analysis of these specimens was able to correctly classify all *H. bicolor* clades at 79%, 3 clades within *H. ater* (two of these occur in Borneo and one in Java) at 90–100%, *H. atrox* at 100%, all the *H. cineraceus* clades at 71%, *H. doriae* at 100%, and *H. dyacorum* at 100%. Echolocation call analysis suggests that all the *H. bicolor* phylogroups echolocate at ~129–131 kHz. Herein we discuss the taxonomic and phylogeographic implications of the *bicolor* species group that accounts for geographic variations and the related type descriptions.

Evaluating the Effectiveness of an Ultrasonic Acoustic Deterrent for Reducing Bat Fatalities at Wind Turbines

Edward B. Arnett, M. R. Schirmacher, C. D. Hein, M. M. P. Huso, and J. M. Szewczak, Bat Conservation International, Austin, TX; U.S. Geological Survey, Corvallis, OR; Humboldt State University, Arcata, CA

We implemented a 2-year study to test the effectiveness of an ultrasonic acoustic deterrent for reducing bat fatalities at wind turbines at the Iberdrola Renewables Locust Ridge I and II Wind Farms located in Columbia and Schuylkill Counties, Pennsylvania. We compared average bat fatality rates between 10 randomly selected turbines fitted with deterrent devices and 15 other randomly selected turbines serving as our controls. We estimated an average of 60% higher fatality (95% CI: 26%, 104%) per control turbine than per deterrent turbine from 15 August to 10 October 2009, or conversely, 21–51% fewer bats were killed per deterrent turbine than per control turbine during this period. From 1 August to 9 October 2010, we estimated 18–62% fewer bats were killed per deterrent turbine than per control turbine. However, in 2010 we found an average inherent difference between turbine groups, and fatality per control turbine was estimated to be 1.09 times greater than per deterrent turbine (95% CI: 0.74–1.61)

prior to implementation of the treatment. Thus, the ratio of fatality per control turbine relative to deterrent turbines after implementing the treatment was estimated to be 1.64 times greater than the pre-treatment period ratio (95% CI: 0.98, 2.76). In other words, between 2% more and 64% fewer bats were killed per deterrent turbine relative to control turbines after accounting for inherent turbine differences prior to treatment implementation. This study and previous experiments with earlier deterrent prototypes reveal that broadband ultrasound broadcasts may affect bat behavior, discourage them from approaching the sound source, and ultimately reduce fatality at wind turbines. However, we caution that we do not yet have a deterrent device ready for operational deployment at wind facilities and further experimentation is warranted. With further development, modifications, and experimentation, this type of deterrent method may prove successful and broadly applicable for protecting bats from harmful encounters with wind turbine blades.

***Duration Tuning in the Auditory Midbrain of Echolocating and Non-echolocating Vertebrates**
Brandon Aubie, Riziq Sayegh, and Paul A. Faure, McMaster University, Hamilton, ON
*** Brandon Aubie** received the **Titley Electronics Award**.

Duration-tuned neurons (DTNs) are found in the auditory midbrains (inferior colliculus; IC) of both echolocating and non-echolocating vertebrates. These neurons have the remarkable ability to respond selectively to a range of auditory stimulus durations with a tolerance to changes in stimulus amplitude. In bats, DTNs tend to prefer very short stimulus durations (< 10 ms) with an overrepresentation of typical echolocation call durations. Non-echolocating vertebrates such as mice, rats, and frogs also have DTNs in the auditory midbrain with preferences for longer stimulus durations and wider temporal response profiles akin to the durations of typical species-specific vocalizations. We hypothesized that mechanisms underlying DTNs are shared across vertebrates and that bats have evolved neural specializations to produce selectivity for short duration stimuli. To test this hypothesis, we produced biologically plausible computational models of DTNs, recorded *in vivo* extracellular potentials from the central nucleus of the IC of awake big brown bats (*Eptesicus fuscus*), and gathered previously reported *in vivo* recordings from the auditory midbrains of mice, rats, and frogs to determine whether similar mechanisms of duration tuning could explain the responses of DTNs across vertebrates. We found that fast dynamics and precise levels of excitation and inhibition in the bat's auditory pathway are important for producing sharply tuned DTNs. Furthermore, models tuned with species-specific parameters accurately reproduced duration tuning responses in mice, rats, and frogs. Therefore, we propose that mechanisms underlying DTNs are shared across vertebrates and that evolutionary pressures on the bat's auditory system have tuned these mechanisms to prefer very short stimulus durations that may play a role in processing echolocation like pulse-echo stimuli.

The Bat Connection: Setting the Stage for High Impact Learning in Conservation Biology
Doris Audet, University of Alberta - Augustana Campus, Camrose, AB

First-hand experiences with wildlife and nature provide an ideal venue for high impact learning especially when they take place in an inquiry-based context. Drawing from my experience in a team-taught field studies course, I will illustrate how bats present remarkable opportunities for undergraduate students to acquire natural history knowledge and research skills while exploring the scope, key concepts, and methods of conservation biology in a reflective manner. I will also highlight strategies that helped in enhancing the learning outcomes for the students and in improving the quality of their research. As a consequence, not only have students gained an appreciation for bats, their collective work has contributed substantial knowledge of the diversity, habitat use, and roosting habits of bats that can benefit conservation initiatives at our field site in northwestern Costa Rica.

Stable Isotope Analysis of Migratory Bats Killed at Wind Turbines in Alberta
E. F. Baerwald, W. P. Patterson, and R. M. R. Barclay, University of Calgary, Calgary AB; University of Saskatchewan, Saskatoon, SK

At some wind energy facilities, large numbers of migratory bats are killed every fall. While this may be troubling from a population perspective, these fatalities provide an opportunity to learn more about migratory bats and bat migration by using endogenous markers. Such markers include stable isotopes, which have been used to study basic ecological questions, such as trophic levels and food webs, and the origins and migratory routes of animals. We analyzed stable isotope ratios of nitrogen ($\delta^{15}N$), carbon ($\delta^{13}C$), and hydrogen (δD) in fur to examine the origins of hoary bats (*Lasiurus cinereus*), silver-haired bats (*Lasionycteris noctivagans*), and eastern red bats (*L. borealis*) killed at a wind energy facility in southwestern Alberta. We were interested in the range of origins of

migratory bats across Alberta, especially of subadults. We found that the mean isotope values varied among the three species. For all three isotopes, the average values indicated that silver-haired bats killed in southern Alberta likely originated in the boreal forest, farther north than the aspen parkland or prairie habitats suggested by the isotopes from hoary bat or eastern red bat fur. The data provide further evidence for a migration route along the eastern slopes of the Rocky Mountains that is used by bats from across Alberta and suggest that fatalities at a single site may have far-reaching consequences.

Effects of Fruit Secondary Compounds on Seed Passage Rate in *Carollia perspicillata*
Justin Baldwin and Susan Whitehead, Hampshire College, MA; University of Colorado, CO

Plants often recruit frugivorous animals to transport their seeds. However, gut passage can have varying effects on plant fitness depending on both the physical and chemical treatment of the seed and the specific site of deposition. In particular, gut retention time of seeds is likely to be a key factor in seed dispersal effectiveness. Many studies have demonstrated a tradeoff between the benefits accrued from higher gut retention times (higher dispersal distance), and the potential costs that higher gut retention times can impose in terms of reduced seed viability. One way in which plants can mediate these costs and benefits is by producing fruit secondary compounds that influence gut retention time. Yet, fruit secondary compounds have not been studied in relation to gut retention times in mammalian dispersers. We present interspecific differences among gut retention times in five species of Neotropical pepper plants (*Piper* spp., Piperaceae) in a chiropteran disperser, *Carollia perspicillata* (Phyllostomidae) from feeding trials in a Costa Rican wet forest. To determine whether differences among species may be attributable to fruit secondary compounds typical of the genus *Piper*, we also tested the effects of two amide-alkaloids (piperine and piplartine) on gut retention times of natural fruits. Piperine supplementation had no significant effect on gut retention times when compared to control fruits, but piplartine supplementation significantly reduced gut retention times. These results emphasize the potential for differences in fruit chemical traits among species to mediate patterns of seed dispersal and plant distribution in a diverse group of tropical plants.

Distribution and Roosting Ecology of North Dakota Bats
Paul R. 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 compared to other states. As bat populations decline due to human development, wind energy growth, and white-nose syndrome, it is imperative to document key characteristics of bat populations in North Dakota so that an appropriate conservation plan can be developed. The objective of this research is to gather baseline data about bat populations throughout the state so that conservation and mitigation efforts can be made to counter the declining bat population trends. We selected study areas in the state where bat activity was expected to be high in natural environments (presence of roosting habitat and available water). 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. In addition, select bats were fitted with a radio transmitter to be tracked to their roost trees. Once roost trees were located, we assessed characteristics of the focal tree, roost opening, and surrounding vegetation. Control trees were randomly selected and the same measurements were taken as described for roost trees. Results document the presence of eleven bat species in North Dakota and suggest that bats are selecting mature cottonwood trees as roost sites.

Acoustic Survey of Summertime Bat Activity in Three Habitats in Northern New York State
Erika Barthelmess, Maria Hall, and Brianna Molter, St. Lawrence University, Canton, NY

Nine species of bats occur in New York State. Since 2006, some have been exposed to the fungal pathogen *Geomyces destructan*s, the fungus that causes white-nose syndrome and as a result, many populations of bats throughout the northeastern United States have been decimated. Limited knowledge of summertime habitat use by bats in New York State has made it difficult to assess the impact of white-nose syndrome across the region. Our study focused on the summertime activity of bats in St. Lawrence County, New York. We conducted active acoustic road surveys using an AR125 bat detector during the summer of 2010 to determine the presence and activity of bats in St. Lawrence County. We conducted 18 surveys, 9 in mixed habitat, 3 in agricultural habitat, 3 in evergreen habitat, and 3 in deciduous habitat. We collected over 11,000 recordings. Preliminary results show that bat activity was highest in deciduous habitats with lower levels of activity in evergreen and agricultural habitats. Bat activity in evergreen and agricultural habitats appeared similar. Big brown bats (*Eptesicus fuscus*) were most common across habitats. We also detected hoary bats (*Lasiurus cinereus*), red bats (*Lasiurus borealis*), and very infrequently

endangered Indiana bats (*Myotis sodalis*), eastern pipistrelles (*Parastrellus subflavus*), and little brown bats (*Myotis lucifugus*).

Do Dissimilarities in the Natural Maternity Roosts of *Myotis sodalis* and *Myotis lucifugus* Hinder Surrogate Use

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The use of common species as surrogates for those that are threatened or endangered is best conducted using species that are biologically related. If the two species are dissimilar then conclusions based on data collected from surrogates may not accurately represent those drawn for the threatened species. The little brown bat (*Myotis lucifugus*) has been suggested as a surrogate for the endangered Indiana bat (*Myotis sodalis*) due to the species morphological similarities. However, deviations in niche factors such as maternity roost characteristics may reduce surrogate use effectiveness. Furthermore, while Indiana bat maternity roost research is abundant, research on little brown bat roosts tends to deal with artificial roosts. The extent of little brown bat natural maternity roost research is almost negligent. Therefore, data were collected on Indiana and little brown bat natural maternity roosts during the summer of 2011 in the Shawnee National Forest, Illinois. Sixteen little brown bats and nine Indiana bats were tracked to their maternity roost using radio telemetry. Data were collected on the characteristics of each roost daily. Maternity roosts for both species tended to have the same approximate roost and tree height. However, little brown bat roosts tended to have larger DBHs and primarily be in crevices rather than exfoliating bark. These dissimilarities may be due to the little brown bats' habit of roosting in the craggy split tops of large trees that had broken off at the peak. This divergence in maternity roost preference may hamper the effectiveness of surrogate use between the two species.

Seasonal Occupancy Modeling of Three Bat Species in Northern Missouri

Larisa J. Bishop-Boros, Shannon L. Romeling, C. Ryan Allen, Benjamin T. Hale, and Lynn W. Robbins, Missouri State University, Springfield, MO

There is limited understanding of the seasonal distribution of bats in Missouri. Occupancy analysis was used to quantify patterns of presence of three species—Indiana bat (*Myotis sodalis*), silver-haired bat (*Lasionycteris noctivagans*), and hoary bat (*Lasiurus cinereus*)—to model seasonal distribution. The software PRESENCE was used to determine the best-fit model for probability of detecting a species within bi-monthly intervals. A total of 14 passive acoustic bat detectors were set out in northern Missouri, during the spring migratory season, summer maternity season, and fall migratory season, from 16 April 2011–30 October 2011. Ten of these were set in transects and four were placed at meteorological towers. Data files were collected over approximately 2,290 detectors nights and analyzed using BCID 10 and then verified by visual inspection. General bat activity was determined by files that contained a minimum of two consecutive echolocation pulses and species identification was determined by files that contained a minimum of five consecutive pulses. Three months of netting were also compared to three months of acoustic detection, to compare acoustic occupancy levels with actual capture rates. Data collection was finished 01 October 2011, and data analysis begun directly after. These data were combined with separate passive detectors across the state to model seasonal occupancy of these three species, during different seasons, and at different geographic locales.

Flight Kinematics of Eastern Red (*Lasiurus borealis*) and Big Brown Bats (*Eptesicus fuscus*) during Take-off and Flight

Joyce Blandino, Kelsey McCusker, Pin-Fen Chen, and Paul Moosman, Virginia Military Institute, Lexington, VA

Mechanics of flight in bats is relevant to the study of ecology and evolution, as well as to the development of small, unmanned aircraft called Micro Aerial Vehicles. However, flight in bats is poorly understood because membranous wings are difficult to measure when moving. Using Dense Surface Modeling (DSM) the three-dimensionally wing shapes were reproduced and the hand-wing angle, wingtip position, and body tilt in eastern red (ERB) and big brown bats (BBB) during take-off and flight were measured. Six synchronized high-speed cameras were used to capture simultaneous images of bats from take-off to the first two cycles of flight. Quantitative analyses were performed using Surfer from DSM wing shape data. Differences in take-off techniques and time were observed between species (time from start to take-off was 0.192 s in ERB and 0.204 s in BBB). The ERB began take-off with wings already spread and pushed off by flapping, as demonstrated by hand-wing angles ranging from 40.98° ± 5.79° to 85.57° ± 10.93°. The BBB used its feet and forearms to launch itself before spreading its wings in flight. Hand-wing angles in the BBB were correspondingly small (0.59° ± 0.57° to 4.65° ± 4.73°) from take-off until start of the first wing cycle. Hand-wing angles followed similar patterns in-flight for both species and were independent of angle

of body tilt during take-off and flight. Further quantification and post-hoc mathematical modeling of such data should improve understanding of take-off, flight, and complex maneuvers.

Landscape Distribution of *Geomyces* spp. Presents Challenges for Detecting *Geomyces destructans*
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White-nose syndrome (WNS) is an emergent wildlife disease that since 2006 has contributed to the loss of over one million cave-dwelling bats in eastern North America. The disease continues to spread and is characterized by cutaneous infection by the fungal pathogen *Geomyces destructans*. However, little is known about the ecology and persistence of *G. destructans* and related fungal species in cave and cave-like (mine) environments. For this study, we screened soil samples from 19 caves within the known range of WNS and 5 caves outside of the known range of the disease using a PCR test originally developed for detecting *G. destructans* on bat skin. Clone libraries were generated for all 24 soil samples, and sequence analysis of the cloned inserts demonstrated that the primers cross-reacted with a variety of closely related *Geomyces* spp. present in cave soil. Additionally, clones that were genetically identical to *G. destructans* were identified in three samples, all of which were collected within the known range of WNS. Follow-up culture analysis of the soil samples confirmed the presence of viable *G. destructans* only in the samples where the fungus was previously identified by DNA analysis. These results demonstrate for the first time that *G. destructans* is capable of surviving in cave soil. The results also caution against using the PCR primers employed for this study as the sole method of screening soil or bats for *G. destructans* because a diversity of other, similar *Geomyces* spp. found in cave ecosystems may yield false-positive results.

Echolocation Passes Evoke Singing in Brazilian Free-tailed Bats
Kirsten Bohn and Michael Smotherman, Whitman College, Walla Walla, WA; Texas A&M University, College Station, TX

Brazilian free-tailed bats (*Tadarida brasiliensis*) use hierarchically structured songs that parallel those of birds and cetaceans. Here we quantify song structure, describe behavioral contexts of singing, and use playback experiments to determine whether acoustic cues alone can evoke songs. Playback experiments showed that echolocation calls alone induce intense singing both in captivity and in the wild. We found an almost ubiquitous immediate (within 1 s) response to echolocation passes across different males both in captivity (n = 3) and in the field (n = 14). Playbacks of songs from unfamiliar males did not induce singing even though they contain similar frequency content as echolocation calls. Not only is this one of the most robust vocal responses to acoustic playbacks observed in mammals, but a remarkable case of listening to unintended cues of conspecifics where the "cue" is an active echolocation signal.

Figs, Nutrients in Figs, and Dispersal of Fig Seeds: Following in the Footsteps of Don Thomas
Frank Bonaccorso, Joy Coleman, and Colleen Downs, U.S. Geological Survey, Hawaii National Park, HI; University of Kwazulu- Natal, Pierermaritzburg, South Africa

Don Thomas devoted much of his early career exploring fruit bat foraging behavior, seed dispersal by fruit bats, and the constraints on how fruit bats obtained adequate protein from protein deficient fruits both in Old World and New World bats. Following upon questions posed by Don, we here investigate the variation in mineral content in *Ficus sycomorous* syconia, which alone form the bulk of the diet of *Epomorphus cryptus* and *E. wahlbergi* in Kruger National Park, South Africa. We report on variation in 11 minerals from syconia at the level of individual trees, near neighbors within river drainages, and between river drainages. Further, we examine the movements of individual radio-collared *E. crypturus* and *E. wahbergi* in relation to the mineral contents in figs from trees that were visited while documenting movements of up to 13 km between *F. sycomorus* within a single night by these fruit bats. Finally, we comment on the quality of seed dispersal offered by epauletted fruit bats in the context of Kruger National Park.

Torpor in Dark Times: Patterns of Heterothermy are Associated with the Lunar Cycle in Freckled Nightjars
Mark Brigham, Ben Smit, Justin Boyles, and Andrew McKechnie, University of Regina, Regina, SK; University of Pretoria, South Africa

Don "the sheep" Thomas's research focused on the physiological ecology of flying endotherms always with a view to understanding the mechanisms prompting animals to do what they do. Many studies have shown that

endotherms become more heterothermic when thermoregulatory costs are high and/or when food availability constrains thermoregulatory capacity. However, the roles of many ecological variables, including constraints on foraging opportunities and/or success, remain largely unknown. To test the prediction that thermoregulatory patterns should be related to foraging opportunities in a heterothermic endotherm we examined the relationship between the lunar cycle and heterothermy in freckled nightjars (*Caprimulgus tristigma*), which are visually orienting, nocturnal insectivores that unlike bats, depend on ambient light to forage. This model system provides an opportunity to assess whether variation in foraging opportunities influences the expression of heterothermy. Nightjars were active and foraged for insects when moonlight was available, but became inactive and heterothermic in the absence of moonlight. Lunar illumination was a much stronger predictor of the magnitude of heterothermic response than was air temperature (T_a). Our data suggest that heterothermy was strongly related to variation in foraging opportunities associated with the lunar cycle, even though food abundance appeared to remain relatively high throughout the study period. Patterns of thermoregulation in this population of freckled nightjars provide novel insights into the environmental and ecological determinants of heterothermy, with the lunar cycle, and not T_a, being the strongest predictor of torpor use.

Observations and Initial Results from Three Years of Sampling Bats Along Acoustic Transects

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As white-nose syndrome (WNS) continues to spread across the eastern United States, there is a great need for an efficient large-scale bat monitoring program. Since 2009, we have overseen a project to use acoustic transects to monitor bat populations. While only three years into a monitoring program, initial results illustrate the promise of this technique. Thus far we have received data from 24 states representing over 200 transects that were sampled in 2009, 2010, and 2011. Examination of the variability among runs of a given transect suggests that the power of the method to detect population changes is very useful. Additionally, early results suggest that species impacted by white-nose syndrome can still be seen declining in New York, despite widespread prevalence of the disease in local hibernacula. These results illustrate the utility of the method for monitoring bats on a large scale. Use of volunteers allows for a very cost effective sampling method. Finally, pending completion of an automated analysis program promises to reduce issues of data analysis. This project establishes a foundation on which regional efforts can be established to assess population-level impacts to bats that cannot be easily assessed in other ways.

Alopecia in *Myotis lucifugus* Bats

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Since 1999, our laboratory has captured bats throughout Atlantic Canada during various research and monitoring projects. Although consistent systematic records of alopecia (balding) were not kept, we estimate between 0.15–0.30% of all captures (including males and females of both *Myotis lucifugus* and *M. septentrionalis*) have had some degree of noticeable alopecia. In typical cases, there is an approximately 1-cm^2 bald patch between the shoulder blades, but we have also seen balding on the abdomen. On 25 June 2011, 52 female *M. lucifugus* from a maternity colony were captured as they exited from their day roost in the walls of an abandoned cabin in a remote region of southwest Labrador. At least 30% of the bats were variably alopecic, and the most severely affected individuals had locally extensive alopecia extending from the dorsal lumbar region over the top of the head. To better understand this problem we reviewed the literature and only found one publication documenting balding in bats and speculating on its possible causes. Later this summer, we were able to perform a complete post mortem on a female *M. lucifugus* captured in Nova Scotia with an alopecic lesion similar to that observed in the Labrador bats. Gross and microscopic findings were consistent with an atrophic dermatosis. This nonspecific lesion is most often caused by underlying hormonal abnormalities or metabolic disturbances. This presentation's purpose is twofold: to raise awareness of alopecia in bats and to determine if other bat researchers have observed this problem.

Mark Recapture Data Reveal Both Age-structure and Seasonal Variation in Survival in Spix's Disk-winged Bat (*Thyroptera tricolor*)

Michael Buchalski, Gloriana Chaverri, and Martin Vonhof, Western Michigan University, Kalamazoo, MI; Boston University, MA

Life history theory suggests that survival rate (ϕ) will vary with developmental stage and/or various ecological factors. Our objective was to identify key life history correlates of survival in Spix's disk-winged bat (*Thyroptera tricolor*) by estimating monthly survival rates. We identified several factors potentially affecting survival rate (e.g., sex, reproductive period, season, and developmental stage) and used Program MARK to construct a set of competing models in which monthly survival could vary. Five years of mark-recapture data, from three local populations in southwestern Costa Rica, were used to estimate the likelihood of each candidate model. Competing models were evaluated using an information-theoretic approach (AIC). The most parsimonious model indicated monthly survival had a distinct 3-stage age structure, with the lowest rate occurring in pups during the first 3 months (ϕ = 0.90 [95% C.I. 0.82–0.95]; followed by a higher rate of juvenile/subadult survival (ϕ = 0.97 [0.95–0.98]) lasting 1 year for males and 2 years for females; transitioning into adult survival rates. Adult survival rates varied by both local population and season (wet season, ϕ = 0.87 [0.81–0.91]; dry season, ϕ = 0.95 [0.92–0.97]). *T. tricolor* is highly specialized for roosting in the rolled, developing leaves of plants in the order Zingiberales, including *Heliconia* spp. Decreased adult survival during the wet season was related to habitat availability, with a reduction in available roost leaves as the season progresses (R^2 = 0.358, $F_{1, 19}$ = 10.59, p = 0.004). Model evaluation by AIC indicated no support for the effects of sex or reproductive period on survival rate. Implications of these estimates for population growth rate (λ) and mean life span will be discussed.

Assessment of Traveling Groups of Bats During Autumn Swarming

Lynne Burns and Hugh Broders, Dalhousie University, Halifax, NS; Saint Mary's University, Halifax, NS

In the autumn, species of bats that spend the entire year in temperate areas visit caves and abandoned mines just prior to hibernation. During this 'swarming' period, bats engage in chasing flights and mating activity in transient and often large aggregations. Also, this period provides an opportunity to introduce young-of-the-year to these mating and overwintering sites. Little is known of the social dynamics and how the transition from summer to autumn proceeds, including if bats travel to autumn sites in groups. To investigate if bats travel in groups and have preferred traveling companions, we captured *Myotis lucifugus* and *M. septentrionalis* every week at a swarming site in Nova Scotia, Canada during the autumn of 2009 and 2010. Bats of the same species that were captured in the same 5-minute interval of the same night were considered as a potential traveling group. Group size and composition was determined with individual bats assigned to class categories of adult females, adult males, and young-of-the-year (YOY). Affinities of members of a class to be associated with other bats of 1) any class (general gregariousness); 2) the same class (intraclass affinity); or 3) other classes (pairwise interclass affinity), were investigated using class gregariousness indices. Preliminary results suggest that relative to adult males and adult females, YOY of both species display a higher degree of general gregariousness. Also, *M. septentrionalis* appear to have higher general gregariousness compared to *M. lucifugus*. These results will be discussed with preliminary data of recaptures from a concurrent study of the autumn movements of marked individuals.

Food Sharing between Unrelated Vampire Bats: Cooperation, Byproduct, or Coercion?

Gerald C. Carter, Organization for Bat Conservation, Bloomfield Hills, MI; University of Maryland, College Park, MD

Altruism towards non-kin produces an evolutionarily unstable 'tragedy of the commons.' The food sharing behavior of vampires is extraordinary in that these bats regurgitate blood meals to feed unrelated roostmates. The evolutionary mechanisms that stabilize this extreme form of cooperation are controversial. Various authors have suggested that food sharing with unrelated individuals is a mutual benefit enforced by reciprocity, a byproduct of kin selection, or a result of manipulation where bats share food to stop harassment. To test the predictions of these ideas, I collected data on food sharing in a captive colony of *Desmodus rotundus* (n = 21). On 35 nights, I fasted a subject for 24 h then reintroduced it to roostmates. I calculated maximum likelihood estimates of relatedness using 13 microsatellite loci, and assessed social bonds by measuring social contact and allogrooming. Mouth-licking predicted subsequent immediate weight gain. Patterns of food sharing were significantly reciprocal and correlated with social bonds, but not genetic relatedness. Harassment was unlikely to explain food sharing because sharing is often initiated by donors. Food sharing occurred in seemingly competitive networks: some subjects rejected potential donors in favor of others, suggesting an important role for partner choice. Future experimental manipulations of help given and received are necessary to test the degree of contingency and the relative importance

of punishment and partner switching as mechanisms to prevent cheating.

Ontogeny of Echolocation in *Artibeus jamaicensis* (Phyllostomidae) as a Model for Understanding the Evolution of Echolocation in Bats
Richard Carter, Rick Adams, and Jason Shaw, University of Northern Colorado, Greeley, CO

The structure of the echolocation calls of the ancestral protobats is unknown. Using the relationship between the development of echolocation and flight in *Artibeus jamaicensis*, we worked to resolve the evolutionary pathway taken by chiropteran ancestors. We hypothesized that echolocation and flight evolved together complementing each other through time and space. We predicted that early sonar-like calls would change in frequency and duration as the capacity for flight increased. Using a captive breeding colony we recorded and analyzed vocalizations of bats using Pettersson D240X detectors and Sonobat V2.9.2 software from 1-day post-partum to adulthood as they descended from a 1-m perch. We classified bats into four developmental stages: 1) Flop: falling with minimal wing movements (n = 13); 2) Flutter: falling with wing movement (n = 33); 3) Flap: attaining horizontal distance while flapping (n = 15); or 4) Flight: sustained flight across the arena (n = 18). Both isolation and sonar calls were identified and grouped by PCA within each stage. Changes in call duration ($R = -0.30$, $p < 0.0000$), highest frequency ($R = 0.31$, $p < 0.0000$), and lowest frequency ($R = 0.29$, $p < 0.0000$) all correlated with changes in flight ability. Sonar calls significantly decreased in duration between flutter and flap stages ($p = 0.0004$). Highest frequency of calls increased significantly between flop and flap stages ($p = 0.0281$) and between flutter and flight stages ($p = 0.0064$). Lowest frequency of calls increased significantly between flop and flap ($p = 0.0292$) stages and between flutter and flight stages ($p = 0.0089$). These data suggest that ancestral calls of early protobats were tonal, lower in frequency, and longer in duration and evolved in concert with flight evolution.

Cryptic Species in *Glossophaga soricina*: Three Distinct Lineages, Only One Reproductively Isolated
Alejandra Ceballos Vasquez and Elizabeth Clare, University of Western Ontario, London, ON; University of Bristol, Bristol, United Kingdom

Cryptic species have been reported in several bat families and recent molecular studies suggested bats known as *Glossophaga soricina* represent three mitochondrial groups. However molecular data alone are not sufficient to delimit species boundaries, it is necessary to combine molecular methodologies with taxonomic information. We analyzed morphological data, DNA barcodes and sequences in males from the DBY 7th intron of the Y-chromosome from the three mitochondrial groups. Our data suggest that the three genetically distinct lineages of *G. soricina* also are morphologically distinct. Discriminate Function Analysis (DFA) correctly classified 80.6% members of the Central American lineage, which had been previously recognized as genetically and reproductively isolated by both mtDNA and DBY 7th from the other two genetic groups (two South American mitochondrial groups). DFA correctly classified 46.5% and 65.2% members of groups 2 and 3, respectively. Phylogenetic reconstruction and divergence time suggest hybridization between the two South American groups is an ongoing process.

Craniomandibular Morphology in Mormoopid Bats
Jeffrey B. Changaris and Winston C. Lancaster, California State University, Sacramento, CA

Neotropical ghost-faced bats of the genus *Mormoops* (Family Mormoopidae) have a radically upturned rostrum, or snout, relative to the neurocranium. This is one of the characters that distinguishes them from the confamilial genus *Pteronotus* (mustached bats) in which the rostrum is only slightly upturned. We examined the behavior and morphology of *Mormoops blainvillii*, the Antillean ghost-faced bat, in comparison to *Pteronotus quadridens*, the sooty mustached bat, to better understand the adaptive significance of this characteristic. Observations of *M. blainvillii* reveal a 25% larger maximum gape relative to the size of their heads in comparison to *P. quadridens*. We dissected preserved specimens of each species focusing on the musculature and associated bony morphology of the craniomandibular apparatus. We found structural modifications in *M. blainvillii*, such as position of the glenoid fossa relative to the auditory bulla and the shape of the mandibular ramus, that may facilitate the larger gape relative to *P. quadridens*. Modifications of the mandibular morphology to match the upturned rostrum have resulted in changes in the geometry and fascicular orientations of the craniomandibular muscles. For example, the line of action of the *musculus masseter* in *M. blainvillii* appears to be nearer to perpendicular to the lever arm of the mandible than in *P. quadridens*. In *M. blainvillii*, the mandibular abductor *musculus digastricus* is relatively longer, and a greater percentage of the craniomandibular muscle mass is allocated to jaw opening than in *P. quadridens*. However, *P. quadridens* appears to have a greater relative muscle mass for jaw adductors.

Dense Surface Modeling as a Tool to Study Flight Dynamics of Bats in Three-dimensions
Pin-Fen Chen, Kelsey McKusker, Paul Moosman, and Joyce Blandino, Virginia Military Institute, Lexington, VA

Wing morphology has been studied in bats using two-dimensional measurements. However, because of deformation of wing membranes two-dimensional methods cannot be used to study flight accurately. A three-dimensional method that does not require physical contact is needed. We developed a method to reconstruct three-dimensional shapes of flying big brown (*Eptesicus fuscus*) and eastern red bats (*Lasiurus borealis*) by applying the method of Dense Surface Modeling (DSM) to digital images obtained by videogrammetry. Three pairs of cameras were synchronized to capture simultaneous images of take-off sequences and flight at a frame rate of 250 Hz. Images from each of six camera perspectives were first spatially oriented and scaled with objects of known dimensions and positions, then were matched to one another to create a three-dimensional model of each frame. Surfer 9 Software was used to create a three-dimensional relief map of the bat in each frame for later analysis. This technique is relatively time-consuming, but provides the possibility for detailed measurements of bats performing complex maneuvers. Inaccuracies were present in the models, but were reduced by stippling bat wings with non-toxic white paint and increasing the amount of lighting. Eastern red bats were already well suited for the technique because of their contrasting pigmentation. Dense Surface Modeling offers a valuable non-contact method to quantify flight dynamics of bats and other flying animals.

Nectar Seeker Sneaks Insect Snacks: Molecular Food Webs and *Glossophaga soricina*
Elizabeth Clare, University of Bristol, Bristol, United Kingdom

The use of DNA to reconstruct the food webs of bats has developed quickly in the last few years from early cloning techniques to direct Sanger sequencing methods and now to next generation sequencing platforms. In this presentation I will use the results of our recent molecular food webs to address insectivory in the nectivorous bat *Glossophaga soricina*. Using a variety of approaches, including field surveys, captive behavioral experiments, acoustic analyses and genetic methods I will outline the species of insects targeted, the method of capture from behavioral, morphological and acoustic perspectives and I will contrast these results with classical insectivorous behavior of similarly sized bats. These results suggest that insects are a common component of the diet of *G. soricina* and that captures are not opportunistic but made using a targeted non-visual aerial hawking approach which resembles that of insectivorous species but contains techniques which are, thus far, unique to *G. soricina*. Insect handling during consumption appears complex and involves both jaw and thumb manipulation of prey items. I provide evidence for prey theft behavior among conspecific roost mates. I demonstrate that insectivory in *G. soricina* is an innate behavior and not geographically restricted. I will also provide a brief overview of the state of the field of molecular dietary analysis, introduce new methodologies designed to work with seeds, pollen and fruit pulp, and provide a prospective on future developments.

Managing White-nose Syndrome in the Face of Uncertainty
Jeremy T. H. Coleman, Mike P. Armstrong, Ann R. Froschauer, Richard Geboy, Christina J. Kocer, Mary Parkin, and Alison L. Whitlock, U.S. Fish and Wildlife Service: Hadley, MA; Frankfort, KY; Bloomington, IL

White-nose syndrome (WNS) has caused unprecedented mortality in hibernating bats in eastern North America since its discovery in 2007. The disease (WNS) and/or the fungus (*Geomyces destructans*) have now been detected on bats at over 190 hibernacula in 19 states and 4 provinces. The rapid spread and devastating impacts of WNS have presented wildlife and natural resource managers with considerable biological and social challenges, which are exacerbated by the many unanswered questions surrounding the origin and nature of the disease. Relatively few tools have become available for managers to combat WNS and conserve vulnerable bat species, but adaptive efforts to both improve our understanding and to make informed management decisions have been underway since 2008. Structured decision making, or SDM, has been employed to examine the potential for captive management of affected species, and the use of containment techniques to slow the spread to new locations. Of the six bat species that have been confirmed with WNS by August 2011, only the Indiana bat (*Myotis sodalis*), is federally listed; the rest of the affected bats are managed as state trust species. Some state agencies have begun efforts to list certain hibernating bat species in order to afford them greater protection, and the U.S. Fish and Wildlife Service is currently reviewing multiple species of hibernating bats for potential listing, three under petition or formal request. Given the scope of the problem, a coordinated effort is required to manage WNS and conserve North American bats, and there are over 100 state and federal agencies, tribes, universities, institutions, organizations, and private entities involved with the organized response. The National Plan for Assisting States, Federal Agencies and Tribes in Managing White-nose Syndrome in Bats, finalized in May 2011, provides the framework for a coordinated national response,

and helps to ensure science-based management of WNS.

Ectoparasites Associated with Phyllostomid Bats in a Coffee Shaded Plantation in Southern Chiapas, Mexico
Helisama Colín Martínez, Juan B. Morales Malacara, and Carlos García Estrada, Universidad del Mar, Puerto Escondido, Oaxaca, México; Universidad Nacional Autónoma de México, D. F., México

The relationships between bats and their ectoparasites can vary in specificity and intensity. Some ectoparasites can be associated with a family or subfamily host (oligoxenous), with a genus host (stenoxenous), or are exclusively associated with one host species (monoxenous). Phyllostomid bats were captured monthly from December 2005 to November 2006 in a coffee shaded plantation, in southern Mexico, using four mist nets. Bats were sacrificed by asphyxia and were examined using a stereoscopic Zeiss microscope. We captured 193 phyllostomid bats belonging to 19 species, of which 17 were infested. We collected 1,975 ectoparasites representing 65 species (48 mites and 17 flies). *Dermanura tolteca* was the most abundant bat species (n = 40), followed by *Artibeus intermedius* (n = 28), and *Centurio senex* (n = 24); however, on average *Enchisthenes hartii* (66.4) and *Phyllostomus discolor* (28.0) had more ectoparasites per individual. The most abundant ectoparasites were *Macronyssoides* sp. A (n = 520), followed by *M. kochi* (n = 339). Thirty-eight ectoparasite species were monoxenous, twenty were oligoxenous, and just seven were stenoxenous. Ectoparasite diversity was higher in the dry season (H' = 2.57) than in the wet season (H' = 2.35, t = 3.03, df = 840, p = 0.002). A non-metric multidimensional scaling of bat species based on the abundance of ectoparasites species, according to Bray Curtis index, formed groups associated to genus level. Relations among bat species suggest that ectoparasites species can be used as an additional tool to produce phylogenetic trees of phyllostomid bats.

Distribution of Reproductive Female Bats Along an Elevational Gradient in the Monongahela National Forest
Jason D. Collins, Eastern Michigan University, Ypsilanti, MI

Elevation likely plays a role in the distribution of bats, particularly reproductive females, which are presumably more constrained by thermoregulatory needs. Understanding variation in elevational distribution is important when investigating life history characteristics, such as population size and composition. The Monongahela National Forest consists of over 371,000 ha of land in the West Virginia highlands and is home to the highest point in the Allegheny Mountains (1482.2 m). The Monongahela National Forest, in conjunction with Sanders Environmental, Inc., has been conducting a long-term bat-monitoring project, with emphasis on locating maternity colonies of the Indiana bat since 1997. Over 400 sites were monitored during 2001–2010, resulting in the capture of more than 10,000 individuals from 10 species. Species, age, sex, and reproductive status of bats caught in mist nets were recorded. The goal of the current study was to determine whether a relationship existed between reproductive status and the distribution of bats along elevational gradients, in the Monongahela National Forest. Of the ten species captured, *Eptesicus fuscus*, *Lasiurus borealis*, *Myotis lucifugus*, and *Myotis septentrionalis* represented about 88% of the total catch and were the only species included in this analysis. The distribution of each species was analyzed with logistic regression to determine the relationship between the proportion of reproductive females captured and elevation. Preliminary analysis indicates an inverse correlation between the proportion of reproductive females and elevation.

Navel Gazing with James Fullard
William E. Conner, Wake Forest University, Winston-Salem, NC

Healthy competition sometimes makes for strong and lasting friendships. James Fullard was a strong competitor and a life-long friend. Our friendship began when he unintentionally issued a challenge in a paper published in 1977 concerning the role of moth-produced anti-bat tymbal sound in courtship. James felt that the moth sounds would not play an important role in courtship because the tymbals were not sexually dimorphic, but we eventually convinced him otherwise. He was right that moth sounds evolved through their selective advantage vis-à-vis bats but the sounds secondarily became involved in courtship. Indeed the two roles may be inextricably linked. James laid down a second challenge in 1979 with a seminal paper on the potential role of moth sounds in jamming bat echolocation. He wanted behavioral evidence that the tymbal sounds jam the bat's sonar. My student Aaron Corcoran provided that evidence shortly before James passed away. James was happy to see the results supporting his hypothesis. Sonar jamming will be one of James' lasting contributions to the bat-moth story. My last communication from James was about navel gazing. In a signed review of one of the papers from my lab he cast a gentle reminder not to get too caught up with speculation, or navel gazing, as he called it. Instead, design the critical experiment and do it. For me

this is James' legacy.

***Contrasting Patterns of Winter Heterothermy in Two Bat Species, *Tadarida aegyptiaca* (Molossidae) and *Nycteris thebaica* (Nycteridae) in Northern South Africa**

Dawn Cory Toussaint, Andrew E. McKechnie, R. Mark Brigham, and Mac van der Merwe, University of Pretoria, Pretoria, South Africa; University of Regina, Regina, SK

*** Dawn Cory Toussaint** received the ***Bat Research News* Award**.

Heterothermy (i.e., torpor and hibernation) is a common response to energetic constraints in bats from tropical, subtropical, as well as temperate latitudes. Despite evidence suggesting that heterothermy is of major significance in the energy balance of tropical and subtropical bats, its occurrence in southern African species has received relatively little attention. We investigated the occurrence of heterothermy in *Tadarida aegyptiaca* (Molossidae) in Pretoria, Gauteng and *Nycteris thebaica* (Nycteridae) in the Limpopo Valley during the winters of 2008 and 2010 respectively. Skin temperatures (T_{skin}) were recorded using temperature-sensitive transmitters, and roost temperatures (T_r) were recorded using miniature temperature loggers. All *T. aegyptiaca* individuals roosted in buildings and used daily torpor as well as hibernation, with the onset of the latter associated with the arrival of a cold front. Heterothermy bouts ranged in duration from 2–84 h, with a minimum T_{skin} of 6.2°C recorded at T_r = 7.7°C. In contrast, *N. thebaica* used multiple roosting sites, including a hollow baobab tree (*Adansonia digitata*) and several caves, and exhibited only moderate heterothermy. In this species, T_{skin} was maintained around normothermic levels, with only small decreases of 6–9°C. A minimum T_{skin} of 28.4°C occurred at T_r = 23.8°C. Roost temperatures in the baobab and over the combined temperature range of the caves did not decrease below 10°C, and averaged 21.2 ± 2.8°C and 23.3 ± 2.9°C respectively. The thermoregulatory patterns of *T. aegyptiaca* were closely linked to prevailing weather conditions, whereas this did not appear to be the case in *N. thebaica*.

A Comparison of Acoustic Detection Systems for Passive Monitoring of Bats (a.k.a. the Wild WEST Inc. Detector Shoot-Out)

Zapata Courage, Donald I. Solick, and Jeffery C. Gruver, Western EcoSystems Technology, Inc., Cheyenne, WY

Passive acoustic monitoring of bats has become increasingly important, particularly in assessing potential risk to bat species posed by wind development and in monitoring the spread and long-term effects of white-nose syndrome. Effective passive monitoring requires that a detector be left unsupervised in the field to collect large quantities of data over extended periods of time. The Anabat detector has largely been the tool of choice for passive monitoring studies because the zero-crossing analysis system it employs extracts basic time-frequency information from ultrasound, allowing it to record a high number of low-resolution files. Full-spectrum (FS) detectors record at high sampling rates, which enable the detectors to record complete acoustic waveforms and to make high-resolution recordings, but at the cost of higher computer processing speed and data storage requirements. Recent advances in technology enable FS detectors to be used more effectively for passive monitoring studies, and several new detectors have been developed specifically for this purpose. The three most popular in the United States are the Pettersson D500x, the Wildlife Acoustics SM2, and the Binary Acoustics Technology AR125/FR125. Each of these detectors has its strengths and weaknesses, and all are changing rapidly, making it difficult to keep track of the details and determine which might be the best tool for particular needs. WEST, Inc. has had the opportunity to use each of these detectors on a number of wind development projects, and we present a table summarizing the relative strengths and weaknesses of the different systems based on our experience.

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

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

We investigated bat foraging patterns and insect activity 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 pseudoreplication transects and collected insects in forested and masticated stands using black-light traps. Calls were analyzed to species using Sonobat 3.0 and total number of calls for 2010 and 2011 were pooled, as there was no significant difference in overall stand use between years ($p = 0.14$, Wilcoxon rank-sum test). Overall bat activity was highest in masticated stands (443 total calls recorded), with 275 calls in forested stands, and 139 on the edge. Dunn's test showed that activity was significantly different between use of masticated stands versus edge ($p = 3.99$) and forested stands ($p = 2.31$), but did not differ between use of forested

stands and edge (p = 1.68). We also present data on species-specific use patterns of stand types. In both years average insect biomass was lower in masticated than in forested habitat: in 2010 biomass was 276.8 mg (SD = 380.9) in forested habitat versus 2.47 mg (SD = 6.4) in masticated habitat; in 2011, biomass was 13.9 mg (SD = 5.1) in forested stands and 8.7 mg (SD = 6.5) in masticated stands. We found significantly more bat activity in masticated habitat and contrastingly significantly more insect biomass found in forested habitat, forest management treatments that promote habitat mosaics are best for supporting bat species diversity particularly in variable environmental conditions.

Monitoring Behaviors and Activity of Bats at Wind Turbines with Near Infrared Videography
Paul M. Cryan, P. Marcos Gorresen, Frank J. Bonaccorso, and Mark A. Hayes, USGS Fort Collins Science Center, Fort Collins, CO; USGS Pacific Island Ecosystems Research Center, Hawaii National Park, HI; University of Hawaii, Hilo, HI

The rapid expansion of wind energy is an important step toward reducing dependence on non-renewable sources of power. However, there is now clear evidence that certain populations of bats are particularly susceptible to wind turbines. We still do not understand why turbines disproportionately affect such bats, but we may be able to better predict and avoid their deaths by determining when they occur near turbines and how they behave prior to collisions. These aims are hindered by the difficulty of observing small animals flying in the dark around structures approaching heights equivalent to 40-story buildings. Cost-effective methods for directly observing bats at turbines have been elusive. We developed a video system composed of high-powered illuminators and cameras sensitive to very low-light conditions in the near infrared (NIR) spectrum. Advanced digital processing algorithms are used to track animal movement against backgrounds in which non-target objects simultaneously move (e.g., turbines blades), and to efficiently filter the large volumes of digital video this system is capable of producing. Motion tracks are used to identify flight attributes (e.g., angle, velocity, direction, and acceleration) indicative of bats being struck by moving turbine blades. Our project is the first field validation of NIR videography to nocturnally track and quantify target motion at distances > 100 m under realistic operational conditions and long-term deployment scenarios. We present the results of surveys conducted in August–September 2011 at wind energy sites in Pennsylvania and Hawaii.

Ectoparasite Community Structure of *Myotis lucifugus* and *M. septentrionalis* from the Maritimes of Canada
Zenon J. Czenze and H. G. Broders, Saint Mary's University, Halifax, NS

Ectoparasites can affect the fitness of their hosts so understanding parasite population dynamics can reveal important information about host biology. Our goal was to characterize parasite community structure, as well as the prevalence and intensity of ectoparasitism on two sympatric bat species: *Myotis lucifugus* and *M. septentrionalis*. These host species exhibit life history differences that likely influence the biology of their ectoparasites. Although males typically roost alone, females of both species roost communally during the summer, which could increase risk of parasitism. Subadults of both species may be naïve in terms of grooming behavior and less proficient at removing parasites. Therefore, we tested the hypothesis that age and sex classes for both species differed in terms of prevalence and intensity of ectoparasites. We captured bats at mating swarms in Nova Scotia and New Brunswick and systematically collected ectoparasites. Six species were recorded, including bat fleas, wing mites, bat bugs, body mites, predatory mites, and an unknown species of the genus *Acanthophthirius*. Of these, the latter three were new records for Nova Scotia. Parasite prevalence was similar for males of the two species (22% and 23% for *M. lucifugus* and *M. septentrionalis*, respectively) but females had 2-3 times higher parasite prevalence than conspecific males (68% and 44% for *M. lucifugus* and *M. septentrionalis*, respectively). Consistent with our hypothesis, subadults exhibited the highest prevalence of ectoparasites (*M. lucifugus* 64%, *M. septentrionalis* 72%). Our findings highlight a cost of living in maternity colonies and suggest that grooming behaviors may take time to develop.

Shifts in Summer Bat Communities Due to White-nose Syndrome
Laura E. D'Acunto and Joseph E. Duchamp, Indiana University of Pennsylvania, Indiana, PA

We analyzed bat diversity and activity levels across the state of Pennsylvania to determine if longer exposure to white-nose syndrome (WNS) changes the surrounding summer bat communities in the state. We used a combination of mist netting and acoustic monitoring within 12 randomly selected 50-by-50 km grids spanning the state. In each grid, two nights of mist netting and three nights of active acoustic monitoring on road transects using Anabat SD1 detectors were completed. Half of the sample grids were located in the eastern portion of the state and the remainder in the west. We compared species diversity and activity levels of bats between these two groups,

noting that WNS has been prevalent in the east a year longer than the west. We caught a total of 54 bats and were able to identify a total of 1,545 calls to species. Preliminary analyses show greater diversity and activity in western sampling areas compared to eastern. Further analyses and ecological modeling taking landscape characteristics into consideration will be reported.

False Positive and False Negative Error Rates in Mitochondrial Species Delimitation
Liliana M. Dávalos and Amy L. Russell, Stony Brook University, Stony Brook, NY; Grand Valley State University, Allendale, MI

Sequence-based species delimitation using mitochondrial sequences is a rapidly growing field of bat taxonomy, promising to help identify species in the face of declining morphological expertise and a catastrophic biodiversity crisis. Such molecular barcoding has also transformed systematics, in that it has become common for species delimitation to rely in part or completely on two criteria: 1) reciprocal monophyly and 2) a threshold of sequence divergence between the putative species. Using coalescent simulations of continuous and interrupted gene flow we show that these commonly applied criteria incur both high false positive and high false negative error rates in species delimitation. Populations maintaining gene flow will commonly evolve reciprocal monophyly in mitochondrial sequences if gene flow is male-mediated. These populations can also attain between-matriline sequence divergence of $\geq 2\%$ just by virtue of a large effective population size. Conversely, genetically isolated populations do not achieve reciprocal monophyly unless effective population sizes stay below 10,000 individuals and the time since isolation exceeds 10,000 years. The genetic distances proposed as thresholds for species delimitation can only be attained by large (~1 M effective individuals) populations isolated for at least 1 M years. Because the simulations applied a short generation time, these estimates of false negative rates are conservative. We maintain that mitochondrial species delimitation requires additional supporting data to ensure that sex-biased dispersal is not the basis for the species proposed. To reduce error rates, species delimitation requires a hypothesis-testing approach that accounts for multiple inheritance systems, divergence times, and criteria beyond monophyly and sequence divergence.

Regional Assessment of Prey Consumed by Bats in Central Appalachia Prior to the Arrival of White-nose Syndrome
Luke E. Dodd, Daniel R. Cox, Joseph S. Johnson, Michael J. Lacki, and Lynne K. Rieske-Kinney, University of Kentucky, Lexington, KY

An understanding of prey consumption patterns across bat species is largely lacking in a community context. Further, a paucity of regional data exists across Appalachia, a part of North America that is of immediate importance to conservation efforts given the recent emergence of white-nose syndrome (WNS). We assessed the prey consumed by 188 bats captured in mist nets from 2006–2008 in Kentucky, Ohio, Tennessee, and West Virginia. Using dissection techniques, we identified eight orders of arthropods consumed by eight bat species. Coleoptera, Diptera, and Lepidoptera formed > 75% of the volume of all identifications. We detected regional variation in the diets of *Eptesicus fuscus*, *Lasiurus borealis*, and *Myotis septentrionalis* ($p < 0.1$). Dietary composition varied across species. The diets of *L. borealis* and *M. septentrionalis*, the most commonly captured species, were most similar to each other (92%). The species that fed most heavily on Diptera, *Perimyotis subflavus* and *M. leibii*, were most similar to one another (89%). While *Corynorhinus* species were most similar to one another (91%), *M. septentrionalis* was most similar to them (71%). The diet of *E. fuscus* was the most dissimilar to all other species. Our results provide evidence that while consumption of arthropod taxa varies across bat species and varies regionally, Coleoptera and Lepidoptera are consistently consumed across the bat communities of Central Appalachia. Nevertheless, our data suggest dietary differences across species, likely due to differences in ecomorphology and foraging strategies. This study provides a regional baseline for investigating prey consumption patterns following the impacts of WNS.

Bat Activity in Hardwood Forests Prior to and Following Harvest
Joseph Duchamp, Amber Nolder, Laura D'Acunto, Jeremy Sheets, Megan Caylor, and John O. Whitaker, Jr., Indiana University of Pennsylvania, PA; Indiana State University, IN

The response of the bat community to forest harvest has long been of interest in bat research. As part of a long-term controlled experiment on forest management, we acoustically sampled for bats within 36 treatment areas in southern Indiana, U.S.A., during the two years prior to and the two years following harvest. Each area instituted one of three types of treatments: no harvest, even-aged harvest, or uneven-aged harvest. Detectors were placed at three locations relative to each treatment area: inside, adjacent to, or outside the timber harvest. To quantify bat activity levels for each species, we counted minutes during which a species was recorded and identified during a night of sampling.

Based on minutes of use, we categorized activity during a night for each species: none, low-level use, and high-level use. We then used a Robust-Design Occupancy Model to test for differences in probability of use at locations among treatments and between years. Prior to harvest, the northern long-eared bat (*Myotis septentrionalis)*, Indiana bat (*M. sodalis*), and tri-colored bat (*Perimyotis subflavus*) were the most commonly recorded species. After harvest, the tri-colored bat, red bat (*Lasiurus borealis*), and big brown bat (*Eptesicus fuscus*) were the most commonly recorded species. After accounting for differences in detection probability, high-level use was more likely for northern long-eared bats relative to other species throughout the study. Activity levels were also elevated for bats overall in and around treatment areas during the two years post-harvest.

MorphoBat

Elizabeth R. Dumont, K. C. Samadevam, and I. R. Grosse, University of Massachusetts, Amherst, MA

Comparative studies often invoke the concept of optimality in search of evidence for adaptation. Similarly, studies of morphological adaptation frequently link organismal form to some measure of mechanical performance that is thought to influence fitness. Comparative biologists recently have turned to finite element analysis (FEA) to model the mechanical performance of complex structures. FEA is used to predict the deformation of structures under specified loads and boundary conditions. These deformations can be used to calculate many different quantities, but stress and mechanical advantage have been used most widely to assess and compare aspects of whole-organism performance. Here we use a parameterized computer-aided design model of a bat skull (MorphoBat) coupled with an FE analysis tool to predict the existing and hypothetical morpho-performance spaces for the crania of New World leaf-nosed bats (Family Phyllostomidae) during routine feeding behaviors. We use data derived from von Mises stress and mechanical advantage morpho-performance spaces to test the hypothesis that selection favored the optimization of stress and high mechanical advantage within phyllostomids. We also test the alternative hypothesis that selection has driven some species away from optimal states of stress in return for other benefits. Specifically, we predict that selection for elongated rostra (low mechanical advantage) in nectar-feeding bats and selection for high mechanical advantage in dedicated frugivores have driven them toward high stress regions of the morpho-performance space. Elements of each hypothesis are supported by comparative statistical analysis and the visualization of phylogeny within the morpho-performance space.

Year of the Bat Conservation Education

James E. Eggers, Bat Conservation International, Austin, TX

The United Nations Environment Programme (UNEP) declared 2011–2012 the Year of the Bat and Bat Conservation International (BCI) as a Founding Partner to organize and promote conservation education events around the globe. BCI aims to have one billion persons exposed to a positive message about bats. To that end, BCI developed a Year of the Bat (YOTB) campaign that offers opportunities for individuals and organizations of all sizes to be involved through partnership and/or sponsorship. We also developed a BCI Year of the Bat web presence, listing bat-related events, linking to BCI Year of the Bat partners, providing free education resources, recommending speakers and live-bat presenters, and offering the possibility to have activities listed on the UNEP Convention on Migratory Species (CMS) Year of the Bat website. BCI is also building partnerships to develop and distribute educational materials for targeted audiences, including decision makers and legislators at all levels of government, land managers, classroom educators, and eco-tourists. Events were held for Southeast Asia YOTB Kickoff, North American Zoos YOTB Kick-off and International Bat Night, with tens of thousands celebrating and learning about the importance of and threats to bats and ways that each person can help in "conserving the world's bats and their ecosystems in order to ensure a healthy planet."

Could Climate Change Affect Reproductive Success in Tropical Insectivorous Bats?

Nurul Ain Elias, R. Hashim, and T. Kingston, Texas Tech University, Lubbock, TX; Universiti Sains Malaysia, Penang, Malaysia; Universiti Malaya, Kuala Lumpur, Malaysia

High energetic and nutritional demands are postulated to occur during pregnancy and lactation, requiring bat species in seasonal habitats to breed when food availability is greatest. Failure to match parturition with food availability could incur individual fitness costs and, should mismatches occur repeatedly, will lead to population declines. In this study, first we determined the possible synchrony of reproductive activity in insectivorous bats to insect availability. Then we investigated the correlation between insect availability and local climate variables (temperature and rainfall). The study was conducted in lowland dipterocarp forest around Kuala Lompat Research

Station at Krau Wildlife Reserve, Malaysia, from February 2009 to January 2010. A HOBO Automated Weather Station was used to monitor the temperature and rainfall. Bats were trapped with four-bank harp traps in the forest understory for five nights each week, and once a month at a nearby cave. A total of 1,337 females of 33 species from the families Hipposideridae, Rhinolophidae, Vespertilionidae, Megadermatidae, Nycteridae, and Emballonuridae were captured. Individuals were assigned to five major reproductive categories based on the examination of mammary glands, pubic nipples, and abdominal palpation. Two light traps were set simultaneously during trapping nights to assess insect abundance at trapping sites. Initial results suggest that lactation is timed to coincide with the period of maximum insect biomass. We discuss our findings relative to projected climate change for Malaysia.

Flight Patterns of Sympatric Insectivorous Bats in Jamaica
Matthew A. Emrich, University of Western Ontario, London, ON

Bat communities may be composed of many species with similar diets, and a traditional competitive view of niches suggests that bats partition available resources. Wing morphology, and as a result flight behavior, has been identified as one factor potentially responsible for faunal structure in communities of insectivorous bats. From 30 May to 4 August 2011, I placed two, four microphone arrays, back-to-back, in cluttered, edge, and open habitats in the vicinity of Windsor Cave in Jamaica. Each habitat type had three sites with slightly different features. The arrays were set up at each site and recorded bat echolocation calls directly to computer from sunset to sunrise for a total of 45 nights. I used a robotic moth and a blacklight for two nights at each site to assess foraging bats' responses to real (insects at UV light) and artificial (fluttering target) prey. Using the program Moonshine, I reconstructed three-dimensional flight paths of seven insectivorous bats, including *Molossus molossus*, *Tadarida brasiliensis* (Molossidae), *Mormoops blainvillii* (Mormoopidae), *Pteronotus parnellii*, *Pteronotus quadridens*, *Pteronotus macleayii*, and *Macrotus waterhousii* (Phyllostomidae). Both intra- and inter-specific differences in speed, maneuverability, feeding behavior, and modifications due to habitat were determined. The results suggest that flight behavior is a factor in resource partitioning between different species of bats.

Bats, Rabies, and Emerging Infectious Diseases
Paul A. Faure, McMaster University, Hamilton, ON

Bats are the second largest order of mammals. They are found on all continents, except Antarctica, and the diversity of habitats they occupy is matched only by variation in their behavior and diet. The shear number of bats combined with their longevity, social behavior, and ability to fly can facilitate disease transmission to humans. There are dozens of pathogens associated with bats, and this has important implications for public health and bat protection. I will review the transmission dynamics of several bat-associated pathogens, including North American and European lyssaviruses, with an emphasis on understanding the co-evolution of host-pathogen relationships. Rabies remains one of the oldest and most feared of human diseases. Worldwide, the majority of human deaths from rabies are caused by dog bites, yet most recent human fatalities in North America have resulted from contact with bats. The proportion of bats naturally infected with rabies virus has probably changed little over time, but increased awareness about bats and their diseases, combined with fear and misconceptions about bats and rabies, can result in additional challenges for public health and bat conservation. The cryptic nature of bat-transmitted human rabies virus infections together with the financial costs of administering rabies post-exposure prophylaxis (PEP) to persons at low risk of contracting disease will be used to illustrate how public opinion and the recommendations for bat rabies PEP have recently changed in Canada. Nevertheless, the pendulum could swing back so it is imperative for biologists to understand the relationship bats play in the transmission and maintenance of zoonotic infections.

Effects of Conspecifics on Vespertilionid Bat Echolocation: Jamming their Transmission?
Kayleigh Fawcett and John M. Ratcliffe, University of Southern Denmark, Odense, Denmark

The jamming avoidance response (JAR) is well documented in the electric fishes, and although a number of studies have documented apparent changes in call parameters of bats flying together—in both the field and laboratory—JAR has not been investigated in as fine of detail in bats. Many studies consider JAR in bats to be down to simply interference or echo ambiguity. We hypothesize, instead, that observed changes in echolocation call parameters may be a mechanism to cope with the excess clutter caused by other bats flying in the same space. We present preliminary data from an in-depth investigation into JAR in three species of vespertilionid bats: *Myotis daubentoni*, *M. nattereri*, and *Pipistrellus pygmaeus*. We used a multi-microphone array system to record all bats flying alone and all combinations of intra- and interspecific species pairs under laboratory conditions. We

complemented our call analysis with flight path reconstruction using time-of-arrival differences to analyze in detail the call variability in single versus pairs of bats. Our initial data suggest that bats flying in pairs increase call bandwidth and peak frequency as compared to when flying alone. Call duration appears to be shorter for bats flying in pairs compared to those flying alone. Taken together, the changes observed are more similar to those of bats in closed habitat than JAR as originally described and support our 'conspecifics as clutter' hypothesis.

James Fullard and Donald Thomas: Bats and Science
M. Brock Fenton, University of Western Ontario, London, ON

The purpose of this presentation is to revisit some of the contributions of two late colleagues, James Howard Fullard and Donald William Thomas, and set the stage for others to address this topic. I had the honor of working with both of them and their enthusiasm for biology in general and bats in particular was astonishing. In any situation, one could depend upon James and Don to bring a smile to your face, a reality that you could repeatedly revisit by just remembering. You also could count on them to ask unexpected questions, and, in conversation, take your idea and turn it around on itself. I never missed an opportunity to run my favorite ideas by Don and James.

***Bat Species Frequency Distributions Shift after White-nose Syndrome Reaches the West Point Military Reservation**
Michael S. Fishman, Matthew D. Schlesinger, James Beemer, and Carl Herzog, Barton and Loguidice, P.C., Syracuse, NY; New York Natural Heritage Program, Albany, NY; U.S. Army Garrison, West Point, NY; New York State Department of Environmental Conservation, Albany, NY
*** Michael S. Fishman** received the **Organization for Bat Conservation Award**.

White-nose syndrome (WNS), an invasion of the non-native fungus, *Geomyces destructans*, was first documented in Schoharie County, New York, U.S.A., in 2006, and quickly spread throughout the northeastern United States. By winter 2007–08, bats in the Hudson Valley of New York exhibited WNS. Mist-net surveys were conducted at West Point Military Reservation (WPMR), Orange County, New York, at 21 sites in 2002 (pre-WNS) and at 20 sites in 2008 (post-WNS), using the USFWS protocol for the endangered Indiana bat (*Myotis sodalis*). The 2002 survey captured 149 bats representing 7 species, of which little brown bats (*Myotis lucifugus*, n = 61) and northern bats (*Myotis septentrionalis*, n = 42) were the most frequently captured species. The 2008 survey captured 144 bats representing 5 species. Big brown bats (*Eptesicus fuscus*, n = 86) and northern bats (n = 44) were the most frequently captured species, while only 10 *M. lucifugus* were captured. WNS has resulted in mass mortalities of cave-hibernating bats, but all species have not been affected equally. *M. lucifugus* populations have declined by 91% in New York, but cave-hibernating *E. fuscus* have declined by only 43%. Increases in relative capture frequency of *E. fuscus* after WNS introduction have been observed elsewhere, but we believe that this is the earliest documented observation of this phenomenon. The tendency of *E. fuscus* to hibernate in buildings, as well as caves, may be preserving their populations, though further study of this is needed. Our findings may reflect an opportunistic niche expansion of *E. fuscus* as populations of other cave-hibernating bat species decline.

DNA Barcodes: A Standardized Tool for Understanding Bat Diversity and Aiding Taxonomy
Charles M. Francis, Canadian Wildlife Service, Environment Canada, Ottawa, ON

Recent studies around the world have shown that DNA barcodes, a short sequence of the cytochrome oxidase I (COI) mitochondrial gene, can be used to identify 95–98% of currently recognized bat species, with only a few closely related species sharing barcodes. Furthermore, all these studies have highlighted deep genetic divides within many "species" that may represent previously unrecognized taxa. In several cases, subsequent morphological or behavioral studies have confirmed multiple species are involved. Based on these results, Francis et al. (2010; PLoS ONE 5(9): e12575) suggested the diversity of bat species in Southeast Asia may be more than double the number currently recognized. Although similar results could potentially have been obtained using other genes such as cytochrome *b*, there are many advantages to working with COI. This gene has been adopted as the standard DNA barcode for animals by the International Barcodes of Life initiative, with the result that many valuable tools are available for linking, sharing, and analyzing data, including a sophisticated database for storing and analyzing data, which include more than 500 bat species and 20,000 sequences. Recently, a dedicated portal has been developed for barcoding mammals of the world. Sequencing COI, whether from a biopsy sample of a live animal, or as one of a suite of genes in a phylogenetic or taxonomic study, will enable bat researchers throughout the world to compare specimens and combine data sets to accelerate understanding the taxonomy, diversity and ecology of bats, and ultimately helping with their conservation.

A Stable Isotope Investigation of the Origins of Fall Migrant Silver-haired Bats (*Lasionycteris noctivagans*)
Erin Fraser, Liam McGuire, M. Brock Fenton, and Fred J. Longstaffe, University of Western Ontario, London, ON

Data collected at migration monitoring sites have been shown to reliably reflect bird population trends at northern breeding sites. Monitoring migrating bats, including silver-haired bats (*Lasionycteris noctivagans*), may similarly provide valuable data about northern bat population trends, but in order to interpret monitoring data for this purpose, it is first necessary to identify the geographical range from which migrants originate. We used stable hydrogen (δD), carbon ($\delta^{13}C$), and nitrogen ($\delta^{15}N$) isotope analyses to investigate the origins of *L. noctivagans* captured during fall migration at Long Point, Ontario, a migration monitoring site where *L. noctivagans* frequently occur during fall migration. We tested the hypotheses that 1) the migrant bats originated from a wide range of latitudes and 2) the timing of fall bat migration varied across latitudes. We conducted stable isotope analyses on fur from 72 bats captured during August and September of 2008 and 2009. The stable isotope profiles (total δD_{fur} variation and $\delta D_{fur}/\delta^{13}C_{fur}$ correlations) of the migrant bats and a reference resident population were similar and there was no trend in δD_{fur} over time, nor was it possible to isotopically distinguish between bats captured during two temporal migratory "waves." These results provide no stable isotope evidence that these bats originated from a range of latitudes or that their latitude of origin varied over time.

Pollinator Effectiveness of Facultative (*Antrozous pallidus*) and Obligate (*Leptonycteris yerbabuenae*) Nectar-feeding Bats
Winifred F. Frick, Ryan D. Price, Paul A. Heady III, and Kathleen M. Kay, University of California, Santa Cruz, CA; Central Coast Bat Research Group, Aptos, CA

Pallid bats (*Antrozous pallidus*) were recently discovered to be frequent visitors of cardon (*Pachycereus pringlei*) flowers in Baja California, Mexico. The bat-adapted flowers of the cardon are a major source of dietary nectar for the lesser long-nosed bat (*Leptonycteris yerbabuenae*). In 2011, we measured the pollinator effectiveness of pallid and lesser long-nosed bats by comparing the amount of pollen deposited to cardon stigmas by each species. We hypothesized that lesser long-nosed bats would be more effective pollinators than pallid bats, given their specialized morphology for nectar feeding. Contrary to our predictions, pallid bats delivered roughly 13 times (95% CI: 4.5, 37.3) more pollen grains to stigmas per visit than lesser long-nosed bats. The amount of pollen delivered by lesser long-nosed bats decreased significantly throughout the night, which we hypothesize may be related to pollenivory. Visitation rates by pallid bats are generally lower than lesser long-nosed bats, but higher rates of pollen deposition per visit make these facultative nectar feeders an effective pollinator even at sites where visitation rates are as low as 1–2 visits per flower. In contrast, lesser long-nosed bats need to average approximately 28 visits per flower to deliver sufficient pollen quantities to approach mean seed set rates in cardon. Visitation rates by lesser long-nosed bats varied significantly across sites from 2007–2011 and were particularly low in 2011. Our results suggest there is considerable spatio-temporal variation in pollinator effectiveness of lesser long-nosed bats for cardon and that pallid bats are an important pollinator mutualist in this system.

Building a Case for the Study of Wound Healing in Bats
Nathan Fuller, Jonathan Reichard, and Thomas Kunz, Boston University, Boston, MA

As the only mammal capable of powered flight, bats depend on their wings for a variety of vital processes including physiological regulation, locomotion, and feeding. However, these functions can be threatened by wing damage that bats naturally gain from interactions with conspecifics, predators, or objects in the environment. Despite the high occurrence of wing defects and the impact that such damage is likely to have on survival and reproduction, there has been little research on wound healing in bats. The few studies that have been conducted show that bats have an impressive ability to recover from not only small scrapes and tears, but also from large-scale tissue loss. While these studies provide basic information on wound healing, they also serve as a reminder that our knowledge is still lacking. Many important details remain unexplored, such as the regenerative ability of wing tissue, whether skin appendages (e.g., hair follicles and glands) are replaced during healing, and the characteristics of scar tissue. With the continuing threat of white-nose syndrome, which can inflict severe damage to the wings of hibernating bats, and the potential effect of such defects on hibernation physiology and foraging ability, it is increasingly important to understand the details of wing healing and the related consequences for long-term survival. In this talk we discuss testable hypotheses regarding wound healing in bats and their implications for our understanding of white-nose syndrome, bat physiology, and the impact of non-lethal wounds on free-ranging animals.

Bat Diversity at the Botanical Garden of the Universidad del Mar, Southern Oaxaca, Mexico
Carlos García Estrada and Helisama Colín Martínez, Universidad del Mar, Puerto Escondido, Oaxaca, México

The Mexican state of Oaxaca is characterized by a high biodiversity; however, there are few studies on bat diversity in this state, particularly along the coastal region. On other hand, human activities have reduced pristine vegetation. One aim of the Botanical Garden of the Universidad del Mar, located in the coastal region of Oaxaca, is to conserve plant diversity of the lowland deciduous forest; therefore, our objective was to understand bat diversity in this area. Sampling was conducted monthly from November 2007 to September 2009. Bats were captured during three consecutive nights, using five mist nets placed along the vegetation. Also a tunnel and three culverts were examined for bat occupancy on the fourth day. We captured 1,401 bats (362 were recaptured giving a total of 1,763 captures) representing 13 species, 9 genera, and 3 families. Seven species were frugivorous, three insectivorous, two nectarivorous, and one hematophagous. We captured ten species in mist nets, seven species in the tunnel, and just one species in the culverts. Bat alpha diversity recorded in mist nets (H' = 1.32) was significantly greater than in the tunnel (H' = 1.48; $t = 3.17$, df = 950, p = 0.001). *Desmodus rotundus* was the most abundant species captured in mist nests, while *Pteronotus parnellii* was the most abundant species found in the tunnel. *Glossophaga soricina* was the only recorded species in all sites. We suggest that both diurnal roosts and plant diversity promote bat richness at the Botanical Garden of the Universidad del Mar.

How to Tease a Bat! Echolocation Behavior and Flight Dynamics during Final Prey Pursuit Stages in *Myotis daubentonii*
Conny Geberl, Lutz Wiegrebe, Signe Brinkløv, and Annemarie Surlykke, Ludwig-Maximilians-Universität Munich, Germany; University of Southern Denmark, Odense, Denmark

The sonar calls of foraging insectivorous echolocating bats comprise three different stages: search, approach, and a final buzz. Up to 200 calls are emitted per second during the final buzz, which for some species can be separated into buzz I and buzz II, the transition between the two being marked by a characteristic drop in call frequency. We studied the flight and echolocation behavior of European *Myotis daubentonii* during prey capture sequences in both laboratory and field to elucidate whether bats extract from and react to the extremely fast feedback throughout the last stages of prey pursuit. *M. daubentonii* is one of several trawling bat species that take prey directly from water surfaces. We used two types of "prey remover devices," with a mealworm suspended in free air on a taught fishing line or stuck on a metal tip protruding from a water surface. This enabled us to quickly remove the worm out of an approaching bat's trajectory at different time delays/distances and compare the behavior to control trials where bats were allowed to catch the worm. Both setups used synchronized high-speed video and sound recordings to document flight and biosonar behavior. Both the echolocation and flight behavior of bats correlated with the timing of prey removal, revealing that the final buzz is not an all-or-nothing behavioral response. Rather, both the number of emitted buzz calls and the duration of capture-related flight behavior gradually decreased as prey was removed at earlier stages of the pursuit sequence.

Reproduction in Two Sympatric Nectar-feeding Bats in French Guiana
Cullen Geiselman, Houston, TX

Lactation in many tropical bat species occurs during peaks in food availability resulting in seasonality in birth peaks often correlated with rainfall. In nectar-feeding bats, birth peaks and lactation frequently occur in the dry season when many plant species flower. I tested the linkage among rainfall, diet, and birth peaks in nectar-feeding bats by following the reproductive patterns in *Anoura geoffroyi* and *Lionycteris spurrelli* in a lowland tropical rainforest in French Guiana. Over the course of two years, I captured 524 individuals in ground-level mist nets, collected 322 fecal samples from them, and followed the flowering of 90 individuals of 9 plant species. Females of both species gave birth to one pup per year in the dry season, though the reproductive period of *A. geoffroyi* appeared to be more synchronized. I identified 14 plant species in bats' diets and observed insect remains in all fecal samples collected from adults. Reproductive females of the two species differed significantly in the frequency with which they utilized the nectar/pollen of four of the five common plant species in their dry season diets; however, their diets did not vary greatly from those of nonreproductive conspecifics. Lactating *A. geoffroyi* were twice as likely to be carrying their young when captured, which may be attributed to differences in foraging behavior related to the distribution of food and/or to differences in roost microclimate and ectoparasite load.

Acoustic Communication and Group Cohesion in Neotropical Tent-making Bats
Erin H. Gillam and Gloriana Chaverri, North Dakota State University, Fargo, ND; Boston University, Boston, MA

Social animals regularly face the problem of relocating conspecifics when separated. Communication is one of the most important mechanisms facilitating group formation and cohesion. Known as contact calls, signals exchanged between conspecifics that permit group maintenance are widespread across many taxa. Foliage-roosting bats are an excellent model system for studying the evolution of contact calling, as there are opportunities to compare closely related species that exhibit major differences in ecology and behavior. Further, foliage-roosting bats rely on relatively ephemeral roosts, which leads to major challenges in maintaining group cohesion. Here, we describe preliminary findings on the communication signals produced by two tent-making bats, *Dermanura watsoni* and *Ectophylla alba*. We found that both species produced calls in the early morning near the roost that were associated with roostmate recruitment. Calling often ended once other bats arrived, suggesting that the primary function of these signals was to announce location. The structure and function of these calls are described and future research directions are discussed.

***Myotis lucifugus* at Maternity Colonies in Massachusetts: Assessing Impacts of White-nose Syndrome**
Katherine M. Gillman, Gordon Towne, Allison J. Harwick, Aaron Gatnick, Thomas T. D. Little, Margrit Betke, Zheng Wu, Jonathan D. Reichard, D. Scott Reynolds, and Thomas H. Kunz, Boston University, Boston, MA; Emmanuel College, Boston, MA; St. Paul's School, Concord, NH

Little brown myotis (*Myotis lucifugus*) populations in the northeastern United States have recently experienced major declines in many hibernacula owing to the spread of *Geomyces destructans*, the fungal pathogen associated with white-nose syndrome (WNS). For the past several years, we have monitored two established maternity colonies of *M. lucifugus* in Massachusetts using infrared cameras (BatCams) to census bats. We present results from these two colonies for comparison with colony sizes at other maternity roosts in the Northeast before and after the appearance of WNS. Weekly censuses were made directly from the video recordings, along with live counts in the field. Current analysis of videos from one site (Paxton) shows that this colony decreased by 70% from 2008 to 2009, by 11% from 2009 to 2010, and by 5% from 2010 to 2011. The second site (Lincoln) decreased by approximately 40% over each of the past two summers. Live visual counts of emerging bats were comparable to counts made directly from the video recordings. Automatic computer counts, made using a specially developed program, were at times 20% higher than results from the two visual counting methods (bats were sometimes difficult to distinguish from insects in the near field). Relative to other maternity colonies in the Northeast, current results suggest that these two colonies may provide refuges for unaffected bats or for survivors of WNS. Similar results could be seen in other locations if suitable roosting sites, such as specially designed roost modules, are made available for small residual colonies.

Comparison of Bat Foraging Activity Levels between Lakes Containing Introduced Trout and Fishless Lakes in the Sierra Nevada Mountains, California
Elizabeth Gruenstein and David Johnston, San Jose State University, San Jose, CA; H. T. Harvey and Associates, Los Gatos, CA

Bats predate heavily on insects associated with aquatic ecosystems, but we know little about the relationship between bats and insectivorous fish that may compete for the same prey. In the Sierra Nevada Mountains in California, widespread stocking of non-native trout into high-elevation, naturally fishless lakes took place for past 150 years. In our study, we hypothesize that bat activity will be greater at lakes without introduced fish than at lakes with fish. We are monitoring bat activity at 10 pairs of high-elevation lakes (ranging between 6,000 and 8,000 MASL) in Yosemite National Park during the summer and fall of 2011 and 2012. Each pair is composed of lakes that are comparable except that one lake contains fish and the other does not. Every night of the survey period, researchers placed Anabat II bat detectors and Z-Caim recorders at analogous locations on the shores of the lakes where they passively record bat activity throughout the night. Additionally, researchers circumnavigated the lakes with detectors to record for five minutes at each of eight locations on the perimeters that correspond to cardinal and ordinal directional points. Bat activity was measured using the number of bat sequence calls and feeding buzzes recorded per hour. When possible, bats' call sequences were analyzed to determine species composition. During initial surveys we recorded a mean of 43.4 calls/h (SD = 50.4) at lakes with fish, and 16.5 calls/h (SD = 14.5) at lakes without fish. However, a meaningful statistical analysis requires more data.

A New Method for Increasing Searcher Efficiency of Post-construction Mortality Surveys at Wind Facilities
Benjamin Hale and Lynn Robbins, Missouri State University, Springfield, MO

Wind turbines are a fast growing form of sustainable energy. Unfortunately, large numbers of bats have been killed at some wind energy facilities due to blade impact and extreme pressure changes (barotrauma). One of the few ways to access a facility's effect on a bat species is to conduct carcass searches using teams of human searchers. Unfortunately, this method has a success rate as low as 25% and is highly variable within and among projects. This project tests several modified agricultural machines for their ability to pick up, or "search" for bat carcasses more efficiently than human search teams. Formalin-prepared bat carcasses were randomly placed across controlled vegetation that was "searched" in transect and grid formation using different combinations of an all-terrain vehicle or tractor and the appropriate pull-behind machine. Grass height, machine deck height, machine speed, power take-off rotations per minute, and grass filter composition were variables in multiple trials. Some of these modified machines successfully collected bat carcasses; one machine was as high as 81% with a variance of 0.011 between trials. These data indicate that carcass searching using machines can lead to a repeatable and more scientific approach to mortality surveys while eliminating the human bias. Additional research, including comparing a newly modified prototype to a searching team, will be presented. Without reliable searcher efficiency, effects of turbine operation cannot be accurately and efficiently assessed and therefore types and level of adaptive management and mitigation cannot be accurately determined.

Modeling the Dispersal of White-nose Syndrome in the United States
Thomas Hallam, Jeffrey Nichols, William Waldrep Jr., Paula Federico, Calvin Butchkoski, Gregory Turner, David Culver, Rebecca Nichols, and Gary McCracken, University of Tennessee, Knoxville, TN; Oak Ridge National Laboratory, Oak Ridge, TN; University of Chicago, Chicago, IL; Capital University, Columbus, OH; Pennsylvania Game Commission, Harrisburg, PA; American University, Washington, DC

For the past two years, regional differences in dispersal of hibernating bats in areas affected by white-nose syndrome (WNS) have been observed along north-south gradients. Prediction of WNS dispersal is lacking. We project the spread of the fungus *Geomyces destructans* and WNS caused by bat-to-bat transmission by using an agent-based, spatially-explicit, temperature-dependent, stochastic model. The spatial base layer of the model delineates caves in the 48 contiguous states. Ambient temperature of each cave is computed using interpolation of average monthly temperatures determined from records of the National Oceanic and Atmospheric Administration (NOAA) weather stations closest to the cave. The disease dispersal structure consists of regional-scale movement from epicenter to epicenter with local corridor expansion ensuing between epicenters. Simulations suggested that a major factor that differentiates dispersal and mortality rates through geographic measures is temperature variance. The regional patchiness of dispersal highlights a temperature-dependent refuge for WNS-susceptible bats in the southern United States where there are no emerging cases of disease. There may be hope for some of our bats!

Seasonal Activity of Migratory Bats Along Coastal and Ridged Landscape Features
Rachel Hamilton, University of Western Ontario, London, ON

The activity of migratory bats across the landscape is poorly understood; however, linear geographical features may be significant areas for migration. I explored the activity patterns of migratory bats along north-south oriented landscape features. Three landscape features were chosen: 1) a forested ridge; 2) a lake shoreline; and 3) a flat, agricultural area. In southwestern Ontario, I selected five sites per feature, totaling fifteen sites. I used Songmeter SM2s to record activity from sunset to sunrise from May through early October (162 days), to encompass spring, summer, and fall activity. I modeled the activity of three migratory species—*Lasiurus cinereus*, *L. borealis*, and *Lasionycteris noctivagans*—at each site while looking for interactions at each landscape feature. The levels of bat activity in relation to landscape features may indicate areas of significance for migratory bats during their annual seasonal movements and may also inform the placement of future wind turbines.

Comparison of Body Temperature and Movements among Reproductive Classes of Roosting *Myotis sodalis* in the Southern Appalachians
Kristina R. Hammond and Joy M. O'Keefe, Indiana State University, Terre Haute, IN

In the southern Appalachians there is little data on roost habitat selection by Indiana bats (*Myotis sodalis*). In particular, we know little about the variables that influence the use of torpor in free-ranging bats. In a laboratory

environment reproductive female bats use different thermoregulatory behaviors and patterns than non-reproductive females and males. Reproductive females use torpor less frequently because it slows neonate development and milk production, thus influencing growth and survival rates. Our objectives were to define normal roosting body and torpor temperatures for free-ranging Indiana bats, and to identify independent variables that influence torpor. In summer 2011, we used a Telonics TR5 receiver to locate 22 roosts and a Lotek SRX-DL data-logger to record body temperature for 11 tagged bats (6 pregnant, 2 lactating, 1 non-reproductive male, and 2 juvenile males) carrying temperature-sensitive Holohil transmitters. We found differences in body temperature due to reproductive class, roost type, and roosting group size, and we found differences in frequency of night visits to roosts between pregnant and lactating bats. These data will lead to a better understanding of body temperature and the factors that influence the use of torpor by Indiana bats in the summer. Ultimately, data on temperature requirements of Indiana bats in the southern Appalachians may help with identification and management of suitable natural or artificial roosting habitat.

***The Use of DNA Barcode (Barcoding) to Determine the Diversity of Phyllostomid Bats of the Yucatan Peninsula and Central America**

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*** Arely Hernández-Dávila** received the **Bernardo Villa Award**.

The systematics of bats has been a source of much discussion within phylogenetic studies in recent years. The goal of this study is to examine patterns of genetic divergence using the barcode, a segment of mitochondrial DNA cytochrome *c* oxidase gene I (COI) for the phyllostomids of the Yucatan Peninsula and Central America. We obtained samples from national and international collections and we caught some specimens in the study area. We obtained DNA samples of 22 species from 42 localities; we performed extraction, amplification, and sequencing of these samples. The sequence was calculated using the Kimura 2 parameter. The results of the tree constructed show that there are more than 13 bats assemblies, which suggests a rich diversity of phyllostomids in the area. Eighteen species showed low intraspecific variation (≤ 2.5%), suggesting that their population densities are low, while four species showed high variation and high haplotype numbers. The majority of these species had low intraspecific variation (mean = 1.32%), but the members of the *Artibeus* complex (3.0%) and individuals of *Desmodus rotundus* (5.1%) had the greatest intraspecific variation, suggesting divergent lineages and potentially new taxa in the region. The tree constructed and bootstrap analysis showed that interspecific divergence is very high and indicates the high variability of these Neotropical bats. We confirmed the effectiveness of the barcode for the bats of the Yucatan Peninsula and Central America, established patterns of genetic diversity, and used the method to identify cryptic species.

High Duty Cycle to Low Duty Cycle: Echolocation Behavior of the Hipposiderid Bat *Coelops frithii*

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Laryngeally echolocating bats avoid self-deafening (forward masking) by separating pulse and echo either in time (low duty cycle, LDC) or in frequency (high duty cycle, HDC). HDC echolocation occurs in rhinolophid and hipposiderid bats (Old World), and in the New World mormoopid *Pteronotus parnellii*. HDC echolocators appear specialized to detect fluttering targets in cluttered environments. To date there has been no evidence of HDC bats adopting LDC echolocation. Here we present data from free-flying individuals in the field to demonstrate that the hipposiderid *Coelops frithii*, ostensibly an HDC bat, uses LDC echolocation. We collected calls of *C. frithii* around an underground roost in Taiwan from January to April 2011. Besides recording calls during resting and flying, we monitored and recorded their echolocation responses while approaching an electronic fluttering target rotating at 50–80 kHz. Echolocation calls of *C. frithii* consisted of a two-part signal, an initial narrowband component (0.5–0.8 ms, 90 kHz), followed immediately by a frequency modulated sweep (160–110 kHz). *C. frithii* consistently produced this call pattern at low intensity, high repetition rates (82–103 Hz) and low duty cycles (7–10%). Moreover, *C. frithii* approached the fluttering target at a rate of 40.4% (n = 80), which was higher than other LDC bats (0%, n = 13), but not different from the HDC species (*Hipposideros armiger*, 53.3%, n = 23; *Rhinolophus monoceros*, 56.7%, n = 154). We propose that *C. frithii* manipulates the harmonic content in their calls and that they use the prominent narrowband component to detect fluttering targets.

Adaptation of Sihler's Staining Technique for Visualization of Wing Innervation in Normal and White-nose Syndrome-Positive Bats

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Sihler's staining technique is a method for visualizing nerves, while maintaining their positional contexts within organs. The technique stains nervous tissue while rendering other tissues translucent. Initial research assessed the feasibility of this technique on the delicate tissues of bat wings that were preserved by different methods. Specimens of *Myotis lucifugus*, previously frozen, were fixed in solutions of either 10% formalin or 80% ethanol by volume. After modifications, the technique proved successful in showing nerves down to the finest branches in specimens preserved in either solution. Dissection after staining revealed the dactylopatagial membranes (total area 9.87 cm^2 ± 0.96) were supplied by branches of the median nerve, and the plagiopatagium (area 16.97 cm^2 ± 1.58) was supplied primarily by the ulnar nerve, along with segmental spinal nerves and at least one nerve originating from the hind limb. Sensory cell complexes, observed to be associated with sensory hairs on dorsal and ventral wing surfaces, were regularly patterned along rows through the wing. Three 5x5 mm areas were compared for number of primary rows and density of sensory cell complexes. Density was highest along the trailing edge of the dactylopatagium between digits III–IV (7 primary rows, 63 ± 4 cells), intermediate along the trailing edge of plagiopatagium (4 primary rows, 47 ± 6 cells), and lower near the center of the plagiopatagium (2 primary rows, 21 ± 7 cells). Application of this technique to a sample (n = 6) of WNS-positive bats is in progress.

New Advances for the Study of Group Behavior in Bats

Nickolay I. Hristov, Louise C. Allen, and Brad A. Chadwell, Winston-Salem State University/Center for Design Innovation, Winston-Salem, NC; Salem College, Winston-Salem, NC; Guilford College, Greensboro, NC

From the seemingly chaotic movement of unicellular organisms to the grandiose migrations of the North American caribou, the collective behavior of organisms belong to some of the most striking displays in nature. Based on the characteristics of the individual but meaningful in the context of the group, the behavior of animal groups poses an evolutionary paradox—how to balance energetic, predator avoidance, and information transfer benefits against the costs of higher visibility, increasing competition and diminishing resources in the group. Rich theoretical and modeling work has proposed striking solutions to this dilemma but with little empirical support from field data and thus with unclear relationship to biological reality. Some of the most compelling answers to how animals group might come from utilizing new model systems and will require an integration of theoretical and experimental evidence, facilitated by new technologies. Although rarely studied, bats represent an attractive model for the investigation of group behavior. The Brazilian free-tailed bat (*Tadarida brasiliensis*) in particular is famously gregarious and thus uniquely suited for such considerations. We describe recent developments in temporal and spatial recording and numerical analysis in order to peek into the complex behavior of free-tailed bat groups. Using high-speed videography, three-dimensional motion capture and laser scanning, we show how a species adapted for fast, solitary flight at high-altitude can navigate the dense environment of the emergence group.

Niche-specific Cognitive Strategies: Object Cues Overshadow Spatial Cues in a Predatory Bat

Katrine Hulgard and John M. Ratcliffe, University of Southern Denmark, Odense, Denmark

Natterer's bat, *Myotis nattereri*, hunts arthropod prey close to vegetation, using echolocation calls of broad bandwidth to resolve prey from background vegetation. Preliminary observations suggest this species associates nearby shapes with food. In our study, we tested the niche-specific cognitive strategies hypothesis. Specifically the prediction that, as opposed to frugivorous and nectivorous species, predatory bats should rely on object recognition over spatial memory to identify potentially profitable prey patches. We observed free-flying *M. nattereri* as they took palatable and unpalatable prey suspended below different three-dimensional objects. Bats in Group 1 experienced each of five experimental scenarios, those in Group 2 only the last (scenario 5). Bats observed in scenarios 1–3 (object recognition) readily associated different shapes with prey palatability but did no better than chance in scenarios 4 and 5 (confounding cues and spatial memory, respectively). Conversely, experimentally naïve bats associated palatability with position (scenario 5), although less quickly than fruit or flower bats. Our results support the niche-specific cognitive strategies hypothesis and suggest that for *M. nattereri* shape cues overshadow positional cues despite echolocating bats' well-established reliance on spatial memory for other tasks.

The Physiological Ecology and Energetics of Bats Revisited
Murray M. Humphries, Amy B. Thompson, and Marianne Gagnon, McGill University, QC

Don Thomas made significant and surely long-lasting contributions to the understanding of the physiological ecology and energetics of bats. Many of his data and conceptual contributions are summarized in a book chapter co-authored with John Speakman, appropriately titled, "The Physiological Ecology and Energetics of Bats." I will revisit some of the topics of emphasis and uncertainty in this chapter and address what has changed in the decade since it was written. I will present new comparative data on two physiological traits that were discussed in the chapter but not explicitly analyzed. The first of these is a simple index of heterothermy that permits the body temperature variability of species that do and do not express torpor to be included in the same analysis. The second of these is lower critical temperature, a trait that should be directly related to the metabolism and thermal conductance of endotherms, yet is remarkably absent from most comparative analyses.

Systematics of *Rhinolophus pearsonii* in Southeast Asia
Howard M. Huynh and Judith L. Eger, Texas Tech University, Lubbock, TX; New Brunswick Museum, Saint John, NB; Royal Ontario Museum, Toronto, ON

Horseshoe bats (Rhinolophidae) represent a diverse and broadly distributed family of bats in the Old World. *Rhinolophus pearsonii* forms a widely distributed species complex, particularly in Southeast Asia. Recent work has uncovered several new species in this species complex, but much geographic variation remains to be documented and studied in detail. In this study, we examined specimens of *R. pearsonii* from Laos (n = 14), China (n = 21), and Vietnam (n = 19). Bivariate plots and univariate statistical tests of craniometric data showed that specimens from Laos were smaller than those from China and Vietnam. Principal component analysis also showed that most character variation (with the exception of interorbital breadth) was related to size (PC1 = 81%). Qualitatively, individuals from Laos had smaller and more gracile skulls. Preliminary genetic analysis of the COI gene revealed some phylogeographic structuring with specimens from Vietnam and China clustering separately from one other, but most specimens from Laos have yet to be genetically assessed. Our results showed that specimens originating from Laos were craniometrically distinct and may possibly represent an undescribed taxon in the *R. pearsonii* species complex in Southeast Asia, but further study will be required to test this supposition.

Winter Bat Trajectories at Hibernacula in Regions Affected by White-nose Syndrome
Tom Ingersoll, C. Herzog, A. Hicks, K. Oconner, G. Turner, C. Stihler, and C. Holliday, National Institute for Mathematical and Biological Synthesis, Knoxville, TN

White-nose syndrome (WNS) is reducing many bat populations in North America, eliciting concerns of extirpation for *Myotis lucifugus,* in regions where it was once the majority of hibernating bats. These extreme effects are easily witnessed, but little is known about conditions that might limit WNS. What differences in WNS response can we expect between different species, different climates, and different locations? We counted bats at 1,200 hibernacula in New York, Pennsylvania, West Virginia, and Tennessee. We modeled smoothed trajectories (GAMMs) for counts of hibernating *M. lucifugus, M. sodalis, M. grisescens, M. leibii, M. septentrionalis, Eptesicus fuscus, Perimyotis subflavus, Corynorhinus townsendii virginianus,* and *C. rafinesquii*. We also produced linear models to estimate the effects of location and climate. We used model selection techniques and parameter estimation via maximum likelihood. Species were affected by WNS unequally. Some exhibited dramatic declines while others appeared to be stable or growing. Within species, hibernacula were affected unequally depending on climate and distance from the disease's point of origin. Counts represent only the proportion of the colony that is visible to the researcher, a proportion that may fluctuate due to the effects of the disease. Furthermore, count dynamics can be strongly affected by differences in survey timing or effort. Despite these shortcomings, hibernation counts are among the most reliable data currently available for many populations as banding data are almost always lacking. Hibernation counts may be particularly relevant considering the speed with which WNS reduces populations.

Echolocation Beam-shape in Two Species of Emballonurid Bats, *Saccopteryx bilineata* and *Cormura brevirostris*

Lasse Jakobsen, Elisabeth K. V. Kalko, and Annemarie Surlykke, University of Southern Denmark, Odense, Denmark; University of Ulm, Ulm, Germany; Smithsonian Tropical Research Institute, Balboa, Ancon Republic of Panamá

Using a multi-microphone array, we investigated the echolocation beam-shape of two species of emballonurid bats, *Cormura brevirostris* and *Saccopteryx bilineata*, navigating a large out-door flight cage on Barro Colorado Island, Panama. The bats emitted calls with near identical beam patterns when comparing corresponding harmonics/frequencies, but with a markedly different energy distribution in the calls. *C. brevirostris* emitted two distinct call types: a multi-harmonic shallowly frequency-modulated call with most energy in the 5th harmonic (68 kHz) and a multi-harmonic sweeping call with peak frequency at 65 kHz. *S. bilineata*, conversely, emitted only multi-harmonic shallowly frequency-modulated calls with most energy in the 2nd harmonic (~46 kHz). Calculating the echo-scene the bats face, it is apparent that, because *C. brevirostris* emits calls with a fundamental frequency markedly lower than *S. bilineata*, the echo-scene close to large reflective surfaces (e.g., the ground) is much less directional at corresponding harmonics. Thus shifting the relative energy into higher harmonics yields a much more directional echo-scene for *C. brevirostris*. This leads us to conclude that frequency dependent adjustment of the echolocation beam is equally important for emballonurid bats as for vespertilionids, and that surface echoes play an important role in shaping echolocation calls under constrained conditions. Further, due to a less flexible emission system, emballonurid bats are forced to adjust relative harmonic energy instead of adjusting the fundamental frequency like the vespertilionids do in response to environment changes.

Influence of Vegetation on Estimates of Bat Mortality at Turbines

Joel W. Jameson and C. K. R. Willis, University of Winnipeg, Winnipeg, MB

Large numbers of bats are killed each year by wind turbines and fatality rates are expected to increase with the continued expansion of the wind industry. To fully understand bat mortality and potentially mitigate it, accurate fatality estimates are essential. Vegetation underneath turbines could undermine searcher efficiency during mortality surveys. We tested this hypothesis by searching for bat carcasses under turbines at which vegetation was regularly mowed versus turbines at which there was no mowing. Mortality estimates were significantly higher at mowed sites and we did not detect any hoary bats (*Lasiurus cinereus*) at non-mowed sites although this species constituted a large proportion of fatalities at mowed sites. Cumulative searcher efficiency was also higher at mowed vs. non-mowed sites. Our results suggest that, when possible, search areas underneath wind turbines should be cleared of vegetation to improve fatality estimates.

Living on the Edge: Bat Activity at a Forest-Agriculture Interface

Meredith K. Jantzen, University of Western Ontario, London, ON

Edges between patches are often the most prominent feature of both natural and altered landscapes. The depth of edge influence (DEI) on animal activity may extend up to 120 m into each surrounding habitat. I investigated the DEI at a forest-agriculture interface for seven bat species in Ontario. I expected that species-specific differences in echolocation call structure would result in bat species exhibiting different DEIs at forested edges. I used eight ultrasonic microphones arranged along a 140 m transect line perpendicular to the forested edge to monitor the activity at varying distances from the edge. I visited each of eight sites ten times, and monitored from sunset to sunrise. Using total number of calls as a proxy for bat activity, I used a generalized additive model (GAM) to model the activity levels at, and away from, the edge for each species. I found that DEI varied among species, and correlated to aspects of call structure. This research may help to inform future habitat surveys using ultrasonic detectors, as well as turbine placement at wind energy installations.

Thermoregulatory Strategies of Rafinesque's Big-eared Bats (*Corynorhinus rafinesquii*) Roosting in Trees, Caves, Rock Shelters, and Buildings

Joseph S. Johnson, M. J. Lacki, and J. F. Grider, University of Kentucky, Lexington, KY

Thermal characteristics of microhabitats are especially important for small mammals, such as bats, whose large surface area-to-volume ratio necessitates high metabolic output to maintain high core body temperatures when outside their thermal neutral zone. The relationship between microclimate and habitat quality of bats is complicated

by the ability of bats to enter torpor. Bats are often presented with a diversity of day roosts facilitating varying degrees of torpor or normothermia. The choice of thermal properties of day roosts of bats is contingent upon many factors, including the sex and reproduction condition of individuals. To investigate the dynamic relationship among sex, reproduction condition, thermoregulation, and roost microclimate, we radio-tagged Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) in two Kentucky study areas and deployed climate data-loggers inside a subset of day roosts during the summers of 2009 through 2011. We radio-tagged 49 adult bats and located 63 roost trees and 1 concrete slab bridge in western Kentucky. Skin-temperature data were collected from 40 bats and 28 roost trees were sampled using climate data-loggers. We radio-tagged 64 adult bats and located 16 tree- (including 5 trees where bats roosted on the exterior of the bole), 13 cave-, 7 rock shelter-, 7 building- and 3 other man-made structure roosts in central Kentucky. Skin-temperature data were collected from 44 bats and 27 roosts were sampled using climate data-loggers. Data presented will include extent and depth of torpor among sex and reproduction classes of bats across study areas and types of roosting structures.

The Role of Foraging as a Possible Cause of Bat Mortality at Wind Energy Facilities
Dave Johnston, Judd Howell, Nellie Thorngate, Scott Terrill, James Castle, Jeff Smith, and Todd Mabee, H. T. Harvey and Associates, Los Angeles, CA; ABR Inc., Forest Grove, OR

We used marine radar, enhanced night vision, full-spectrum acoustic monitoring, and bat mortality based on daily carcass searches at Montezuma Hills in central California to investigate relationships between bat fatality rates and activity indices, spatial variables, habitat variables, and weather variables. The probability of finding a Mexican free-tailed bat (*Tadarida brasiliensis mexicanus*) fatality increased with higher wind speeds ($F = 4.5$; $p = 0.037$), higher altitude passage rate of migrants ($F = 4.5$; $p = 0.037$), and higher barometric pressure (SE = 0.066; $p = 0.052$). Hoary bat (*Lasiurus cinereus*) fatalities increased with lower wind speeds and lower migrant passage altitudes. Unlike bats and birds above the sweep area that showed strong directional movement, bats observed within and below the rotor sweep area (< 125 m) showed no directional trend, suggesting bats were not migrating while at risk of collision. Using the GIS-based Hot Spot statistical analysis, we found hot spots for hoary bats at two turbines, each with a Z-score of 3.60 and $p < 0.01$, and one hot spot for Mexican free-tailed bats, also with a Z-score of 3.60 and $p < 0.01$. Both hot spots for hoary bat fatalities occurred southeast of a eucalyptus grove and for all fatalities, direction to a eucalyptus grove within 2 km was significant ($p = 0.013$). All hoary bat fatalities during the fall months of 2009 and 2010 were males with relatively full stomachs, suggesting fatalities at Montezuma Hills are not related to male–female interactions but more likely foraging behavior.

Variation in Hibernation Patterns of Free-ranging Little Brown Bats
Kristin A. Jonasson and Craig K. R. Willis, University of Winnipeg, Winnipeg, MB

Hibernation is one way that mammals survive the winter energetic bottleneck resulting from seasonally low food availability and increased thermoregulatory costs. Energy savings result from reduced body temperature (T_b) and metabolism during torpor bouts but all hibernators briefly return to euthermic temperatures, presumably to correct physiological imbalances that occur during torpor. These periodic arousals account for the majority of hibernation energy budgets. The expression of hibernation in captivity is not always consistent with patterns observed in free-ranging individuals. Therefore data from free-ranging individuals are needed to understand the energetics of hibernation in wild populations. We used radio telemetry to monitor skin temperature (T_{sk}) of free-ranging little brown bats (*Myotis lucifugus*) hibernating in central Manitoba, Canada. We examined the duration of torpor bouts (i.e., arousal frequency) as well as average T_{sk} during arousals. The duration of torpor bouts was highly variable both within and among individuals and, in contrast to some studies, torpor bout duration was not strongly influenced by ambient temperatures (T_a) within hibernacula. In several instances bats appeared to use shallow torpor in the midst of arousals. During these "heterothermic arousals" we observed large fluctuations in T_{sk} often to levels below those normally considered euthermic (i.e., < 25°C), yet clearly distinct from T_{sk} during prolonged torpor bouts. This pattern has not been observed previously for any hibernator and may represent a unique adaptation of bats for conservation of energy during the most costly phase of hibernation.

Effect of Artificial Night Lighting on Little Brown Bat Behavior
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Light pollution caused by artificial night lighting has become an ecological problem for a variety of species. Light pollution and conservation implications stemming from it would be important for nocturnal species such as

bats. Our purpose was to discover if there is an effect of artificial night lighting on the activity and sonar use of the little brown bat (*Myotis lucifugus*). We hypothesized there would be an effect demonstrated by an alteration in activity and sonar use and predicted increased response during dark periods. Sixteen bats from Chautauqua Institution were tested in four randomized treatments including: 1) 1 min light off; 2) 1 min light on; 3) 30 s light off and 30 s light on; and 4) 30 s light on and 30 s light off. We controlled for sound and heat emission from the lights. Treatment 4 resulted in a significant difference in activity (less in light) and sonar call use (less in light) comparing the first and last 30 s. We did not find this difference within treatment 3 or comparing treatments 1 and 2. Our research suggests bat behavior is altered more with a switch rather than constant light environment. In addition, the switch from light on to off had an effect whereas light off to on did not. This may be due to the difference in adaption of the eye where adaption to light takes less time than to dark. Our results can also be explained by natural responses to light and dark cues in the environment.

What We Need to Know to Understand the Long-term Impacts of White-nose Syndrome on Bat Populations: A Disease Ecology Perspective

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Enormous declines in populations of multiple species of bats have occurred in the five years since white-nose syndrome (WNS) was first detected in North America. However, it is currently unknown if WNS will drive some species to extinction and at what population sizes the remaining species will persist once WNS has become established. We draw from theory, data, and other disease systems to identify six critical questions that must be answered to determine the long-term impact of WNS on bat populations. We will present model results to identify key gaps in our current knowledge and demonstrate relevance of these data to conservation and management of WNS. By identifying critical data gaps and their utility for assessing disease impacts on bat populations, we hope to enlist the efforts of wildlife managers, bat biologists, and the greater research community, as well as the general public, in combating this emerging threat to bats.

Networking Networks for Global Bat Conservation

Tigga Kingston, Texas Tech University, Lubbock, TX

Established in 2007, the Southeast Asian Bat Conservation Research Unit (SEABCRU) is an open network of researchers, educators, and conservationists that seeks to promote the conservation of Southeast Asia's bat fauna through research, capacity building, and outreach. Recent support from the National Science Foundation has enabled the SEABCRU to begin a 5-yr regional assessment of the distribution, abundance, and status of Southeast Asian bats through research and training activities centered on four priority areas identified by group consensus: flying fox distributions and population ecology; taxonomy and systematics; cave bat diversity and conservation; response of forest-dependent bats to landscape change. An online community of practice facilitates international communication and collaboration, and the sharing of research and outreach resources. The SEABCRU is one of the more recent regional bat conservation networks; others include the Latin American Network for Bat Conservation (RELCOM), Chiroptera Conservation and Information Network of South Asia (CCINSA), Australasian Bat Society, BatLife Europe, and NASBR. Some of these networks link national programs (e.g., RELCOM, BatLife Europe), while others have gone straight to the regional level because of the paucity of researchers in individual constituent countries (SEABCRU, CCINSA). I posit that regional networks provide for robust and resilient conservation efforts that promote consensus approaches to priority setting and action, as well as equitable distribution of management and leadership roles. I suggest that global bat conservation efforts would be best served by a network of geographically complementary networks, and that gaps in the existing coverage should be identified and plugged with new network initiatives posthaste.

Thermoregulatory Patterns of Hoary Bats (*Lasiurus cinereus*) during Lactation and Early Development

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Endothermy is beneficial to mammalian reproduction because it provides a stable thermal environment during gestation and lactation, which promotes rapid growth of the young. However, staying warm, when coupled with the high cost of lactation, may become too great an energetic demand, especially in small mammals. The hoary bat (*Lasiurus cinereus*) is a solitary, foliage-roosting species that births and rears young in a relatively exposed environment. We investigated the influence of ambient conditions and energetic demand of the young on the

thermoregulatory patterns of lactating *L. cinereus*. We also examined the consequences of *L. cinereus* roost ecology on the development of thermoregulation in juveniles, and their use of torpor throughout early development. We found that lactating individuals continued to use torpor strategically throughout lactation, especially during periods of inclement weather (e.g., rain and high winds) and gradually decreased torpor expression as pups aged. Juveniles appeared to have the ability to actively thermoregulate shortly after parturition but continue to use torpor, with patterns closely reflecting those of the mother and torpor use decreasing with age. In general, for both mother and pups, the benefit of maintaining a high body temperature appear to be outweighed at times by the energetic demand of actively thermoregulating. Although occasional use of torpor by *L. cinereus* during early development results in relatively slow rate of growth in juveniles, a relaxed pressure on development due to their migratory nature may mitigate this cost.

Eating What's in Season: Linking Bat and Insect Migratory Behavior
Jennifer J. Krauel and Gary F. McCracken, University of Tennessee, Knoxville, TN

Vast numbers of insects are known to migrate great distances in search of seasonal resources, and the insects themselves represent ephemeral resources for other animals, including bats. Many insects achieve these feats by leveraging favorable winds, and thus these events are subject to variations ranging from large disturbances such as hurricanes to the vagaries of daily local weather. In North America, noctuid moths, including agricultural pests such as the corn earworm (Lepidoptera; Noctuidae; *Helicoverpa zea*), move north in the spring with prevailing winds from tropical regions into the United States to take advantage of ripening crops. Large colonies of Brazilian free-tailed bats (*Tadarida brasiliensis*) are known to track and feed on these migratory insects during their northward movements in the spring. As fall approaches, these bats prepare for their own migration into Mexico but resources are scarce in the hot, arid region after the summer growing season. Noctuid moths, representing a very high quality but transitory food resource, move south in the fall by taking advantage of wind shifts associated with cold fronts, although little is known about this return migration. We investigated the behavior of bats before and during fall insect migration events, both at ground level and higher altitudes. At ground level, we trapped insects with black light and pheromone traps, and collected data and fecal samples from bats upon their return to Frio cave in the morning. We used a Helikite to record echolocation behavior and collect insect samples at varying altitudes before and during migration events. Preliminary results show that insect availability during this time fluctuates with weather and wind patterns, and that bat behavior as well as rapid increases in body mass of bats follow similar patterns. Thus, bats appear to use the migrating insects to fuel their own seasonal migration.

MHC Diversity in Little Brown Myotis and Resistance to White-nose Syndrome
Jason Kubinak and Thomas Kunz, Boston University, Boston, MA

The emergence of white-nose syndrome (WNS) is threatening regional extinction of the little brown myotis (*Myotis lucifugus*), one of the most abundant bat species in North America. Because of the importance of bats as predators of pest insect species, it is imperative that we begin to address this problem to avoid the potential collapse of both natural and agroecosystems. MHC genes are the most polymorphic loci known in vertebrates and this diversity is widely acknowledged to play an important role in resistance to infectious diseases. MHC genes encode cell surface glycoproteins whose primary role is to present self and non-self peptides to circulating T lymphocytes (T-cells), which are essential components of the vertebrate adaptive immune response. A project is currently underway in our lab to characterize MHC genetic diversity in little brown myotis to determine whether there is an MHC-mediated genetic basis for resistance to WNS. Results of this study will be important for identifying whether adaptive immunity plays a significant role in resistance to WNS, and insight into how an emerging infectious disease influences contemporary patterns of selection on immunologically relevant loci. This research represents one of the first focused attempts to determine how adaptive genetic variation in bat populations impacts the ecology of an emerging infectious disease. From a practical perspective, identifying genetic markers of resistance to WNS may allow biologists to focus conservation efforts/resources on more susceptible bat populations and to refine models of population viability and epidemiology.

Three-dimensional Flight Trajectories of *Eptesicus fuscus* from Thermal Imaging in a Temperate Forest Reconstructed Using Ground-based LIDAR
Thomas H. Kunz, Xiaoyuan Yang, Nathan W. Fuller, Zheng Wu, Diane H. Theriault, Amy L. Norris, Crystal B. Schaaf, Alan H. Strahler, and Margrit Betke, Boston University, Boston, MA

Bats emerge, disperse, feed, and migrate in a three-dimensional (3-D) world, yet few studies have been conducted to establish how bats navigate in 3-D space either in open airspace or in cluttered landscapes such as forests and urban areas. We used two or three synchronized and calibrated FLIR SC-8000 thermal infrared cameras to record the flight trajectories of big brown bats (*Eptesicus fuscus*) as they emerged from a barn and dispersed to feed in cluttered airspace in a mixed deciduous/coniferous forest in central Massachusetts. The 3-D flight trajectories of bats were reconstructed using computer vision algorithms to characterize velocity, height above ground, proximity to vegetation, turning radius, and distance to nearest neighbor. To quantify the forest structure in 3-D, we used ground-based LIDAR (Light Imaging, Detection, and Ranging) to characterize its physical dimensions and spatial features. Novel computer algorithms were developed to estimate and calibrate DBH, tree height, and crown dimensions. Flight trajectories were identified from thermal videos and quantified, indicating how bats from the same roost use different flight routes to disperse to and forage along the edge of the forest and to enter the forest understory. These and similar results provide new insight into how bats navigate and forage in different spatial environments, and are being used to help inspire aeronautical engineers to design and construct autonomous unmanned aircraft for both environmental and military surveillance purposes.

Is It Better to Give Than Receive? Dominance and Food Sharing Behavior in *Desmodus rotundus*
David LaMarche and Miranda Dunbar, Southern Connecticut State University, New Haven, CT

Common vampire bats (*Desmodus rotundus*) are socially unique. Previous studies show that this species (wild-caught and captive) participates in reciprocal food sharing and males interact within a dominance hierarchy for mating opportunities. However, whether a link exists between food sharing and dominance behaviors in isolated male populations is unknown. To test this, we observed a captive colony of male common vampire bats during two phases of food availability; ad libitum and food restriction. During each phase, our objectives were to extrapolate patterns of dominance behavior (defined as feeding order, food guarding, and paired grooming), and to observe whether food sharing occurred, and if so, between whom to determine if these parameters correlate. Video-recording devices were installed at the designated feeding area and the primary roosting site within the enclosure to monitor all interactions within the colony. Bats were previously PIT-tagged and later banded with reflective aluminum bands for visual identification. We expect that during the ad libitum phase, there will be a dominance hierarchy, but little-to-no reciprocal food sharing. We expect that during the food restriction phase, individuals who feed more frequently than other colony members will become the dominant individuals, regardless of their rank during the ab libitum phase, and will participate in reciprocal food sharing. We suspect the ability to forage successfully and provide within the social group (as simulated during the food restriction phase) will be a factor that strongly drives individual dominance within a hierarchy.

Seasonal Patterns in Infection Prevalence and Intensity of *Geomyces destructans*: A Preliminary Analysis
Kate E. Langwig, J. T. Foster, W. F. Frick, K. P. Drees, M. M. Shuey, and T. H. Kunz, Boston University, Boston, MA; Northern Arizona University, Flagstaff, AZ; University of California Santa Cruz, Santa Cruz, CA

White-nose syndrome (WNS) is a recently emerged infectious disease of bats that is associated with the fungal pathogen *Geomyces destructans*. Mortality from WNS occurs primarily during winter hibernation, and it is likely that environmental conditions inside hibernacula, paired with torpid immunocompromised bats, present optimal growing conditions for this psychrophilic fungus. Presence of *G. destructans* has been documented on nine species of hibernating bats, but mortality from WNS varies among these species. We investigated seasonal patterns in pathogen prevalence and intensity on three species of hibernating bats (little brown myotis, *Myotis* lucifugus; big brown bats, *Eptesicus fuscus*; and eastern-small footed myotis, *M. leibii*). Swabs from exposed wing and muzzle tissue of bats were collected and analyzed using real-time quantitative PCR. Prevalence of *G. destructans* was high during the winter on all three bat species tested. Infection intensity may vary among species, but these results are complicated by the presence of other *Geomyces* species on eastern small-footed myotis and big brown bats. Pathogen prevalence during the summer maternity season was very low, suggesting that bats in the active season likely shed infections shortly after emerging from hibernation, with little-to-no transmission between mother and offspring. Understanding seasonal changes in *G. destructans* transmission on multiple host species will allow for

targeted disease management that may help to ameliorate the consequences of WNS.

Patterns of Roosting Association in a Maternity Colony of Little Brown Bats (*Myotis lucifugus*)
Lissa M. Lawrence and Hugh G. Broders, Saint Mary's University, Halifax, NS

It is well known that the social interactions that accompany group living have important fitness consequences. To characterize the social structure of a group of animals requires understanding association patterns and the driving forces behind them. Individual *Myotis lucifugus* females live in 'colonies' during the summer, which consist mostly of reproductive females that select from a suite of potential roosts each day. On any one day, colony mates may be roosting in several roosts with individual bats potentially switching roosts daily. Roost selection on a given day may be determined by roost microclimate and/or social factors related to the presence of specific other females (e.g., those that may be related or of a particular age or reproductive status). The goal of this study is to characterize the roosting association patterns of individual bats in a maternity colony and determine the extent to which any nonrandom association patterns may be explained by roost temperatures. We monitored roost selection of 63 PIT-tagged female *M. lucifugus* bats living in a maternity colony in Tatamagouche, Nova Scotia, Canada by deploying automated PIT-recorders at entrance and exit points of different roosts. Future work will consist of determining the extent to which kin selection may explain the patterns of roost association in this colony by genotyping individuals at several microsatellite loci. We hope that this study will add to our understanding of the complex social interactions amongst *M. lucifugus* females.

Maximum Entropy Modeling of *Myotis sodalis* Maternity Roost Habitat
Joseph Lemen and Lynn Robbins, Missouri State University, Springfield, MO

Many approaches have been used to describe and predict maternity roost habitat for *Myotis sodalis*, providing many different results. MaxEnt is a machine learning program that utilizes maximum entropy theory techniques to analyze a wide range of topics. Recently, MaxEnt has been used to model species distribution of various taxa and provide a platform for the use of presence only data. Reproductively active female *M. sodalis* were radio-tracked to 14 primary roosts and 5 secondary roosts during the summers of 2009 through 2011 in 6 counties in northern Missouri. Primary roosts are defined by the presence of more than 30 bats at a single exit count. We define secondary roosts as those that are used multiple times by the same bat while containing other bats (< 30). No alternate roosts, those with only a single bat visit, were used in this analysis. Thirty-meter raster grids of landscape variables, including elevation, vegetation type, and proximity to foraging habitat and water sources were used for the modeling features. Foraging habitat was determined using relevant literature and the capture locations and foraging habits of the same reproductive female bats that were tracked to the 19 roost trees. We used the jackknife approach and percent contribution to determine variable response in the model. Outputs of MaxEnt include spatial estimates of occurrence probability in the form of predictive GIS maps and response curves for environmental variables.

Mammals of Toronto Biodiversity Series: Bats
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The City of Toronto initiated a biodiversity publication series to coincide with the United Nation's Year of Biodiversity in 2010. The objectives of these booklets are to educate and re-connect people with the natural world, especially in light of the global trend towards urbanization. With the success of the pilot project on birds, the City of Toronto has partnered with the Royal Ontario Museum to expand the series to other groups of organisms including fishes, butterflies, mammals, spiders, reptiles, and amphibians, and also trees and shrubs. Contents in each publication cover topics such as historical perspectives, habitats, invasive species, and species accounts. In the mammals of Toronto booklet, bats have a prominent five-page spread covering information on roosts, reproduction, food, hibernation, migration, and health concerns. There are already plans for future publications on moths, dragonflies and damselflies, beetles, bees, wasps, ants, wildflowers, mosses and lichens, mushrooms and other fungi, and ferns and grasses. Based on the successful distribution of the bird booklet at public libraries throughout the city, future issues will also be distributed through the public school system to target children and teens on the appreciation of biodiversity.

Activity and Habitat Use of Bats in the Chugach National Forest, South Central Alaska
Susan C. Loeb, Eric A. Winters, Marion E. Glaser, Marian L. Snively, and Kevin S. Laves, USFS Southern Research Station; USFS Chugach National Forest; Alaska Department of Fish and Game, Juneau, AK

Despite increased research on forest bats in many parts of the world, very little is known about the bats of Alaska, particularly south-central and interior Alaska. The goal of our study was to obtain baseline data on the bats of the Kenai Peninsula that will allow biologists to assess and monitor the effects of threats such as global climate change, forest disturbances, and white-nose syndrome. We used Anabat II detectors, mist-netting, and radio-telemetry to obtain information on species composition, habitat use, and reproductive activity during mid-July 2011. All bats captured were little brown bats (*Myotis lucifugus*) and all echolocation calls were consistent with *M. lucifugus.* Bats were detected at 20 of 25 acoustic sampling points. Although the differences were not statistically significant, the number of files and calls per file tended to be greater at water sites and lower at road or trail sites. Activity measured at a maternity colony began an average of 18 minutes after sunset and ended approximately 20 minutes before sunrise for a total activity period of 5.2 h; activity periods at sites across the landscape averaged 3.4 h. Fourteen of fifteen adult females captured at a maternity colony were lactating or post-lactating indicating a high level of reproduction. A radio-tagged adult male was tracked to a large (35.0-cm DBH, 15.8-m tall) Sitka spruce (*Picea sitchensis*) snag. This is the first natural roost documented for bats in this part of Alaska. Far more information on bats in this area is needed before effective management and conservation can occur.

Investigating the Relationship between Energy Allocation Strategies and Movement Patterns during Swarming in the Little Brown Bat
Amanda J. Lowe and Hugh G. Broders, St. Mary's University, Halifax, NS

Myotis lucifugus have a reputation of "wandering considerably after leaving the maternity colony," but the movement patterns prior to hibernation and the factors that influence them remain largely unknown. Should the cost and benefits of swarming vary among male bats, it is expected that individual movement patterns of adult male *M. lucifugus* will vary with body condition (BC; mass/forearm) and reproductive status (RS) during the swarming period. Males of a poor BC and RS are predicted to have a higher fitness by investing more energy into behaviors that ensure winter survival, rather than into swarming behaviors (reproduction). In contrast, males of a good BC and RS are expected to invest in swarming behaviors because they are likely to gain reproductive success without jeopardizing their chances of survival. We trapped bats at an abandoned-mine swarming site (SS) in Nova Scotia to assess BC and RS, and monitored the mine entrance using an automated PIT-recorder to record the number of revisits to the site by each male. In addition, a subset of males with extreme BCs and RSs (both good and poor) were tracked daily using 0.28-g radio-transmitters between August 10th and September 30th to assess movement patterns and roost use. Automated monitoring of the SS was done using a five-antenna, data-logging receiver. Preliminary results to be discussed include: BC and RS data; duration and frequency of SS revisits; proximity of roost(s) to SS; days spent within 10 km of a SS; the date of hibernation entry; and roost use.

Phylogeography of Mexican Free-tailed Bats on the Bahamian Archipelago
Kristin C. Magrini, J. Angel Soto-Centeno, and David L. Reed, Florida Museum of Natural History, Gainesville, FL

We assessed genetic differentiation using mitochondrial DNA (mtDNA) in the Mexican free-tailed bat (*Tadarida brasiliensis*). We collected specimens from the Bahamas and Florida and extracted DNA samples from fresh tissue. mtDNA sequence data were obtained for the d-loop of the control region. Additional sequences were obtained from GenBank for localities in the Untied States, Mexico, and South America. Ocean straights between islands are thought to reduce the movement of bats between islands. Therefore, we tested the null hypothesis that bats from each island of the Bahamas were monophyletic using Maximum Likelihood implemented in PAUP*4.0b. Based on control region sequences, *T. brasiliensis* samples from the Great Bahama Bank (southeastern islands) are sister to *T. brasiliensis* from South America on a long branch. Sister to them are the bats from the Little Bahama Bank (northwestern islands), the United States (including Florida), and Mexico. The gene tree indicates *T. brasiliensis* from the Great Bahama Bank are more closely related to bats from localities 4,200 miles away in South America than to bats in neighboring islands of the Little Bahama Bank that are less than 100 miles away. Furthermore, we have found no genetic differentiation in *T. brasiliensis* throughout localities in the Little Bahama Bank and North and Central America that span a maximum distance of 2,700 miles apart. The lack of gene flow between localities of the two Bahama banks suggests that within the islands of the Bahamas there is great genetic diversity present indicating a complex history in the region that warrants further investigation.

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

The mammalian pelvic girdle consists of the ilium, ischium, and pubic bones. In bats, where the hindlimbs are rotated up to 180 degrees from the typical mammalian condition, the pelvic girdle exhibits a number of unique features. Although the structure is also involved in flight, predation and parturition, there are few studies on its anatomy and limited work to determine its phylogenetic relevance. This study investigated anatomical variation in the pelvis, focusing on structures that may show phylogenetic relevance. Skeletal specimens were examined across all chiropteran families using a digital camera and stereoscopic microscope (and *camera lucida*). Additional data came from previously produced sketches. Morphological characters were developed and Morphobank was used to store and organize the data. Characters defined thus far included the occurrence of a medial flare on the pubic spine, fusion between the pubic spine and ilium, and angles of the inferior ramus. The ischial symphysis (or lack there of), also differs significantly across bat taxa. In some species, a thin layer of bone on the lateral sides of the ilium appears to provide increased surface area for muscle attachment. We also reevaluated previously described features such as the dorsolateral tilt of the ischium, projection of the pubic spine, shape of the obturator foramen, and variation in the sacral curve. Adding these characters to the existing phylogenies will contribute to our knowledge of chiropteran evolution, while the study of comparative pelvic morphology will provide new information on topics like form and function and convergent evolution.

Genetic Demography of *Perimyotis subflavus* Reveals Regional Population Trends
Alynn Martin, Amy Russell, and Maarten Vonhof, Grand Valley State University, Allendale, MI; Western Michigan University, Kalamazoo, MI

White-nose syndrome (WNS) is an epidemic affecting hibernating bats across eastern North America. It is generally associated with the presence of a white, soil-dwelling fungus, *Geomyces destructans*, which usually grows on the nose, ears, and patagial membranes of infected individuals. Since its discovery in New York in 2006, WNS has been responsible for hundreds of thousands of bat deaths. Mortality rates of affected individuals have reached 90–100% in some hibernacula. Many of the studies regarding WNS focus on little brown myotis, *Myotis lucifugus*, which has experienced an 87% decline through 2010 in states including New York, Vermont, Massachusetts, New Hampshire, and Pennsylvania. Though attention has focused on *M. lucifugus*, at least five other species (*Perimyotis subflavus, M. septentrionalis, Eptesicus fuscus, M. leibii,* and *M. sodalis*) have also been significantly affected. Tri-colored bats, *Perimyotis subflavus*, have experienced an 85% decline in the northeastern states, yet little work has been done involving *P. subflavus* and the genetic data available for this species are lacking. Questions exist for this species regarding the accuracy of roost counts and the contribution of unsurveyed hibernacula to population counts, as well as the level of gene flow among colonies and potential patterns of spread of *G. destructans* that may result from bat-to-bat transfer. We present phylogeographic analyses of mitochondrial sequence data from *P. subflavus*, focusing on patterns of population genetic structure and estimates of effective population size.

Population Genetic Structure, Social Networks, and Clustering Behavior in *Myotis lucifugus* (Little Brown Bats)
F. Martinez-Nuñez, S. Good, and C. K. R. Willis, University of Winnipeg, Winnipeg, MB

Climate change, other anthropogenic activities, and emerging wildlife diseases threaten ecosystems and increase numbers of endangered species. To develop effective conservation strategies it is important to understand population and social structure, and genetic relatedness within and between populations. We aimed to identify factors influencing the social and genetic structure of little brown bats (*Myotis lucifugus*) from central Canada. To date we have genotyped 400 bats from different summer colonies and hibernacula in Manitoba and northwestern Ontario, using microsatellites and sequences from mitochondrial DNA. Specifically, we are testing the hypotheses that: 1) individual bats that cluster together during hibernation exhibit relatively high genetic relatedness because of possible kin selection benefits of social thermoregulation; 2) bats in our study area exhibit relatively low rates of maternal compared to paternal gene flow, based on the prediction that females will be loyal to mating swarms while males disperse more widely during autumn; and 3) despite paternal gene flow, bat populations from the southern half of Manitoba will show genetic structure related to the boreal transition zone, with populations in southwestern Manitoba (which roost in farm buildings and woodlots during summer) being genetically distinguishable from those living in more heavily forested areas of southeastern and central Manitoba (which roost primarily in trees during

summer). This work will improve our knowledge on population dynamics and social structure of bats, which are critical aspects to understand emerging wildlife disease dispersal such as WNS, and will help to develop future conservation policies.

Development of Frequency Modulated Vocalizations in Big Brown Bat Pups
H. W. Mayberry and P. A. Faure, McMaster University, Hamilton, ON

Developing bat pups produce distinct vocalizations called isolation calls (I-calls) that serve to attract the bat's mother. How individual pups shift their vocalizations from I-calls to downward frequency modulated (FM) sweeps during development remains unclear. By recording individual bat pups from the day of birth to twenty-five days postnatal we observed behavioral and bioacoustic (temporal and spectral) changes in pup calls. Temporal characteristics examined were call duration and call rate; spectral characteristics were minimum frequency, maximum frequency, peak spectral frequency, total signal bandwidth, maximum frequency of the fundamental acoustic element, and bandwidth of the fundamental. I-calls were produced only until a certain point in development, after which pups change from emitting long-duration, tonal I-calls to downward FM signals and eventually short-duration biosonar vocalizations. We discovered additional spectral changes in the harmonic structure of pup calls, with the number of harmonic elements decreasing with age. We also recorded pup vocalizations during prolonged separation from their mothers to determine if extended isolation alters the type, number, or acoustic structure of emitted vocalizations. Rate of calling was influenced by prolonged separation; younger pups had higher calling rates and called longer than older pups. We also compared temporal and spectral characteristics of spontaneous and provoked calls. We found that provoked calls were more similar to vocalizations produced by younger pups. By documenting the vocal behavior and acoustic structure of pups calling in different situations, this research provides groundwork for further studies on the ontogeny and development of FM vocalizations in bats and other mammals.

Fecal Rain over Texas
Gary McCracken and Erin Gillam, University of Tennessee, Knoxville TN; North Dakota State University, Fargo, ND

Guano from insectivorous bats may provide ecosystem services in the form of nutrient transfer to habitats below as the bats fly, feed, and defecate (i.e., the "pepper-shaker" effect). Patterns of fecal rain may also provide information on habitat use by free-flying insect-eating bats. While the ecosystem service proposition seems probable, quantitative estimates of fecal rain are lacking. The only (somehow) published study on the use of guano traps to assess habitat use (of Canadian bats) reported the capture of only five fecal pellets. We measured fecal rain over the Winter Garden Region of south-central Texas, an agricultural production area where Brazilian free-tailed bats (*Tadarida brasiliensis*) are abundant. For three years in summer, ~9.2-m^2 (100-ft^2) fecal traps were deployed in escalating efforts (in 2003—5 traps, 11.4 nights/trap; 2004—8 traps, 20 nights/trap; 2006—40 traps, 13.5 nights/trap). Traps were deployed in agricultural fields, along presumed flight corridors, and at varying distances from a major bat roost, and were checked each morning. A total of 278 fecal pellets (2003 = 34; 2004 = 53; 2006 = 191) as well as many insect fragments were captured. Fecal pellet retention efficiency was estimated at 61.4% from three pairs of replicate traps where one trap in each pair was coated with tanglefoot. Extrapolating from the m^2 of traps deployed and their fecal pellet retention efficiency, the average numbers of pellets deposited per ha each night are estimated at 877 pellets/ha (2003), 576 pellets/ha (2004), and 668 pellets/ha (2006).

On the Morphological Variation in *Platyrrhinus vittatus* (Peters, 1859) (Chiroptera: Phyllostomidae)
Molly M. McDonough and Paúl M. Velazco, Texas Tech University, Lubbock, TX; American Museum of Natural History, New York, NY

Platyrrhinus vittatus is distributed in Costa Rica, Panama, western and northern Colombia, western Ecuador, and northern Venezuela. Specimens throughout the distribution of this species present variation on the number of accessory cuspules mesial to the main cusp on the second lower premolar. We evaluated this variation using molecular and morphological techniques. The cytochrome-*b* analysis did not show a clear pattern of grouping based on the number of cuspules. Specimens from Central America present one or two cuspules mesial to the main cusp on the second lower premolar, whereas specimens from Ecuador and Venezuela lack these cuspules. Based on our analyses we show evidence that the presence of accessory cuspules mesial to the main cusp on the second lower premolar is not a diagnostic characteristic of *P. vittatus*. We present a new set of diagnostic characteristics useful in

differentiating *P. vittatus* from *P. albericoi*.

Ontario's Science-based Approach to Bat Protection for Wind Power Projects
Fiona McGuiness, Peter Carter, and Lesley Hale, Ontario Ministry of Natural Resources, Peterborough, ON

Ontario has recently finalized science-based Bat and Bat Habitat Guidelines for Wind Power Projects. This presentation will describe the science informing three key components of these mandatory guidelines: 1) regulated, habitat-based protection for bats; 2) mandatory operational mitigation should a mortality threshold be exceeded at a wind power project; and 3) post-construction monitoring and adaptive management approach. The presentation will also describe the Wind Power Bird and Bat Monitoring Database, developed through a collaborative Industry-ENGO-Government partnership. Finally, an overview will be provided of Ontario's current research initiatives and science needs related to wind power and bats.

Migration-related Changes in Adipose Composition, Muscle Membranes, and Fatty Acid Transport Proteins in Hoary Bats
Liam P. McGuire, M. Brock Fenton, and Christopher G. Guglielmo, University of Western Ontario, London, ON

Migration poses numerous physiological challenges. For flying animals, energy dense lipids are particularly important as a fuel source. We measured migration-related changes in adipose neutral lipid fatty acid (FA) profiles, muscle membrane phospholipid composition, and FA transport protein gene expression in hoary bats (*Lasiurus cinereus*). We collected adult hoary bats from a summer resident population (post-reproductive) and during spring migration. We found numerous sex*migration interactions, indicating that females are often subject to different physiological demands than males (e.g., reproductive constraints). Adipose neutral lipid composition generally indicated a shift towards an increase in polyunsaturated FA, which may be selectively mobilized during periods of elevated energy demand. Muscle membrane phospholipid FA composition changes were sex specific. In males, n6:n3 ratio increased and double bond index decreased. For females the pattern was reversed. Sex-specific changes in muscle membranes may reflect differences in thermoregulatory strategy, with males more likely to use daily torpor during spring migration. Finally, we measured gene expression of FAT/CD36 and FABPpm (membrane bound FA transport proteins) and H-FABP (cytosolic FA transporter). There was no sex or migration effect for FAT/CD36 or FABPpm. Expression of H-FABP increased 9-fold in migrating females, with no changes in males. We may not have observed increases in FA transport protein expression because unlike previously studied birds (e.g., sparrows, shorebirds), the aerial hawking foraging behavior of hoary bats may lead to elevated expression of FA transporters year-round. Combined, our results contribute to a growing understanding of the physiological demands of migration for temperate bats.

Repeatability of Personality and Torpor Expression in Little Brown Bats
Allyson K. Menzies, Chantal J. Carrière, Mary E. Timonin, and Craig K. R. Willis, University of Winnipeg, Winnipeg, MB; Cornell University, Ithaca, NY

Animal "personality" or temperament refers to consistent, repeatable patterns of behavior exhibited by different individual animals. Recent studies suggest that personality is phenotypically correlated to within-species variation in a range of behavioral, physiological, and ecological traits and that personality and energy expenditure may be genetically correlated. One energetic trait that could reflect individual temperament or personality for bats is the propensity to express torpor. Given that repeatability is a defining characteristic of "personality," we quantified short-term repeatability of both behavioral traits and torpor expression in little brown bats (*Myotis lucifugus*). We devised an ecologically relevant novel-environment test to measure behaviors related to activity, exploration and anxiety, and measured body temperatures of resting animals to assess use of torpor. We then measured both behavioral traits and body temperatures of 50 individuals at 24-h intervals. We found that behaviors related to activity and exploration, as well as the tendency to express torpor, were significantly repeatable within individuals after controlling for capture location, demographic and body condition. Repeatability reflects how much variation in a given trait is caused by intrinsic variation within individuals and, therefore, represents an upper boundary of the potential heritability of a particular trait. This work leaves open the possibility that personality traits and the tendency to express torpor are heritable traits in bats that, given their potential importance to hibernation energetics, could be subject to strong selection in the face of white-nose syndrome.

Revisiting the Phylogeny of New World Sheath-tailed Bats (Emballonuridae: Diclidurini) Using 16S Mitochondrial rRNA

Jacqueline R. Miller and Burton K. Lim, Royal Ontario Museum, Toronto, ON

Robust molecular studies of systematics commonly employ combinations of markers that reflect different pathways of genetic transmission. Such markers, originating from the mitochondrial and autosomal genomes including X and Y chromosomes, are characterized by different molecular properties and variable rates of substitution, and thus have resolution at varying phylogenetic depths. Among the bat family Emballonuridae, species relationships have been previously explored using loci from each genetic transmission pathway. However some clade relationships remain inconclusively resolved. Furthermore, divergent evolutionary signals result when comparing mitochondrial cytochrome-*b* sequence with autosomal and sex chromosome markers, possibly an artefact of saturation. We use a 1,725-base pair sequence of another mitochondrial gene (16S) to evaluate species relationships within Emballonuridae and compare both topology and nodal support against previously used markers. The resulting tree provides strong support for the monophyly of two subfamilies (Emballonurinae and Taphozoniae), as well as the monophyletic tribes Emballonurini and Diclinurini within Emballonurinae. Subtribal arrangements are congruent with the three nuclear genes, although some intergeneric relationships are not well supported.

Stream Benthic Macroinvertebrate Communities and Habitat Influence Bat Foraging Activity

Kate Miller and Barry Chernoff, Wesleyan University, Middletown, CT

The purpose of this study is to identify associations between the benthic macroinvertebrate community and bat call activity within the context of stream habitat and landscape. Sampling was conducted in 2008-2009 at eight study sites along two small rivers in Connecticut. Bats were recorded between June and August and identified to species/group; invertebrates were sampled in June and identified to family. The eight sites varied significantly in abundance of bat calls and invertebrates, and in bat community composition (ANOVA, $p < 0.05$). Feeding buzzes were most strongly associated with the calls of *Myotis* and *Perimyotis* (GLM, $p < 0.001$, $r^2 = 0.55$ and $r^2 = 0.48$ respectively). Sites with greater abundance of invertebrates had a greater abundance of bat calls (Spearman's Rank Order Correlation = 0.69, $p < 0.05$). Correlations were generally stronger in 2008 than in 2009; *Myotis* call abundance was also greater in 2008 (ANOVA, $F_{(1, 65)} = 4.09$, $p < 0.05$). Variation in high frequency calls were better explained by invertebrate abundance of selected orders (primarily Trichoptera, Ephemeroptera, Plecoptera, and Diptera) than were low frequency calls (e.g., mean high frequency x Trichoptera, GLM, $p < 0.001$, $r^2 = 0.53$). Bat call and invertebrate abundances were greater at sites in the basin with more development (ANOVA, $F_{(1,59)} = 14.81$, $p < 0.001$). Correlations were weaker with invertebrate families typically used to indicate water quality (Plecoptera, certain Trichoptera and Ephemeroptera). Canopy attributes and stream width helped to explain some of the site differences in both bat call and invertebrate abundance, and their direct and indirect effects are explored.

Population Genetic Structure of *Myotis lucifugus* Predicts the Pattern of Spread of White-nose Syndrome in Pennsylvania

Cassandra Miller-Butterworth, Maarten Vonhof, Joel Rosenstern, Greg Turner, and Amy Russell, Penn State Beaver, Monaca, PA; Western Michigan University, Kalamazoo, MI; Pennsylvania Game Commission, Harrisburg, PA; Grand Valley State University, Allendale, MI

Until recently, the little brown bat (*Myotis lucifugus*) was one of the most common bat species in North America. Its range extends across much of the United States and Canada; however, the high density of caves in the Appalachian Mountains provides an abundance of suitable hibernacula, which support populations of *M. lucifugus* that are among the highest in its range. 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 Pennsylvania. We report results from an ongoing study to determine the impact that habitat fragmentation and WNS are likely to pose to *M. lucifugus* populations, both locally and on a landscape scale. Data consist of mitochondrial cytochrome oxidase I sequences from > 200 individuals from hibernacula throughout Pennsylvania, as well as West Virginia and Vermont. Curiously, hibernacula in westernmost Pennsylvania remained WNS-free for 1–2 years after the disease had swept through the rest of the state. We found no difference in genetic diversity between WNS-positive and WNS-negative sites, suggesting that survival in WNS-positive sites is not the result of selection at a mitochondrial locus. We did find evidence of significant population genetic structure between WNS-positive and WNS-negative hibernacula, suggesting reduced gene flow (either directly between hibernacula/swarming sites or indirectly via summer colonies) between these clusters of hibernacula. This genetic structure correlates strongly with the geologic

feature known as the Allegheny plateau; coalescent analyses suggest this pattern of population structure may date to the Pliocene.

Feature Extraction and Classification of Bat Echolocation Calls
Golrokh Mirzaei, Mohammad Wadood Majid, Jeremy Ross, Mohsin M. Jamali, Joseph Frizado, Peter V. Gorsevski, and Verner P. Bingman, University of Toledo, Toledo, OH; Bowling Green State University, Bowling Green, OH

A large number of bat fatalities have been reported near wind turbines. The goal of this research is to examine the susceptibility of different bat species to be found near wind turbines. Acoustic characteristics can be employed for bat call recognition to better understand the behavior of bats near wind turbines. Acoustic features of bat echolocation calls were extracted based on three different techniques: Short Time Fourier Transform (STFT), Mel Frequency Cepstrum Coefficient (MFCC), and Discrete Wavelet Transform (DWT). In order to classify the calls, three-layer Evolutionary Neural Network (ENN) was developed. ENN is based on the Genetic Algorithm, which can be used for optimization of the weight selection of the neural network. Features extracted by STFT, DWT, and MFCC were applied as the inputs of the Network and the output was five neurons representing the five species of interest to be classified: *Myotis sodalis* (*Myso*), *Eptesicus fuscus* (*Epfu*), *Lasionycteris noctivagans* (*Lano*), *Lasiurus borealis* (*Labo*), and *Nycticeius humeralis*. Classification accuracy for *Labo* calls with DWT feature extraction and ENN Classification was the highest; for *Epfu*, *Lano*, *Mylu*, and *Myso* classification accuracy was 95.83%, 91.66%, 95.83, and 83.33%, respectively. The classification results with STFT and MFCC feature extraction techniques were less accurate, ranging from 8.33% to 20.83%. We conclude that ENN is the most effective bat-call classifier.

Links Between Acoustic Communication and Group Stability in a Leaf-roosting Bat
Karina Montero and Erin H. Gillam, North Dakota State University, Fargo ND

Complexity of social communication systems has been associated with environmental conditions and ecological constraints. Yet, relatively little is known about how communication strategies impact group stability. Bats have developed a series of morphological, physiological, and behavioral characteristics that have allowed them to exploit diverse roosting structures. Spix's disk-winged bat, *Thyroptera tricolor*, illustrates these adaptations with the presence of suction disks that bats use to attach to the inner sides of developing furled leaves (Order Zingiberales). Despite the need for regular roost switching, Spix's disk-winged bats maintain stable associations of 2–9 individuals for up to 22 months. Moreover, these socially stable bats have developed a strategy of information exchange between conspecifics, concerning location of suitable roosts. Therefore, we hypothesize that *T. tricolor* may use complex acoustic signaling behaviors to overcome the challenges of using an ephemeral roosting resource. To assess the role of acoustic communication in the evolution of group stability in Spix's disk-winged bats, we monitored night activity of known roosts and available leaves with synchronized video and acoustic recordings. Preliminary results suggest the presence of complex vocal repertoires, such as differentiated call designs used in various behavioral contexts (bats emerging from roosts, evaluating roost availability, contact calls between conspecifics). This study will allow us to gain a better understanding of how particular roosting strategies shape behavior, and will be valuable for identifying ecological correlates and the consequential adaptive value of communication.

Synthesis of White-nose Syndrome Immune Function Studies: 2008 to the Present and Beyond
Marianne Moore, Jonathan Reichard, Elisabeth Buckles, Kenneth Field, DeeAnn Reeder, and Thomas Kunz, Bucknell University, Lewisburg, PA; Boston University, Boston, MA; Cornell University, Ithaca, NY

Using immune responses against fungi in other mammals as a reference, we present how aspects of immune function in hibernating white-nose syndrome (WNS)-affected and unaffected bats may relate to attempted resistance against *Geomyces destructans* (GD). Results to date show that, as compared with unaffected bats, WNS-affected *Myotis lucifugus* sampled during mid-hibernation have: 1) greater complement protein activity against bacteria, but a lesser ability to kill fungi; 2) more leucocytes present in blood and skin tissues; 3) a greater ability to mount cutaneous immune responses; 4) no difference in circulating antibodies; and 5) significantly lower levels of circulating antioxidants. Based on components of a destructive body composition analysis, affected *M. lucifugus* may be allocating energy to mounting immune responses and subsequently experiencing reductions in energy stores. Additionally, torpor reduces cutaneous immune responses and euthermia is required for effective complement protein activity; as the hibernation period progresses, *M. lucifugus* demonstrates reductions in complement protein activity. Current efforts are focusing on interspecies differences in immune responses and preliminary results suggest that WNS-affected *M. lucifugus* have less responsive B and T lymphocytes and lesser complement protein

activity as compared with affected *Eptesicus fuscus*. Overall, it appears that euthermia is required for effective immune responses and that bats may be allocating energy essential for survival to mounting immune responses against GD. There may also be considerable variation in the ability of different species to resist GD through immunological mechanisms, which may help to explain the observed differential mortality among species.

Ecology of *Myotis leibii* and Trends in Capture Success Associated with White-nose Syndrome in New Hampshire

Paul Moosman, Jacques Pierre Veilleux, and Howard Thomas, Virginia Military Institute, Lexington, VA; Franklin Pierce University, Rindge, NH; Fitchburg State University, Fitchburg, MA

Declines in populations associated with white-nose syndrome (WNS) highlight the need for information about the ecology of all species of bats, particularly those previously not considered endangered. Most aspects of the ecology of *Myotis leibii* are unknown and its hibernation habits make it difficult to quantify mortality from WNS during winter. We studied habitat use and relative abundance of *M. leibii* in New Hampshire (185 km from where WNS was first observed) during summer from 2005 until 2011. Changes in relative abundance were compared to those of co-occurring species to estimate susceptibility to WNS. Both genders were present at the study site at least from April until late October, and probably longer. Maternity colonies of ≤ 15 bats occurred in crevices between relatively large boulders of a man-made dam or in cliffs. Males also used these habitats but were typically in crevices formed by smaller boulders. Crevices that were on south-facing slopes, and were larger, narrower, and warmer than random crevices were most likely to be used as roosts. Roosts were consistently warmer than the air, with temperatures fluctuating daily from ca 20°C in the morning to > 30° in the afternoon. Maximum temperature recorded in roosts was > 51°C. Rates of capture indicate populations of *M. leibii* have not declined as much as those of *M. lucifugus* and *M. septentrionalis*, perhaps suggesting they are less susceptible to WNS.

Specializations in the Echolocation of Cuban Bats: Biodiversity as a Research Tool

Emanuel Mora, Havana University, Cuba

For the last 15 years my research group has been studying echolocation in Cuban bats and we have found remarkable specializations in call repertoires and auditory systems. Within Molossidae, *Molossus molossus* shows frequency alternation in search calls to increase duty cycle and thus the temporal continuity of scanning. A neurophysiological correlate reveals 64% of neurons in the inferior colliculus respond to search call frequencies. The high frequency approach calls of *M. molossus* demonstrate that spectral shifts may be used by bats to defeat moth hearing. Within Mormoopidae, *Pteronotus parnellii* broadcasts long and constant frequency calls of 61 kHz and shows a specialized auditory system, suited for studying hearing development. Studying new born bats we showed that before onset of echolocation, the auditory cortex already contains functional circuits to calculate target distance. Within Phyllostomidae, *Artibeus jamaicensis* emits relatively low-intensity and short calls and is therefore appropriate to look for the effects of call intensity on the neuronal selectivity of call duration. We showed that in this species best durations of duration-selective neurons are shorter than 4 ms and occur predominantly for < 65 dB SPL calls. Many other specializations in the Cuban bats' echolocation will undoubtedly guide our future research. The behavioral implications of the single-harmonic calls of *Phyllonycteris poeyi*, the auditory correlates of the large call repertoire of *Mormopterus minutus*, and the neuronal specialization processing, respectively, the high and the low call repetition rates of *Nyctiellus lepidus* and *Eumops ferox*, are only a few topics to be investigated.

Bats on the Pendulum Attract Biology Students to Physics

Emanuel Mora, L. Sanchez, A. Padron, S. Macias, and L. Diago, Havana University, Cuba

At Havana University, not all biology students value physics or are aware of its impact on modern biology so efforts to attract biology students to physics often do not succeed. To mitigate this problem, faculty from biology and physics at Havana University started a joint laboratory exercise that combines the methodological advantages of the "simple" pendulum with the attractive echolocation behavior of the high duty cycle bat *Pteronotus parnellii* (Mormoopidae). When this bat species is on the wing, they emit long calls with a prominent CF component and adjust the CF value to compensate for flight-speed induced Doppler shifts in the frequency of the returning echoes. Such behavior is known as Doppler shift compensation (DSC). When mounted on a swinging pendulum, *P. parnellii* readily echolocate and show DSC, and its echolocative behavior can be recorded by having a microphone attached to the pendulum. Frequency differences between call and echo are, therefore, indicators of the bat-and-pendulum speed and can be used by the students to estimate factors and parameters involved in the equations that characterize

the pendulum. The main equations (Doppler shift equation and Pendulum's period and velocity equations) are provided to the students, who need to understand echolocation and characterize calls/echoes before resolving the exercise. Even when relatively complex, biology students love this practical exercise where bats are the key motivation. At present, echo intensity compensation and call-echo time delays are under study to look for the inclusion of other species of bats in this "physics" laboratory experience.

Ultrasonic Vocalizations by Flying Squirrels

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Recent studies of flying squirrel behavioral ecology have suggested the existence of intraspecific information transfer about cavity use and food caches. Field observations have suggested that flying squirrels commonly make vocalizations that are inaudible to humans. Furthermore, anecdotal records indicate that flying squirrels use ultrasound. Thus, we used laboratory and field methods to explore the use of ultrasound by both northern (*Glaucomys sabrinus*) and southern (*Glaucomys volans*) flying squirrels. Our assessments confirmed that both species used ultrasound, including vocalizations at frequencies up to 50 kHz. The main types of calls were a broadband sound burst, frequency and amplitude modulated call sets, and two-part frequency modulated and constant frequency calls. We were unable to elicit behavioral responses using playbacks however, and thus, the functions of ultrasound in flying squirrels remain unclear.

Variability and Inter-relatedness of Survival Traits among Captive Big Brown Bats, *Eptesicus fuscus

Chelsey D. Musante, Marianne S. Moore, Allyson Menzies, Kenneth A. Field, Craig K. R. Willis, and DeeAnn M. Reeder, Bucknell University, Lewisburg, PA; University of Winnipeg, Winnipeg, MB

*** Chelsey Musante** received the **Avinet Award**.

The widespread mortality of hibernating bats affected by white-nose syndrome (WNS) has directed much attention to the question: Who will survive? The ability of infected bats to effectively combat WNS may depend upon phenotypic variation in different "survival traits" including immunological competence, stress responsiveness, thermoregulatory activity, and behavioral adaptability to environmental novelties. The objective of this study is to characterize and quantify potential intra-species variability and inter-relatedness of these traits in a captive colony of *Eptesicus fuscus* (n = 69). The complexity of the immune system necessitates multiple levels of evaluation, thus all individuals are being assessed for total leukocyte count, wound-healing rate, microbicidal ability, and B-cell activation. To test responsiveness to and recovery from a stressor, we used a stress-restraint challenge and measured circulating levels of glucocorticoids preceding the challenge, after 30 minutes of restraint, and after 120 minutes of recovery. Preliminary results indicate that there is marked inter-individual variation in peak cortisol levels as well as in time to recovery. Hibernation temperature profiles (i.e., torpor/arousal bout lengths) were monitored throughout the winter of 2010 and were variable among individuals and related to body condition. Behavioral adaptability was tested by exposing each bat to a "hole-board" chamber (a "personality" test commonly used in rodents) and exploratory, anxious, and active behaviors are being scored according to an ethogram. The final phase of this study will include a heritability analysis of the candidate "survival traits" to predict the potential of WNS-survivors to pass on advantageous traits to their offspring.

Investigation of Surrounding Habitat of Roosts Used by *Dermanura watsoni* and *Vampyressa nymphaea* in Costa Rica

Julia Nawrocki, Ball State University, Muncie, IN

Twenty-two bat species demonstrate the distinct behavior of modifying leaves to create tents in which to roost. Knowledge of this behavior and preferences of tent-making species is poorly understood, yet crucial to the protection and understanding of species. The objective of this study was to examine the habitat surrounding the tent roosts of big yellow-eared bats (*Vampyressa nymphaea*) in *Potalia turbinata* plants and of Thomas's fruit-eating bats (*Dermanura watsoni*) in *Asterogyne* plants, and to uncover any preferences these species might have. *Asterogyne* and *Potalia* plants with and without bat tents were located within Tirimbina Biological Reserve, Heredia, Costa Rica. Habitat measurements were taken on each plant and the surrounding vegetation. The big yellow-eared bat showed the most selective preference for the height of the plant and the distance to the closest tree ($p = 0.004$). Thomas's fruit-eating bat displayed a discriminating partiality towards height of the plant and canopy

cover (p = 0.013). Because bats have a highly sensitive and selective attitude towards their habitat, these results may have direct implications on conservation efforts in the tropics.

***Development of "The Nixon" Over-water Mist-netting System**
Josiah Nelson, Paul Barnhart, and Erin Gillam, North Dakota State University, Fargo, ND
*** Josiah Nelson** received the **Speleobooks Award**.

The unique habitat of the Northern Great Plains presents challenges to bat researchers in the field. Due to limited vegetative cover, mist-netting efforts often times must be concentrated to ponds, streams, or rivers to be effective. This may present problems such as deep water, soft mud bottoms, or uneven terrain that may make traditional mist netting difficult and unproductive. Although boats can be useful under these circumstances, boat use leads to additional safety and logistical challenges. The purpose of this work was to develop a means to solve these problems for field biologists. To do this, a basic conceptual design for a mechanical gate-like mist-net support system that could swing out over water was developed and tested. This system, called "The Nixon," supports traditional mist-net poles and nets. Once a preliminary model was proven effective, a stronger, more durable, and versatile device was built. This system was deployed in Spring of 2011 to test for efficiency and effectiveness. Initial results indicate that the Nixon mist-netting system could be more effective for capturing bats than traditional mist netting in challenging field conditions.

Can Molecular Methods to Study Bat Diets Detect Secondary Predation?
Morgan Ness and Kimberly Williams Guillen, University of Washington, Bothell, WA

The use of DNA barcoding to study diets is a recently developed method that is being adopted by bat biologists. However it is unknown if it is possible to detect secondary predation: If we amplify DNA from a bat fecal sample, are we getting DNA from an insect the bat ate or are we getting DNA from prey the insect ate? To explore this question we fed known diets to wild-captured bats, and collected fecal samples. *Rhogeessa tumida* and *Myotis keaysi* were used. Captured individuals were first fasted over several hours to clear their systems of any food ingested earlier in the night, then fed a combination of mealworms (*Tenebrio molitor*) and *Azya obrigera*. *Azya obrigera* is a type of ladybug whose larvae live on coffee plants and feed exclusively on green scale insects (*Coccus viridis*). Afterward, fecal samples were collected and the bats released. Several primers were used—a universal arthropod primer, a mealworm specific primer, an *Azya* specific primer, and two scale insect primer sets—yielding the following results: 12/12, 9/12, 0/12 (306 bp), and 2/12 (95 bp), respectively. Research is ongoing with other samples. Our preliminary results suggest that it is possible to detect secondary predation with short segments of DNA, and it is detected much less frequently than primary predation. We expect to show that by adjusting PCR conditions and by using primer sets that amplify longer DNA segments, bat biologists can avoid detection of secondary predation in molecular studies of bat diets.

Automated Acoustic Bat Monitoring for Conservation—Use in Habitat Structure, Landscape Connectivity, and Red List Assessments
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Tools for recording and analyzing of bat echolocation calls have advanced dramatically with evolving digital techniques. We track recent Swiss developments of hard- and software for processing such data automatically and exemplify its use in three projects. 1) Chestnut orchards: the abandonment of orchards traditionally managed for food supplies leads to overgrowth of the structure formerly kept open by human management. This in turn has implications for the accessibility of bats to these forests. With acoustic sampling in 30 pairs of managed and abandoned orchards we demonstrated reduced activity and species numbers of bats in overgrown forests. Traditional management of chestnut orchards thus has conservation implications. 2) Red List: a large sampling design has been implemented and is being pursued to collect acoustic data of bats at 100 sites across Switzerland. The vast amount of data is being processed automatically to locate species and estimate detectability to finally come up with species distribution maps needed for the classification of species according to IUCN rules. By using acoustic techniques on a large scale, some species prove to be considerably more common than previously anticipated, which will have

consequences for their Red List status. 3) Landscape connectivity: bats make extensive use of landscape structures like hedges and forested patches. We used state of the art data-loggers to repeatedly record georeferenced activity of bats on 180 such elements of varying degree of connectivity. Our results show that the effect of fragmentation in agricultural landscapes on bats depends on the presumed range of their echolocation and foraging. But the better a landscape's connectivity the better is its use by bats. We comment on some downsides of automatisms, such as proper species identification or the management of the tremendous amount of amassed data. However, applying automated techniques allows us to ask novel questions and tackle sampling schemes of unprecedented dimensions.

Are Bats Exceptional among Mammals as Viral Reservoirs?

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In recent years bats have received growing attention as reservoirs for emerging infectious diseases. Particularly, a number of high profile viral zoonoses with significant human and animal mortality have been linked to bat reservoirs, including SARS, Ebola, Marburg, Hendra, and Nipah virus. Several studies have suggested that bats may be special among mammals in their ability to harbor and transmit viruses, particularly in terms of their unique ecology and possible immune function. In this talk, we will take a critical and quantitative look at the question "Are bats exceptional among mammals in their ability to harbor viruses?" Using a database we recently compiled of virus-mammalian host species associations from the past 70 years of literature, we will examine two main hypotheses: 1) Bats are reservoirs of a disproportionate number of previously emerging human diseases given their diversity relative to that of other mammalian orders; and 2) Bats have higher levels of viral diversity as compared to other mammalian orders. We test these hypotheses in a framework that controls for sampling effort/research bias, species diversity, and also phylogeny. We will conclude with a brief discussion on how to reconcile public health studies in bats with conservation research, and why it is necessary that we do so.

Survival and Movement of Pre-White-nose Syndrome Little Brown Bats from Manitoba and Northwestern Ontario

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Basic information on the natural history of North American hibernating bats has become even more vital since the appearance and rapid spread of white-nose syndrome (WNS). Many factors are thought to influence survival in bats but few long-term studies exist. Knowledge of overwinter survival for populations before and after the arrival of WNS will be important for precisely quantifying between-population variation in mortality. It will also help identify populations with already low survival rates that, presumably, will be at greatest risk. We report preliminary results of a mark-recapture analysis quantifying overwinter survival in little brown bats across Manitoba and northwestern Ontario. We banded over 10,000 bats captured at hibernacula, mating swarms, and summer roosts between July 1989 and May 2010. So far, we have recaptured 1,365 of these individuals allowing us to examine factors influencing annual survival prior to the arrival of WNS in western Canada, including the influence of sex and hibernaculum microclimate. In addition we PIT-tagged over 1,500 individuals between May 2008 and September 2011 and are currently monitoring their presence at, and movements between, five hibernacula in Manitoba and one hibernaculum in northwestern Ontario using stationary PIT-tag readers. These data will improve our understanding of survival and movements in bats and provide an important baseline for comparison to survival rates in different sites after the arrival of WNS.

Microsatellites for *Leptonycteris yerbabuenae*

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The lesser long-nosed bat (*Leptonycteris yerbabuenae*) occupies a wide range of ecosystem types from southwest Arizona and southwestern New Mexico through Mexico, including tropical regions of southern Mexico, Guatemala, Honduras, and El Salvador We screened two individuals from one locality in Mexico, to develop a genomic library, for which no markers were previously published. We used a second-generation sequencing to

rapidly develop microsatellite loci for the species, by randomly sequencing the DNA genome of the species. We discovered 1,061 microsatellites, but we only designed primers for 12 loci that contained flanking regions for suitable primer development. We tested the 12 loci on 15 individuals and all were polymorphic. We tested ascertainment bias on *Glossophaga soricina*, *G. morenoi*, and *L. nivalis* with successful cross-species amplification.

The Role of *Artibeus jamaicensis* and *Brachyphylla cavernarum* in the Dispersal of the Endangered *Stahlia monosperma* (Leguminosae) in Puerto Rico

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We present data on food choice experiments of the phyllostomid bats, *Artibeus jamaicensis* and *Brachyphylla cavernarum*, as related to the endangered tree *Stahlia monosperma*. The distribution of *S. monosperma*, an endangered tree for which no dispersal vector is known, is restricted to a few locations around the island of Puerto Rico and eastern Hispaniola, Greater Antilles. It has been speculated that bats or land crabs might be the dispersal vector, that the extinct echimid rodents could have been the dispersal vector, or that the tree is thalassochorous rather than zoochorous. We released bats in a flight cage where they were presented with two food choices, with the purpose of assessing their role in the dispersal of *S. monosperma*. We also made nightly observations of the trees to determine whether bats in the wild were attracted to the fruits. *A. jamaicensis* and *B. cavernarum* commonly carry fruits about the size or larger than those of *S. monosperma*. Our results showed that when presented only with *S. monosperma*, bats will feed on the fruits. When presented with a choice, *B. cavernarum* will select *S. monosperma* occasionally, while *A. jamaicensis* explored the plates briefly before moving to the other choice offered. However, both species of bats show a strong preference for the introduced mango (*Mangifera indica*). There was considerable bat activity around the *S. monosperma* trees and, on one occasion, seeds were found under a tree at least 15 m from where the fruits could have been obtained. The fact that some bats will carry and feed on the fruits of *S. monosperma* has important implications for the conservation of this endangered species, although it should be noted that these fruits appear to be at the bottom of the dietary preferences of bats.

Psychoacoustic, Ratio-comparisons, Sex, and Dinner: Stimulus Perception in Frogs and Bats

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Across the animal world, males have evolved elaborate traits to attract females. It is well known that one check on continued trait elaboration is predation—males that are highly conspicuous to mates are also vulnerable to predators. Another, less considered check to continued trait elaboration, however, is females themselves. Here we show that female cognitive biology constrains the elaboration of male traits. Both female túngara frogs, *Physalaemus pustulosus*, and their predators, *Trachops cirrhosus*, prefer complex calls to simple ones, but both show a decrease in selectivity as signals become more elaborate, functions that closely mirror Weber's Law. For males producing complex calls, it is a case of diminishing returns: as males increase call complexity, differences in relative attractiveness decrease. We discuss these results in light of shared perceptual mechanisms across disparate taxa, and the relative roles of predation and female cognition in the evolution of sexual signal elaboration.

The Lipids of Chiropteran Integument: Characterization of Triacylglyceride Molecules from Three Species of Bats

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White-nose syndrome (WNS) is a fungal disease that has devastated North American hibernating bat populations and is associated with the newly describe fungal species *Geomyces destructans*. In order for the fungus to cause disease, a fungal propagule must contact host tissue and subsequently recognize and attach to that tissue for infection to proceed. Biomolecules present on host tissue play a role in pathogen sensing and attachment. Lipids secreted by sebaceous glands on host integument may affect fungal pathogenicity. We extracted lipid with chloroform/methanol from the hair and wing tissue of eastern red bats (*Lasiurus borealis*), evening bats (*Nycticeius humeralis*), and big brown bats (*Eptesicus fuscus*). Lipids were initially separated by preparative thin-layer chromatography (TLC), then triacylglyceride (TAG) fingerprints were obtained by matrix assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS). TLC indicated four major bands

correlating to cholesterol, fatty acids, TAGs, and sterol esters. TAG MS profiles indicated sodiated TAG ions representing variable fatty acid moieties that ranged from *m/z* 633.52-911.81, with intense peaks at *m/z* 879.74, 881.76, 905.76, and 907.77. These high intensity peak masses correlated with oleic and palmitic acid being dominant fatty acid moieties of TAGs. Higher proportions of TAGs were present in hair tissue than wing tissue. Thus, we have identified putative target molecules for experimental growth of *G. destructans* to elucidate the fungal response to these targets or alternatively, to reveal antifungal properties contained within bat tissue.

Estimating Interisland Migration of *Artibeus jamaicensis* across the Caribbean
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Artibeus jamaicensis (Phyllostomatidae: Stenodermatinae) is a wide-ranging frugivorous bat, inhabiting Central America, the Caribbean Islands, and South America west of the Andes. Behaviorally, *A. jamaicensis* forms harems and is philopatric. Our goal is to address the migration of this species through the Caribbean as well as recent migration among these islands. Historically, *A. jamaicensis* entered the Caribbean from the Yucatán Peninsula and migrated eastward across the Greater Antilles and southward across the Lesser Antilles. This trans-Antillean migration, predominantly supported by molecular data, is hypothesized to have begun during the Late Pleistocene. Microsatellites are a useful marker to study gene flow and the genetic consequence of range extension across islands. Structure was used to estimate genetic structure and gene flow among the Caribbean Islands. Our preliminary results include 33 individuals and 8 microsatellite loci. Structure failed to recover geographically correlated genetic structure among Antigua, Barbuda, Dominica, Saba, and the U.S. Virgin Islands, suggesting extensive interisland migration exchange of individuals. Future analyses will include data for 10–20 individuals from more Caribbean Islands and the Yucatán Peninsula. Increasing sampling size will aid in the identification of rare alleles, which will contribute to our understanding of the migratory patterns among individual islands as well as whether observed genetic similarities are the result of common ancestry. This study provides an invaluable opportunity to merge morphological, molecular, and fossil data, and understanding evolutionary success under these constraints of population bottlenecks and island ecology will provide valuable information on the biology of this important fruit bat.

Using Occupancy Estimates to Assess the Effectiveness of Indiana Bat Management in Northeast Missouri
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This study is one component of a long-term interagency collaboration between the Missouri Department of Conservation, USFS Northern Research Station, and University of Missouri in an effort to provide a tool to measure the effectiveness of habitat mitigation efforts for the benefit of the federally endangered Indiana bat. The overall objectives are to determine probability of patch occupancy and probability of detection for Indiana bats on Charlie Heath Memorial Conservation Area, Fox Valley Lake Conservation Area, and Deer Ridge Conservation Area, and develop predictive occupancy and habitat use models based on site and landscape covariates. Furthermore, we look to understand the role that competition among co-occurring bat species may have on the patch occupancy of Indiana bats. We annually (2009–2011) sampled 100 points for two consecutive nights across different types of forest management within each of the three study areas (n = 900). We passively collected bat echolocation calls using Anabat SD1 and Anabat II detectors coupled with zero-crossing analysis interface modules with CF memory card storage (CF ZCAIM; Titley Electronics). We will analyze the resulting detection history using program PRESENCE 3.0 to estimate proportion of sites occupied and objectively evaluate multi-season models and Royle-Nichols heterogeneity models relative to both probability of detection and site occupancy. We will also evaluate multi-species models to assess inter-species interactions.

Bat Trypanosomes
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Trypanosomes are protozoan blood parasites. Trypanosomes in vertebrates use blood-feeding invertebrates as vectors. Bats are hosts of at least 10 trypanosome species including *Trypanosoma cruzi*. *T. cruzi cruzi* in humans is the causative agent of Chagas disease. To better understand the evolutionary association of bats and *T. cruzi*, we

explored the phylogenetic placement of *T. cruzi* lineages with special emphasis in those that exclusively infect bats. With a combination of model-based phylogenetics, ancestral host reconstructions, and Bayesian population genetics we inferred phylogenies of the parasites and time estimates of host switching events. As main results we show that: 1) bats were key hosts in the appearance of *T. cruzi*; 2) we determined that one bat specific lineage (*T. c. marinkellei*) should be warranted recognition as a different species; and 3) bats were re-gained as hosts of *T. cruzi* relatively recently. These results highlight the importance of bats in the appearance of *T. cruzi*, and also indicate a complex scenario where ecological and historical factors shaped the origin of Chagas disease. Finally, we stress the attractiveness of studying bat trypanosomes for exploring additional directions in ecological and evolutionary research.

Seasonal Variation in Hawaiian Hoary Bat *Lasiurus cinereus semotus* Acoustic Activity on Leeward Kauai Island

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The endangered Hawaiian hoary bat, the state's only native terrestrial land mammal, is an insectivorous, solitary tree-roosting species dependent on forest habitats at many different elevations. On windward Hawaii Island, we have observed that bats annually migrate from high elevation forested slopes, where they spend the winter and spring months, to low elevation habitats to reproduce during the summer and fall. We investigated the seasonal nature of bat activity across an elevation gradient in western Kauai to determine if bats undergo similar elevation migrations between the dry coastal lowlands of Mana and temperate forests along the ridgelines of Koke'e. We monitored nightly bat activity with automated full-spectrum acoustic detectors, on a bi-monthly basis for one full year. We chose a total of 20 recording stations, 12 within the Barking Sands Pacific Missile Range Facility and 8 within the Pu'u Ka Pele Forest Reserve. We examined the timing and patterns of nightly echolocation activity in relationship to roost proximity and movement to determine seasonal patterns in occupancy by Hawaiian hoary bats in western Kauai.

Wing Damage Patterns of North American Bats: Indicators of White-nose Syndrome Survival?

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White-nose syndrome (WNS) is an emerging infectious wildlife disease that has killed over one million bats in the eastern United States since its discovery in winter 2006-2007. The disease is associated with a cold-adapted fungus that infects bats during winter hibernation. Wing damage has been documented in bats with WNS and could become a useful detection method for use in post-hibernation seasons, but because there are no historical records of wing damage prior to the emergence of WNS, it is unknown what types of damage are specific to WNS. To address this knowledge gap, we inspected the wings of hundreds of bat carcasses collected in Illinois from 2005 to 2010, and compared the frequencies of different wing damage types by age, sex, year, month, region, and species. Wing damage scores of 1 or 2 are not uncommon in bats from this WNS-negative state. We found significant differences in wing damage scores for *Eptesicus fuscus* between age groups, years, and months, with the highest scores occurring in June. The cause of non-WNS wing damage is unknown, but could be due to ectoparasites.

Evolutionary Relationships of Living and Fossil Vampire Bats

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Vampire bats (Phyllostomidae: Desmodontinae) are a highly specialized lineage of sanguinivores that subsist on the blood of other vertebrates. Numerous lines of evidence have established the monophyly of extant vampire bats, including morphological, molecular, immunological, and chromosomal data. In addition to the three living species, four Pleistocene fossil species of vampires are now recognized: *Desmodus archaeodaptes*, *D. draculae*, *D. puntajudensis*, and *D. stocki*. The relationships of extinct vampire bat taxa can only be assessed through examining their preserved fossil remains. Unfortunately, much of the bat fossil record consists of fragmentary evidence, particularly teeth. In order to assess the phylogenetic relationships of fossil and living phyllostomids we are building an online morphological database of bat dental data using MorphoBank. Analyses of 279 dental characters, combined with molecular evidence, allow placement of fossil species into phylogenies to evaluate their relationships to living forms. We evaluated the relationships of living vampires to other phyllostomids using > 8,000 bp from 8

nuclear and 12 mitochondrial genes, and found support for placement of desmodontines among the basal branches in Phyllostomidae. Using the molecular tree as a scaffold, we assessed relationships of those fossil vampires for which dental remains are known. Details of dental morphology were assessed using light microscopy, digital photography, and CT scanning. Our findings support monophyly of *Desmodus* including the fossil species attributed to the genus. Consideration of the phylogeny of desmodontines provides a means of testing various hypotheses about the evolution of blood feeding in bats.

Overview of the Distribution and Dynamics of *Geomyces destructans* Across Europe and Potential Threats to Bats

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Recent investigations in Europe confirmed the presence of the fungus *Geomyces destructans* without associated mass mortality in hibernating bats in six countries but its distribution remains poorly known. We collected data on the presence of bats with white fungal growth in 13 countries in Europe between 2003 and 2011 and conducted morphological and genetic analysis to confirm the identity of the fungus as *G. destructans*. Our results combined with previously published data demonstrate the presence of the fungus in 12 countries spanning over 2,000 km from West to East and provide compelling photographic evidence for its presence in another 5 countries including Romania, Bulgaria, and Turkey. Furthermore, matching prevalence data of a hibernaculum monitored over two consecutive years with data from across Europe show that the temporal occurrence of the fungus, which first becomes visible around February, peaks in March but can still be seen in some torpid bats in May or June, is strikingly similar throughout Europe. Finally, we isolated and cultured *G. destructans* from a cave wall adjacent to a bat with fungal growth. *G. destructans* is widely found over large areas of the European continent without associated mass mortalities in bats, suggesting that the fungus is native to Europe. The characterization of the temporal variation in *G. destructans* growth on bats provides reference data for studying the spatio-temporal dynamic of the fungus. We also provide evidence that bats can groom off the fungus during the hibernation period. Finally, the presence of viable *G. destructans* spores on cave walls suggests that hibernacula could act as passive vectors and/or reservoirs for *G. destructans* and therefore, might play an important role in the transmission process. In light of these findings, we will discuss the potential threat of *G. destructans* to European bats.

Population Genetic Structure of the Lesser Long-nosed Bat (*Leptonycteris yerbabuenae*) in Arizona and Mexico

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The lesser long-nosed bat *(Leptonycteris yerbabuenae)* is a nectarivorous member of the subfamily Glossophaginae, and is found in southern Arizona, Mexico, Guatemala, and El Salvador. A group of *L. yerbabuenae* females is migratory, mating in southern Mexico and migrating to maternity roosts in northern Mexico and southern Arizona to give birth. For this present study, 12 microsatellite loci markers and 1 fragment of the control region (CR) of mitochondrial DNA (mtDNA) were amplified to examine the population structure and phylogenetic relationships among roosts for *L. yerbabuenae*. The 12 microsatellite markers were isolated from *L. yerbabuenae*, and all loci were polymorphic (average of 13 alleles). A total of 16 localities in Arizona and Mexico was sampled. The mtDNA CR fragment resulted in 102 unique haplotypes produced from 331 individuals. The phylogenetic results showed that unique haplotypes form two clades, but there was no observable geographic structuring. The average F_{st} value across all loci and all sampled localities was 0.022. Program STRUCTURE results indicated low population structuring and one population (K = 1) throughout the sampling area. Sampled individuals belong to one population suggesting movement between maternity colonies in Arizona and Sonora southeastern transient roosts. In addition, results show the sample site Chamela, Jalisco, Mexico as a possible winter roost for the northern migratory bats. Consequently, individuals found in the northern migratory range and in Chamela should be managed as a single population.

Identification and Characterization of Swarming Sites Used by Bats in Nova Scotia
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For bats, one of the most critical habitat components is the underground sites used for hibernation and mating. Beginning in late summer, bats congregate and mate at caves and abandoned mines in an activity known as swarming. In Nova Scotia, the location of several such sites are known and documented. However, many abandoned mines and caves exist that have never been surveyed for bats. The objectives of this study were to: 1) identify additional abandoned mines and caves that are used by *Myotis lucifugus* (little brown bats) and *M. septentrionalis* (northern long-eared bats) for swarming and hibernation, and 2) quantitatively characterize factors that best differentiate between caves and mines used for swarming/hibernating, and those that are not. Acoustic and/or trapping surveys were conducted at 17 abandoned mines and 9 caves in Nova Scotia. Of bats captured, 55% (n = 797) were *M. lucifugus* and 45 % (n = 661) were *M. septentrionalis*. Survey data suggest that at least 12 of the 26 sites were swarming sites. Logistic regression analysis of nine *a priori* selected models was used to determine the extent to which each of five variables (chamber length, entrance size, degree of shelter at entrance, area of forest in surrounding landscape, and total stream length in surrounding landscape) influence swarming. When ranked by AIC_c, the top model included chamber length and degree of shelter. Multi-model inference indicated that chamber length was the best predictor of swarming. The swarming sites identified should be targeted for conservation initiatives.

Adaptive Auditory Risk Assessment in the Dogbane Tiger Moth when Pursued by Bats
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Moths and butterflies flying in search of mates risk detection by numerous aerial predators. Under the cover of night, the greatest threat will often be from insectivorous bats. During such encounters, the chemically-defended dogbane tiger moth, *Cycnia tenera*, uses the received intensity, duration, and emission pattern of the bat's echolocation calls to determine when, and how many, defensive ultrasonic clicks to produce in return. These clicks, which constitute an acoustic startle response, act as acoustic warning signals against bats in flight. Using an integrated test of stimulus generalization and dishabituation, we found that *C. tenera* is able to discriminate between the echolocation calls characteristic of a bat that has only just detected it versus those of a bat actively in pursuit of it. We also demonstrate that *C. tenera* habituates more profoundly to the former stimulus train ('early attack') than to the latter ('late attack'), even though it was initially equally responsive to both stimuli. Matched sensory and behavioral data indicate that reduced responsiveness reflects habituation and is not merely attributable to sensory adaptation or motor fatigue. In search of mates in the face of bats, the ability of *C. tenera* to discriminate between attacking bats representing different levels of risk, and to habituate less so to those most dangerous, should function as an adaptive cost-benefit trade-off mechanism in nature.

High-throughput Sequencing Offers Insight into Mechanisms of Resource Partitioning in Cryptic Bat Species
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Sympatric cryptic species, characterized by low morphological differentiation, pose a challenge to understanding the role of interspecific competition in structuring ecological communities. We used traditional (morphological) and novel molecular methods of diet analysis to study the diet of two cryptic bat species that are sympatric in southern England (*Plecotus austriacus* and *P. auritus*). We used Roche FLX high-throughput sequencing and uniquely tagged arthropod-specific primers and identified 142 prey molecular operational taxonomic units (MOTUs) in the diet, 60% of which were assigned to a likely species or genus. The findings from high-throughput sequencing supported the results from microscopic analyses in showing that the diets of both species were dominated by lepidopterans. However high throughput sequencing provided a sufficiently high resolution of prey identification to determine fine-scale differences in resource use that facilitate coexistence. Both bat species appeared to have a generalist diet, including a variety of prey items that were detected only once. Eared-moths in the family Noctuidae were the main prey consumed. Interspecific niche overlap was greater than expected by chance ($O_{jk} = 0.72$, $p < 0.001$) due to overlap in the consumption of the more common prey MOTUs. Habitat associations of non-generalist prey species found in the diet corresponded to those of their respective bat predator. Overlap in

common dietary resource use combined with differential specialist prey habitat associations suggests that habitat partitioning is the primary mechanism of coexistence. The performance of high-throughput sequencing is discussed in relation to previous methods of molecular and morphological diet analysis. By enabling species-level identification of dietary components, the application of DNA sequencing to diet analysis allows a more comprehensive comparison of the diet of sympatric cryptic species, and therefore can be an important tool for determining fine-scale mechanisms of coexistence.

Bridging the Gap: The Development of a New Trap to Capture Bats Roosting in Bridges
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The disturbance or destruction of natural bat roosts is considered to be one of the main threats to bat populations. Nonetheless, some bat species occupy man-made structures that mimic the conditions of their natural roosts. Many countries have already recognized the importance of bridges as bat roosts and some of them have ongoing projects to specifically monitor bat colonies in such structures. Species such as *Tadarida brasiliensis* seem to be common bridge dwellers in parts of the United States, while in Portugal colonies with significant numbers of *T. teniotis* among others have only recently been found. Crevice-dwelling species are particularly difficult to study because of the low detectability and inaccessibility of their roosts, being even more challenging in sites where colonies are usually small, as in Europe. The occupation of bridges by such species presents an excellent opportunity to reduce the knowledge gap of these poorly studied bats. In response to this situation, we developed a trap to increase the capture efficiency of bats in bridges. The trap consists of an aluminum frame that can be secured to the bridge rails or walls and can be easily assembled by two people. This system has a vertically adjustable capturing area and uses up to two mist nets. The first assays were quite promising, capturing *T. teniotis*, *Eptesicus serotinus*, and *Pipistrellus pipistrellus* during all nights. With this new tool we hope to add an important contribution to ongoing monitoring projects and to make research on these poorly studied bats less problematic.

Bat Fatalities at Wind Turbines: Assessing the Feeding Attraction Hypothesis
Jesika P. Reimer, Erin F. Baerwald, and Robert M. R. Barclay, University of Calgary, Calgary, AB

Despite the continued development of wind energy facilities and the increased demand for wind energy, concerns about fatalities of migrating insectivorous bats at wind turbines in North America and questions as to why these fatalities occur still remain. Numerous hypotheses have been developed to address why bats are killed by wind turbines, including a feeding attraction hypothesis that suggests bats may be attracted to insect congregating near turbine nacelles. To test this hypothesis, we analyzed 508 echolocation passes of hoary bats (*Lasiurus cinereus*) and 703 passes of silver-haired bats (*Lasionycteris noctivagans*) recorded over 72 nights at wind energy facilities located in southern Alberta during July–September 2007. Passes were recorded using Anabat detectors mounted at three different heights: 1) 67 meters, attached to turbine nacelles; 2) 30 meters, attached to meteorological towers; and 3) ground level at both wind turbines and meteorological towers. Passes were classified as: “complete sequences,” which included search, track and terminal calls; “partial sequences,” which included search calls but no terminal calls; and “non-feeding” sequences, which consisted of only tracking calls. We found no significant evidence that bat activity types (as determined by sequence classification) differed among the three heights, suggesting that migrating bats do not preferentially feed around turbine nacelles. In addition, the presence of “abrupt sequences” may suggest that bats echolocate infrequently while migrating and display “abrupt” calls when they observe a large object in their flight path.

Stay Cool or Eat? Torpor and Foraging Patterns in Reproductive Female *Eptesicus fuscus*
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Producing and raising young is energetically expensive for mammalian females, especially in temperate areas where the amount of time for this to occur is limited. Temperate mammals often have ways to cope with these issues. For example, temperate bats have the flexibility to alter torpor use and foraging behavior throughout the different stages of reproduction (pregnancy, lactation, and post lactation) when energy demands vary. However, because foraging and torpor are often studied separately, there is little knowledge what relationship exists between these two factors. The purpose of this research was to determine how the relationship between torpor and foraging patterns varies among reproductive stages in big brown bats (*Eptesicus fuscus*). I equipped pregnant, lactating, and post-lactating big brown bats with temperature sensitive radio transmitters in Saskatchewan, Canada. While

transmitters were active, skin temperature data were collected using a Lotek data-logger and foraging location and duration were determined by triangulation. Bats were found to use torpor differently throughout reproduction, with torpor used the least during lactation. Bats tended to forage in generally the same areas while pregnant and lactating, but post-lactation females foraged further from roost and in more diverse areas. When coupled together, I found that, contrary to expectations within each reproductive stage (as one factor increases, the other decreases), bats foraged similarly regardless of torpor. These data provide support that the relationship between torpor and foraging is not constant, but changes, likely depending on the trade-off between torpor use and risky foraging in suboptimal conditions, as well as short term energetic demands.

Home Range Delineation and Activity of an Indiana Bat Maternity Colony
Lynn Robbins, Ben Hale, and Joseph Lemen, Missouri State University, Springfield, MO

The determination of home range size and areas of activity is critical for assessing risk to individuals within a reproductive unit (maternity colony). We conducted a survey during the summer of 2011 to determine the possible presence of one or more maternity colonies within or near a proposed wind energy facility. Home range was determined using a minimum radius of 2.5 miles from a maternity roost. If the distance from capture to roost was greater, this distance was used. We tracked seven reproductively active females to a total of five primary or multiple bat/multiple day-roost trees. A total of 23 bat tracking nights (one bat tracked for one night) resulted in 359 separate telemetry points and an average of 27 hours of tracking per bat. We placed three Anabat detectors beginning on June 15 in an area of activity associated with primary and alternate roosts at 25 and 240 feet away from this forested habitat. These data indicated that activity of this species is concentrated in areas of suitable habitat relative to adjacent but unsuitable habitat. Home range estimates based on capture site, roost sites, and telemetry differed by bat and by capture date but showed large areas of overlap. Combining these data for each bat increased the home range estimate for the entire colony. Home range estimates alone should not be used to infer risk without describing and delineating suitable habitat and activity within the estimated home range.

Physiological Benefit of Roosting in Tents: The Case of *Ectophylla alba* and *Uroderma bilobatum*
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The effect of the microclimate of a roost on the daily energy balance of bats could be a fundamental factor determining their survival. For bats that roost in "tents" (modified leaves), we wanted to determine: 1) If there was a difference in temperature between tents and unmodified leaves (UML); 2) If there was a difference between tents and UML (with a source of heat); 3) If there was a difference between types of tents; and 4) If the temperature of the tents is an important physiological factor for *Ectophylla alba* and *Uroderma bilobatum*. Work was conducted at Tirimbina Biological Reserve, Costa Rica. We measured the temperature under the UML and three types of tents, and obtained heating and cooling curves under laboratory conditions using a standard 25-W light bulb as a source of heat. This comparison was made between tents and leaves and between the different types of tents. Basal metabolic rate was calculated as the mean rate of oxygen consumption (OC) at the temperature of lowest oxygen consumption. We determined there was no difference between under leaf temperature and uninhabited tents and between different types of uninhabited tents, but the tents were significantly better at conserving heat than UML. The OC of *E. alba* was 2.92 ml $O_2 \bullet g^{-1}h^{-1}$ at 31ºC and decreased 55% from 20ºC to 25ºC. The OC of *U. bilobatum* was 1.93 ml $O_2 \bullet g^{-1}h^{-1}$ at 31ºC. The OC decreased 48% from 20ºC to 25ºC, and decreased another 47% from 25ºC to 31ºC. In this locality, temperature drops below 25ºC every night until mid-morning. Thus, a roost that contributes to saving heat can be a significant benefit for bats, particularly during the breeding season.

***Pests, Poop, and PCR**
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*** Ashley Rolfe** received the **Bat Conservation International Award**.

Molecular approaches, such as the use of polymerase chain reaction (PCR), provide the opportunity to analyze the diet of bats in more detail than conventional dietary analysis by targeting the DNA of prey found within feces. Diets of the Antillean ghost-faced bat (*Mormoops blainvillei*) and sooty mustached bat (*Pteronotus quadridens*) on Puerto Rico were analyzed via PCR. Guano collected in the field was preserved in one of three ways: 1) placed in plastic bags and air dried; 2) stored in 95% ethanol; 3) or kept in lysis buffer. All samples were frozen within 2 h of

collection. DNA was isolated from 960 insect fragments, from 221 bats, and mitochondrial DNA was amplified using two sets of primers, one that targets a 648-bp region of the mitochondrial cytochrome oxidase *c* subunit 1 (COI) gene, and another set that targets a 157-bp region of this same gene. COI sequences were compared with the database in the Barcode of Life Data Systems (BoLD), and the identity of sequences was determined for samples at least 98% similar to a reference insect. A total of 18 species were identified in the diet of *M. blainvillei*, 7 of which are insects of agricultural or human-health concern. Similarly, six species were documented in the diet of *P. quadridens*, one of which is considered a vector of human disease, whereas another is a known agricultural pest. Significant differences in the rate of amplification were found in both the method of preservation of guano, as well as the set of primers used.

A Comparison of Full Spectrum and Anabat Calls on a Finite Time Scale
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In 2010, we conducted a study to compare both the hardware and software of full spectrum and zero-crossing acoustic bat technology in a manner consistent with the manufactures' recommended use. While that study produced valuable insights into the behavior of the hardware and software systems analyzed, it also opened the door to many more questions. In order to further explore the make up of individual call files and reported call parameters produced by each detector, an additional study was performed. Two zero-crossing Anabat (SD1 and SD2 units by Titley Electronics, Inc.) and an SM2 (Wildlife Acoustics) were aligned next to each other on a table approximately 1 m off the ground and manually set to record in unison for 15-sec sessions. Parameters were measured using AnalookW, ScanR, and Sonobat software. The total number of files, noise files, calls files, and pulses in each 15-sec session were determined, along with the mean Fmax, mean Fmin, mean duration, Fc, and Fk. Preliminary analysis of 27 sessions resulted in 106 SD1 files, 50 SD2 files, and 225 SM2 files. Although the number of files from these sessions varied widely, the number of pulses recorded by each detector was fairly similar. In total, over 27 sessions, the SD1, SD2, and SM2 recorded 653, 619, and 636 pulses, respectively. These results indicate that reporting the number of pulses recorded may be more appropriate than reporting the number of files recorded, especially if different detectors types were used during a study.

Genetic Demography of *Pteronotus parnellii* Reveals Historic Isolation of Island Populations
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Pteronotus parnellii is a widely distributed Neotropical bat. Its echolocation behavior is unique among New World bats by the obligate use of long-duration constant frequency (CF) calls and Doppler shift compensation (DSC). This highly sophisticated echolocation strategy is otherwise seen only in the Old World horseshoe bats, yet key differences between the groups, such as oral vs. nasal emission, and phylogeny suggest these traits are convergent in *P. parnellii*. CF echolocation is arguably an adaptive innovation, as it allows access to cluttered habitats that are not readily available to species using frequency-modulated (FM) echolocation. Our analyses of *P. parnellii* populations from Puerto Rico and Hispaniola revealed a significant shift in both frequency of the CF component and body size between islands. As expressed in *P. parnellii* and horseshoe bats, CF echolocation requires a hard-wired connection between echolocation frequency, cochlear structure, and neuroanatomy, suggesting that the evolution of DSC and subsequent shifts in call frequency involve adaptive genetic change at many loci. Analysis of the genetic demography of Caribbean populations of *P. parnellii* found that area strongly predicted population size across space and time. The common ancestor of modern populations in Puerto Rico and Hispaniola was likely located in Hispaniola and was significantly more numerous than either current population. Divergence of island populations dates to the Pleistocene, and has been followed by extremely low levels of inter-island migration. An accurate understanding of the demographic history of these populations is key to assessing potential signals of selection at loci involved in echolocation.

Characterizing Social Structure and Group Cohesion under Different Habitat Perspectives: Insights from the Peter's Tent-roosting Bat, *Uroderma bilobatum*
Maria Sagot and Richard D. Stevens, Louisiana State University, Baton Rouge, LA

Coloniality is widespread among mammals. Early work on the molecular ecology of social organisms focused on defining membership in genetic terms, emphasizing relatedness as the main factor promoting group cohesion. Furthermore, in many cases, coloniality is coupled with female recruitment into natal groups and subsequent long-

term philopatry. Therefore, these groups are formed from female kin originating from one or more matrilines. However, no correlation has been found between relatedness and roosting associations in multiple bat species. Thus, it is still not clear why individuals live in high densities and which factors influence cohesion of social groups. Further, since animals need to adapt to multiple habitat and environmental conditions throughout their range, variation in group cohesion should be expected as a consequence of differences in adaptative adjustment of males and females to different ecological factors. Thus, when studying factors promoting coloniality and different levels of group cohesion, it is important not only to consider genetic structure above the level of the social group, but also at different habitat levels. Peter's tent-roosting bat, *Uroderma bilobatum*, is a widely distributed and gregarious bat; yet, little is known about its genetic structure and factors influencing coloniality and group cohesion. Thus, our objective was to test relative contributions of habitat factors on *U. bilobatum* social structure and group cohesion. We compared the genetic structure of multiple social groups using mitochondrial and microsatellite markers at three different habitat scales: macrohabitat, microhabitat, and structural. Understanding how social structure responds to different habitat perspectives will shed light into factors influencing sociality in animal societies.

***Using Species Distribution Modeling to Predict Bat Fatality Risk at Wind Farms**

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*** Helena Santos** received the **Luis F. Bacardi Bat Conservation Award**.

We aimed to predict which areas presented higher fatality risks to bats at wind farms. In an innovative approach, species distribution modeling was employed together with mortality data and the ecological conditions at wind farms located in Portugal. Predictive models were calculated to determine areas of probable mortality and which environmental factors are promoting it. Mortality data for four bat species, *Hypsugo savii*, *Nyctalus leisleri*, *Pipistrellus kuhlii*, and *Pipistrellus pipistrellus*, were used. These are the species that have suffered the most fatalities at wind farms in Portugal, comprising 290 of the 466 fatalities recorded from 2003 to 2010. The mortality risk models showed robust performances, with all respective AUCs of ca. 0.99. Models determined that wind farms sited at humid areas with mild temperatures, closer than 5,000 m to forested areas and within 600 m of steep slopes showed higher probabilities of mortality. The areas with high probability of mortality also overlapped with a considerable portion of *N. leisleri*'s potential distribution, suggesting that populations of this species might be at high risk from wind farm fatalities. Due to the predictive approach of this work, it was considered necessary to ground-truth the models. These results will also be presented. In summary, by identifying mortality risk in areas prior to wind farm installation, determining conditions that promote mortality, the approach used in this study could be paradigmatic for the development of important preemptive conservation measures for bat populations.

No Energetic Benefit to Group Flight in the Free-tailed Bat *Tadarida brasiliensis*

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Striking examples of group behavior abound in nature—insects, fish, birds, and mammals come together guided by individual rules to form impressive patterns of movement at the level of the group. Several explanations exist for why organisms group and behave collectively, e.g., energetic benefit, information transfer, and predator defense among others. Members of the group balance the benefits against the costs of the group—limiting resources, competition for optimal position, and increased visibility to predators. Bats are particularly good models for the study of group behavior but little is known about how and why they structure and maintain their aggregations. In this study we examined the group behavior of Brazilian free-tailed bats (*Tadarida brasiliensis*) and tested the hypothesis if free-tailed bats group to gain an energetic benefit. We recorded the emergence of free-tailed bats using an array of thermal cameras and reconstructed the three-dimensional position of individual bats in the group. In addition we measured the wing beat frequency of bats as a function of group size, ambient light conditions, and relative position in the group. Our results indicate that there is no energetic benefit to being in the group; in fact it is costly for the bats to aggregate in such dense clusters. Furthermore, there are no relative positions in the flight formation that give an energetic advantage to its members. This suggests that other reasons, such as predator defense or information transfer, drive the group behavior of these fascinating bats.

Recovery Cycles of Duration-selective Neurons in the Big Brown Bat
Riziq Sayegh, Brandon Aubie, and Paul A. Faure, McMaster University, Hamilton, ON

Neurons selective for stimulus duration, known as duration-tuned neurons (DTNs), are first observed in the auditory midbrain of both echolocating and non-echolocating vertebrates. Duration tuning in the auditory midbrain is hypothesized to arise from an interplay of excitatory and inhibitory synaptic inputs offset in time. Although inhibition cannot directly be seen through extracellular electrophysiology alone, its presence can be inferred by presenting pairs of excitatory tone pulses (presented at best duration) in rapid succession and comparing the neurons spiking response to the first pulse with the response to the second. Through single unit extracellular recordings in the auditory midbrain (inferior colliculus, IC) of the big brown bat combined with paired tone stimulation, we determined the recovery cycles of DTNs and non-DTNs in the IC. We systematically varied the inter-pulse interval (IPI) to determine the minimum IPI required to observe a $\geq$ 50% response recovery (when the second pulse elicits at least a 50% spiking response compared to the response to the first pulse). We compared the recovery cycles of DTNs and non-DTNs in an attempt to observe the time course and strength of inhibition known to be involved in duration selectivity. Initial analysis revealed no significant difference in recovery cycles between DTNs and non-DTNs at both +10 dB and +20 dB above threshold, and that recovery cycles are not significantly different as a function of amplitude above threshold. These results suggest that recovery cycles do not capture the differences between the mechanisms underlying DTNs and non-DTNs.

Bat Education through Undergraduate Service-learning
Jodi L. Sedlock, Lawrence University, Appleton, WI

Education is an essential component of bat conservation; however, appropriate education materials are often lacking, particularly in developing countries. Undergraduates at liberal arts colleges, many of whom have interests in science and the arts, seeking to deepen their understanding of biology can help meet this need. I have taken this approach at Lawrence University and, over the past nine years, have involved undergraduates in Biology, Environmental Studies, Fine Arts, Film Studies, and English in the generation of environmental education materials for the Philippines. Some of these students traveled with me to the Philippines and others were enrolled in a tutorial or an independent study in which they researched the topic (e.g., Philippine crop pests) and then produced materials for use in the Philippines. These efforts resulted in posters, fliers (used by the Philippine Department of the Environment and Natural Resources), learning modules used by an indigenous peoples school in Mindanao, and videos (e.g., *Into the Caves: Protecting the Bats of the Philippines*).

Fiber-type Proportions and Size in Two New World Fruit Bats during Postnatal Development
Jason B. Shaw and Rick A. Adams, University of Northern Colorado, Greeley, CO

Bat muscle composition is primarily fast-twitch with oxidative metabolic pathways that are maintained throughout development. In this study we analyzed the fiber-type composition and size of pectoralis major and acromeodeltoideus in two closely related bats, *Artibeus jamaicensis* and *Carollia perspicillata*, during development. Muscle samples were taken at each of four flight developmental stages (flop, flutter, flap, and flight) as well as adults. Pectoralis major in *Artibeus jamaicensis* had the majority of fiber type being fast-twitch in the flop (97%) and flutter (92%) stages while increasing slow-twitch fibers occurred at flap (69% fast). Slow-twitch fibers were significantly more prevalent in the flight stage (44% fast-twitch; $t = 2.85$, $p = 0.006$) and adult stage (39% fast-twitch; $t = 4.96$, $p < 0.0001$). Surface area followed a trend of increase throughout development for *A. jamaicensis* and *C. perspicillata*, however fiber area became similar in the pectoralis major between flight stage and adults ($t = 2.72$, $p = 0.07$) and *C. perspicillata* acromeodeltoideus at flap and flight ($t = 0.933$, $p = 0.353$). Pectoralis major in *C. perspicillata* and acromeodeltoideus in both *C. perspicillata* and *A. jamaicensis* had greater than 90% of all fibers being fast-twitch in all stages. Fiber type and area in both species followed the general trends found previously in bats, with fiber type being homogeneous for fast-twitch with an overall increase in size throughout development. The pectoralis major in *A. jamaicensis* switched fiber type from overall fast-twitch to overall slow-twitch as the bat ages. Muscle fibers may adjust their phenotype to meet changes in functional demand such as age, mass, and overall muscle use.

Looking Backwards: Diversity in the Bat Fossil Record
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Bats are a very diverse group. There are over 1,240 extant species, and as such Chiroptera comprises roughly 20% of the known species diversity of living mammals. Less well known is the fossil diversity of bats, which is likewise very impressive but which has never before been systematically surveyed. In order to develop a reference volume and begin the process of integrating bat fossils into phylogenetic analyses, we conducted a comprehensive survey of the literature on fossil bats. The oldest known bats are Early Eocene in age (roughly 54–55 Ma), and Eocene bats are known from all continents except Antarctica. Of the 28 currently recognized families of bats, 8 are extinct (Archaeonycteridae, Hassianycteridae, Icaronycteridae, Mixopterygidae, Onychonycteridae, Philisidae, Palaeochiropterygidae, and Tanzanycteridae). All of these are limited to the Eocene and Oligocene. However, fossil taxa are known from most extant families as well—only Craseonycteridae and Cistugoidae entirely lack a fossil record. In total, the fossil record of bats presently includes 436 species, some of which are still living today. Currently 73 extinct genera and 272 extinct fossil species are recognized as distinct and valid. In addition to extinct bats, 164 extant bat species are known from Pleistocene and/or Holocene fossils as well as from living populations. When all valid bat taxa are considered together, 29% of families, 26% of genera, and 18% of known bat species are extinct.

Automated Acoustic Detection and Classification of Bats Using a Correlation Detector
Mark Skowronski, Gainesville, FL

Conventional acoustic detection of bats relies on energy-frequency thresholds that are computationally efficient and provide high sensitivity but low specificity (high false positive rate). Model-based detection increases specificity by using more information about bat calls. In an experiment of call detection in white background noise, model-based detectors outperformed a conventional detector by 2.5 dB SNR, which increased effective detection range by 5 m at 60 kHz. By comparison, human observers outperformed the model-based detectors by 4 dB, while an ideal linear detector (matched filter) outperformed human observers by 5 dB and model-based detection by 9 dB. While performance of a matched filter cannot be obtained in practice, near-optimal performance may be achieved by using a filter (or bank of filters) that nearly matches the bat calls of interest. A detector that uses a bank of prototypical bat calls for filtering is called a correlation detector, and several issues of a correlation detector are discussed, including the tradeoff between accuracy and computational cost, filter bank design, species-specific performance, call-specific performance (e.g., detection of only feeding buzzes), and the effects of call properties on performance.

Relationship between Personality and Ectoparasite Load in Little Brown Bats
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Consistent individual differences (CIDs) in activity, exploration tendency, and anxiety (i.e., animal personality) are linked to individual variation is a range of behavioral, physiological, and life history traits, including the tendency to disperse. Therefore, behavioral CIDs could influence the risk of encountering and spreading parasites or pathogens in the wild. To test this hypothesis we quantified behavioral CIDs and ectoparasite load in 40 juvenile and 20 adult male little brown bats from three sites in Manitoba and northwestern Ontario during mating swarms in August and September 2011. Behaviors of individual bats were quantified using a novel environment test, modified from the “hole-board” test widely used in studies of rodent behavior. Trials were scored for traits that we predicted could increase risk of parasite exposure (e.g., activity and exploration tendency), as well as traits that could mitigate ectoparasite load (e.g., time spent grooming). Ectoparasite load was quantified for each individual immediately after its behavioral trial. Parasites we observed included fleas (*Myodopsylla insignis)*, wing mites (*Spinturnix americanus)*, white mites (family Macronissid), and chiggers (family Trombiculidae). In light of the emergence of white-nose syndrome, it is especially important to understand how individual behavioral tendencies might influence the risk of pathogen or parasite transmission and exposure in the wild.

A Study of Bat Activity and Fecal Production at a Man-made Bat House in Central Texas
Lauren Snyder, Elizabeth Braun de Torrez, and Thomas Kunz, Boston University, Boston, MA

Providing habitat for insectivorous bats on agricultural lands by installing bat houses is one possible way that landowners could enhance natural pest suppression services. However, little is known about variation in nightly activity, flight behavior, and fecal production by bats in bat houses—information that is important for a comprehensive evaluation of this ecosystem service. During our study on an organic pecan orchard in San Saba, Texas, we quantitatively described three flight behaviors, and quantified the inter- and intra-nightly variation in bat activity around a man-made bat house. We hypothesized that warm temperatures would correspond to high bat activity, which in turn would result in high fecal production. We also expected an increase in the number of bats around the bat house to correspond to a higher frequency of the flight patterns if the bats were exhibiting group social behavior. Using a thermal imaging camera (model S60, FLIR technologies), we recorded flight behavior around the bat house for 15 seconds each hour from 2100 h to 0630 h weekly. Fecal pellets were collected in bins and counted during each time period. The 15-sec burst recordings were analyzed with ThermaCAM Researcher Pro 2.8 to count the number of bats present in each frame and to analyze flight patterns. We found a significant negative relationship between both temperature and bat activity ($r^2 = 0.2704$, $p < 0.01$), and bat activity and fecal production ($r^2 = 0.1725$, $p < 0.01$). We did not find a relationship between group size and flight patterns.

Activities Rates and Call Quality by Full-spectrum Detectors
Donald Solick, C. Nations, and J. Gruver, Western Ecosystems Technology, Inc., Cheyenne WY

Assessing potential risk to bats at proposed wind energy facilities relies primarily on estimates of overall bat activity collected by ultrasonic detectors. To date, the Anabat™ ultrasonic detector has been the industry standard for passive monitoring of bat activity, but full-spectrum (FS) detectors such as the Pettersson D500x, Wildlife Acoustics SM2, and Binary Acoustics AR125 are gaining popularity. Because Anabat and FS detectors use different types of microphones, utilize different sensitivity settings, and process the data differently, they may not produce comparable activity rate data, and thus could yield very different risk assessments. The goals of this study were to determine which settings on the D500x, SM2, and AR125 produce similar activity rates to the Anabat, and which settings produce the best call quality for species identification. We initially tested a wide range of settings by broadcasting a 30-sec sequence of known echolocation calls at side-by-side detectors. Detectors were also placed side-by-side in the field to record nightly bat activity May–August 2011. FS detector settings were varied, while Anabat sensitivity was held constant. Call quality was assessed using the SonoBat West 3.02 automatic species classification algorithm, and the FS settings that yielded the highest number of classified calls were identified for each detector. We will present data on which settings for each FS detector yielded activity rates similar to the Anabat, and which settings yielded the highest proportion of classified calls. The results of this study will help ensure consistency in measured levels of activity across studies.

Assessing the Effects of Historical Climate on Greater Antillean Long-tongued Bats (*Monophyllus redmani*)
J. Angel Soto-Centeno and David L. Reed, University of Florida, Gainesville, FL

Some studies suggest that climatic conditions during the last glacial maximum (LGM, ca. 21 ky) may have contributed to the current distribution pattern of lineages in continental bat populations. Due to their natural boundaries, island bat populations are especially susceptible to the effects of climate change and glacial cycles. For example, insular bat populations may increase or decrease gene flow as sea level changes and this directly affects island size, connectivity, and availability of habitat. Few molecular studies have assessed patterns of bat population differentiation and the possibility of gene flow on islands. We integrated population distribution models (PDM) with phylogenetic and coalescent analyses to understand the phylogeography of the Greater Antillean long-tongued bat (*Monophyllus redmani*). We used molecular data to assess the demographic history, genetic diversity, and population sizes of *M. redmani* on the Greater Antilles. PDM show large range over-prediction expanding populations from Puerto Rico into La Hispaniola and vice versa. Results from molecular data show correlation with PDM, with shared lineages suggesting admixture of populations between Puerto Rico, La Hispaniola, and Turks and Caicos islands. This study also reveals insight into the importance of ocean straits as barriers to gene flow on West Indian bat populations.

Bat Occupancy of Forest and Managed Savanna and Woodland in the Missouri Ozarks
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Many Missouri agencies are restoring native savannas and woodlands with prescribed fire and forest thinning. Little is known about how bat foraging varies among savanna, woodlands, and forest. We identified management compartments that are actively managed for savanna and woodland conditions and control areas that consist of sites with similar landform but no recent management and have succeeded to more closed canopy forest. We used Anabat II bat detectors with zero-crossing analysis interference modules with compact flash memory storage (CF ZCAIM) and SD1 (combined Anabat detectors and CF ZCAIM unit; Titley Electronics) to survey bats at several points during May to July of 2011 and 2012. The objectives were to evaluate a priori hypotheses concerning how bat foraging activity varies among savanna, woodland, and forest habitats in the Missouri Ozarks and their relative location within the landscape. We hypothesized that: the probability of detecting bat species with acoustic detectors will vary by species and is affected by temperature, relative humidity, tree density, Julian date, distance to water, time of night, and abundance; the probability a site is occupied by foraging bats varies among species as a function of forest type, tree density, distance to water, distance to flyways (trails or small forest roads), distance to urban areas, canopy closure, tree diameter, vegetative composition, interspersion, and road density; and vegetative structural conditions created by savanna woodland restoration and management result in greater occupancy by *Myotis septentrionalis*, *Lasiurus borealis*, *Nycticeius humeralis*, *Eptesicus fuscus,* and *Perimyotis subflavus* than in mature, un-managed forest.

***The Role of Hepcidin in Regulation of Iron Balance in Bats: A Pilot Study**
Iga Stasiak, Brandon Lillie, Dale Smith, Graham Crawshaw, Dorothee Bienzle, and Tomas Ganz, University of Guelph, Guelph, ON; Toronto Zoo, Scarborough, ON; UCLA David Geffen School of Medicine, Los Angeles, CA
*** Iga Stasiak** received the **Basically Bats–Wildlife Conservation Society Award**.

Hemochromatosis, or iron storage disease, has been associated with liver pathology and mortality in captive *Rousettus aegyptiacus*. Although evolutionary adaptation to low levels of iron in their diet has been implied, the physiologic basis for susceptibility has not been established. In humans, the regulatory hormone hepcidin influences iron absorption in the intestine, recycling by macrophages, and mobilization from hepatic stores. A deficiency or resistance to hepcidin has been implicated in human hereditary hemochromatosis and may play a role in *R. aegyptiacus.* A preliminary investigation was done into the role of hepcidin in iron metabolism in bats. The coding gene sequence of the hepcidin gene was determined for two megachiropterans *(R. aegyptiacus* and *Eidolon helvum*) and one microchiropteran (*Desmodus rotundus*). The latter two species do not commonly develop hemochromatosis in captivity. Baseline blood and liver iron parameters were compared to those obtained 14 and 30 days after IM administration of iron dextran (25 mg/kg or 100 mg/kg) in two representatives of each of *E. helvum* and *R. aegyptiacus.* Hematologic parameters assessed included plasma ferritin, transferrin saturation, plasma iron, and a complete blood cell count (CBC). Levels of hepcidin gene expression were evaluated and liver biopsy samples were obtained at each of the three time points from all three species. Liver morphology and iron content were assessed using histopathology and atomic absorption spectrophotometry, respectively. Iron injection resulted in increased plasma ferritin and hepatic iron content in all species. Comparisons of hepcidin gene expression in a larger subset of the captive population are underway.

Year of the Bat 2011–2012: Experiences and Successes of the First Year, Outlook to the Second Year of the Campaign
Andreas Streit, UNEPEUROBATS Secretariat, United Nations Campus, Bonn, Germany

Year of the Bat was launched in September 2010 jointly by the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and the Agreement on the Conservation of Populations of European Bats (EUROBATS), which are both part of the United Nations Environment Programme (UNEP). The key goal of the campaign was to raise awareness for the need of bat conservation, their irreplaceable role in all terrestrial ecosystems as well as the invaluable ecosystem services provided by bats, and to strengthen the international cooperation of NGOs as well as governments in their conservation and research efforts. The presentation will discuss what has been achieved in 2011 and what is planned for 2012.

Linking Morphology to Diet in the Phyllostomine Bats
Erin E. Stukenholtz, Rachel V. Gibson, and Heather A. York, Doane College, Crete, NE

The Neotropical leaf-nosed bats (family Phyllostomidae) are regarded as the most ecologically diverse mammalian family, due in large part to the wide range of dietary habits they exhibit. Subfamily Phyllostominae offers an excellent representation of this diversity, as it includes frugivorous, nectarivorous, insectivorous, and carnivorous species, many of which are omnivorous to a significant degree. Nonetheless, detailed information about dietary breadth is lacking for many species. Within the family, morphometrics of the skull are important indicators of diet, whereas the morphology of the ears and noseleaf are closely tied to foraging mode. However, several deviations between morphology and dietary behavior are known among the leaf-nosed bats. In this preliminary study, we explored the relationships among cranial, ear, and noseleaf morphometrics and known diet for several species of phyllostomines in an attempt to reveal patterns and exceptions that will inform continued work aiming to elucidate the foraging ecology of this subfamily of bats.

Responses of Singing Neotropical Katydids to Bat Echolocation Calls
Hannah M. ter Hofstede, P. A. Faure, R. A. Page, P. L. Jones, and E. K. V. Kalko, University of Cambridge, Cambridge, United Kingdom; McMaster University, Hamilton, ON; Smithsonian Tropical Research Institute, Barro Colorado Island, Panama; University of Texas, Austin, TX; University of Ulm, Ulm, Germany

Gleaning bats are significant predators of katydids in the Neotropics, and some appear to use the calling songs produced by katydids to locate them as prey. We tested the hypothesis that katydids will cease singing when they hear the echolocation calls of gleaning bats as a defensive reaction, but will not cease singing in response to harmless sounds. Katydids of various species were captured and tested in Panama. They were housed individually in cylindrical metal mesh cages and each katydid was exposed to four sound treatments broadcast in random order for 30 min each: *Trachops cirrhosus* search phase echolocation calls, conspecific calls, white noise, and silence. An ultrasonic microphone was placed close to the katydid and the number of calls produced during each 30-min treatment was counted. Two katydid species produced significantly fewer calls during the bat call treatment than the other treatments (Friedman test, $p < 0.05$), three species showed a trend in this direction but the test was not significant, and two species sang for equal amounts of time during each of the four treatments. For the species that sang less during the bat call treatment than the other treatments, there was evidence of habituation. These katydids mostly stopped singing for the first 15 min of bat calls, but started singing again during the second half of bat call playback. We discuss some potential ecological variables that could lead to some katydid species showing a reactionary defense while others do not.

A Fast-spreading Fungal Disease Is Likely to Extirpate an Endangered Bat over Large Parts of its Range
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We developed a stochastic, stage-based population model to describe the life history and forecast the population dynamics of the endangered Indiana bat (*Myotis sodalis*) subject to the fast-spreading disease white-nose syndrome. This population model explicitly incorporated annual variability in survival and reproductive rates and demographic stochasticity in predictions of extinction. Using a model of disease spread, we found > 90% of wintering populations were expected to face white-nose syndrome within 20 years, causing the proportion of quasi-extirpated populations to increase by 33.9% over 50 years. At the species' lowest median population level, ca. year 2022, we predicted 13.7% of the initial population to remain, totaling 28,958 females (95% CI = 13,330, 92,335); in 2022, only 12 wintering populations were expected to possess wintering populations exceeding a quasi-extinction level of 250 females. After 50 years (year 2057), 3.7% of wintering populations were expected to be above the quasi-extinction threshold after a 69% decline in abundance (from 210,741 to 64,768 [95% CI = 49,386, 85,360] females). At the nadir of projections, we predicted regional extirpation of wintering populations in two of four Recovery Units (management regions designated by the U.S. Fish and Wildlife Service) whilst in a third region, where the species is currently most abundant, > 95% of the wintering populations were predicted to be below the quasi-extinction level of 250 females. Our modeling suggests white-nose syndrome is a fast-spreading disease capable of bringing about severe numerical reduction in population size and local and regional extirpation of the Indiana bat.

Roosting Ecology of the Eastern Small-footed Bat in the Southern Appalachian Mountains
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Little is known about the ecology of the eastern small-footed bat (*Myotis leibii*), a rare species now threatened by white-nose syndrome. Our objective was to examine the roosting ecology of eastern small-footed bats, including locating natural roosts and measuring bats' movements. From 1 July to 2 September 2011, we attached 0.30–0.36 g transmitters (5.8–7.7% of body weight) to nine adult males and four adult females captured from expansion joints of two high elevation bridges in the southern Appalachians. On multiple visits from 23 May to 12 August 2011, we observed 8–20 bats using Bridge 1 and 1–12 bats using Bridge 2. Five males traveled ≤ 0.7 km from the capture site to the first natural roost site we found; however, two males traveled up to 8.8 km. Males traveled ≤ 1.1 km between consecutive roost sites and switched roosts every 1.3 ± 0.7 (range 0–5) days, while females traveled ≤ 0.3 km between roost sites and switched every 1.5 ± 1.5 (0–3) days. Eleven roosts for males were ≤ 92 m from a road, but one male roosted 1.2 km from a road. All roosts for females were ≤ 31 m from a road. Although movements among roosts were greater and switching rates were lower than values reported for this species in the central Appalachians, individuals and this population showed fidelity to specific rock outcrops. The locations and characteristics of these outcrops may be important for developing local and regional management plans for this species.

Morphological and Molecular Variation in Townsend's Big-eared Bat (*Corynorhinus townsendii*) in West Texas
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Several specimens of Townsend's big-eared bat (*Corynorhinus townsendii*) from Big Bend National Park (Brewster County, Texas) were found to display morphological characteristics of both the Mexican big-eared bat (*C. mexicanus*) and Townsend's big-eared bat (*C. townsendii*), two species that live in sympatry in northern Mexico. Thus, the first goal of this study was to use molecular sequence data from the cytochrome *b* gene to determine the specific and sub-specific identity of the specimens found in this region. Previous studies were limited and inconclusive regarding the expected identity of specimens from this region. One study based on molecular data suggested that *C. t. australis* occurred nearby, while an older study using morphological data documented a zone of morphological intergradation between *C. t. australis* and *C. t. pallescens*. Therefore, another goal of this study was to illuminate possible morphological variation within the molecular lineages recovered in west Texas specimens. Based on Bayesian and maximum likelihood analyses of cytochrome *b* data, there was support for the presence of a single subspecies, *C. t. australis*, throughout west Texas. Principal component analysis of morphological data does not recover distinct groups that would be expected if *C. t. australis* and *C. t. pallescens* occurred sympatrically in these areas. These results confirm morphological variation exists with the single *C. t. australis* lineage found from molecular data.

Bats in Education: Creating a Curriculum for Elementary Schools in the Northern Mariana Islands
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Throughout the Commonwealth of the Northern Mariana Islands (CNMI), the Mariana fruit bat (*Pteropus mariannus*) has been used as a food source since humans first arrived on the islands, and consumption of bats represents a significant Chamorro cultural tradition. However, because previously used cultural hunting methods have been replaced with the use of shotguns, which allows for a high take of fruit bats, serious declines in the population of fruit bats throughout the Mariana Archipelago have occurred in the last several decades. In January of 2005 the Mariana fruit bat was listed as threatened under the Endangered Species Act (ESA) and Endangered on the IUCN Red List. A primary objective of the drafted 2010 Mariana Fruit Bat Recovery Plan is to develop education and outreach programs. In previous years small-scale education programs have been implemented at various schools on Rota. Currently, the CNMI Division of Fish and Wildlife is working with local teachers to create a self-sustainable education program for the Sinapalo Elementary School in Rota. It is a literature-based curriculum that will meet government-set benchmarks using bats as primary examples in learning and will be directed at students in grades K through 6. The goal is to build knowledge systematically from year-to-year in order to create a stewardship between the students and fruit bats on Rota. In the future the education program will be adapted for the Rota High School and replicated for use in schools on Sapian and Tinian.

Amplification of Novel Nuclear Genes from Fecal Samples of Paleotropical Fruit Bats
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Working with endangered animals such as flying foxes (*Pteropus*) presents challenges in sampling due to their rarity and logistical difficulties related to capture. As a result, genetic work has lagged behind other genera. The development of reliable noninvasive sampling techniques is crucial to further understanding of current population trends in lieu of fresh tissue. In this study, I explored the efficacy of amplification of nuclear genes from DNA extracted from fecal matter. Fecal samples were collected from a mixed exhibit of *Pteropus vampyrus* and *Cynopterus brachyotis* from the Singapore Zoo. Fresh samples of muscle and wing punches for each respective species were available as positive controls. Novel nuclear markers were developed using the draft genome of *P. vampyrus* as a reference. Species identities for each sample were confirmed using mitochondrial loci. Mitochondrial and nuclear genes successfully amplified when using primers specifically designed for studying *Pteropus*. However, generic mammalian primers did not reliably amplify DNA extracted from fecal samples.

Effects of Inoculation with European and North American *Geomyces destructans* on North American Bats
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The origin of white-nose syndrome (WNS) and the fungal pathogen *Geomyces destructans* (GD) in North America is still unclear, and the cause of bat mortality from WNS is still not understood. We obtained 54 male little brown bats (*Myotis lucifugus*) from a WNS-negative hibernaculum in central Manitoba. Bats were divided into three equal groups, two of which were experimentally inoculated with either North American or European isolates of GD for comparison to a sham-inoculated Control. Each group was housed separately within environmental chambers at 7°C and 99% relative humidity for four months during hibernation. We recorded skin temperature of bats using temperature data-loggers and monitored behavior using motion-sensitive infrared security cameras. At the conclusion of the experiment we conducted necropsy, histopathology, and blood hematology analyses. Preliminary results suggest that both GD isolates alter patterns of torpor during hibernation and invade wing tissues. Our findings may shed light on the cause of mortality in WNS-affected bats and provide insight into the origin of the disease in North America.

***The Pre-White-nose Syndrome, Mycological Flora Associated with Cave-hibernating Bats in New Brunswick, Canada**
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*** Karen Vanderwolf** received the **Karl F. Koopman Award**.

White-nose syndrome (WNS), or geomycosis, is a rapidly spreading fungal disease that has caused unprecedented mortality of hibernating bats in eastern North America. The North American origin of the WNS fungus, *Geomyces destructans*, is unknown, but it may have been recently transported from Europe and accidentally introduced to North American caves by humans. Worldwide, very little is known about the mycobiota normally associated with cave-hibernating bats, and the natural mycobiota of caves, while better known, is likewise poorly understood. Cave mycological data collected prior to the arrival of WNS have the potential to advance our understanding of the environment that *G. destructans* may have first encountered in North America and also provide baseline data on the pre-WNS mycological environment. From both perspectives, such information may provide insight useful in the management of this devastating wildlife disease. Working in New Brunswick, Canada, during the winter of 2009-10, prior to when we believe WNS was present (WNS was first detected in 2011), 312 swabs were taken from 81 hibernating bats (*Myotis lucifugus* and *M. septentrionalis*) in 6 New Brunswick caves and 2 abandoned manganese mines. Samples were cultured at 7°C on dextrose-peptone-yeast and Sabouraud-dextrose agar. Microfungi were recovered from all bats. A preliminary total of 114 taxa comprising 80 genera were isolated from bat fur and skin. The most common taxa isolated were, in decreasing abundance, *Geomyces* sp., *Penicillium* sp., *Mortierella* sp., *Mucor* sp., *Cephalotrichum stemonitis*, *Polypaecilum botryoides*, *Cladosporium* sp., and *Trichosporon dulcitum*. The prevalence of *Geomyces* sp. on the external surface of bats will complicate diagnostics for *G. destructans*.

Combined Analyses of Extant and Fossil Phyllostomid Bats (Chiroptera, Phyllostomidae)
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The Neotropical family Phyllostomidae is the most ecologically diverse family within Mammalia, containing species variously specialized for insectivory, carnivory, omnivory, nectarivory, pollinivory, frugivory, and even sanguivory. It is the second largest chiropteran family with more than 55 genera and 160 species. Fossils of four taxa referred to Phyllostomidae are known from Mid-Miocene deposits in Colombia. Unfortunately, these fossils are fragmentary and consist only of some isolated teeth. Previous phylogenetic studies have sought to resolve phyllostomid relationships, but there is no consensus regarding the relationships among subfamilies. In this study we evaluated the phylogenetic relationships of these bats using molecular data from eight nuclear and two mitochondrial genes. To date, all analyses of the timing of phyllostomid diversification have relied on placing fossils based on a limited number of morphological characters. In order to assess the phylogenetic relationships of fossils we developed a data set of 270 dental characters to help place the fossils. Using the molecular tree as a scaffold, we assessed relationships of those fossils for which dental remains are known. We recovered a strongly supported phylogeny of phyllostomids, consistent with recent multilocus phylogenies. The four fossil taxa were recovered nested into two subfamilies (Lonchophyllinae and Phyllostominae). Our analyses provide the first robust phylogenetic context for studies of the tempo and mode of evolution in phyllostomids.

Geographic Variation in Echolocation Calls of *Myotis lucifugus*
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We examined the geographic variation in the echolocation calls of *Myotis lucifugus* at four sites throughout North America: Hotsprings Island, Queen Charlotte Islands, British Columbia (2003); Longpoint, Ontario (2008); Chautauqua, New York (2007); and Hudson River near Stillwater, New York (2008). All calls were recorded in the field on a four-microphone array set in an open habitat. We selected a total of 20 sequences, each consisting of five consecutive search calls from the recordings, and measured call duration, intercall interval, minimum frequency, maximum frequency, maximum energy, and frequency of maximum energy. We found significant site-to-site differences in all aspects of call structure except for minimum frequency, which remained relatively consistent between the sites. Calls recorded on Hotsprings Island had the shortest duration (3.5 ± 0.9 ms), and intercall interval (64.2 ± 21.8 ms) when compared to the other sites. A linear discriminant function analysis assigned 82.5% of the sequences to the correct site of collection; however, variation in call structure was not associated with geographical distance or local weather conditions. We hypothesize that calls may show site-to-site variability due to differences in prey availability or surrounding habitat structure.

The Trinity of Energy Conversion—Kinematics, Aerodynamics, and Energetics of the Lesser Long-nosed Bat *Leptonycteris yerbabuenae*
J. Rhea S. von Busse, Brown University, Providence, RI

I examined the interactions of kinematics, aerodynamics, and energy consumption in *Leptonycteris yerbabuenae*, flying in a wind tunnel over a range of flight speeds from hovering to 7 m/s. The kinematics was recorded using two high-speed cameras. The wake structure was captured using stereo digital particle image velocimetry (SDPIV) and open flow respirometry was used to measure the energetics over the range of flight speeds. The angle of attack of the armwing shows positive values above 1 m/s throughout the stroke, indicating continuous force production for this part of the wing. The different slackness of the membrane of the inner and outer wing during the upstroke induces a different airflow over the wing, which may cause a pressure difference along the wingspan that is responsible for the shedding of a reversed vortex loop. Both the minimum angle of attack and the minimum angle of the leading edge flap coincide with the maximal strength of the reversed vortex loop. The comparison between the force coefficient of the tip-vortex and the angle of attack showed a time lag, indicating a delayed vortex shedding relative to the wing motion and the presence of unsteady effects. The metabolic power input did not differ significantly between flight speeds. The u-shaped mechanical power output and the flat metabolic power input indicate a changing mechanical efficiency over speed, with the highest mechanical efficiency at low and high speeds. This study was a first approach to examine interactions of different aspects of flight over a large speed range, which is important to understand animal flight in all its facets.

Genetic Structure and Demographic History of the Eastern Red Bat (*Lasiurus borealis*)
Maarten J. Vonhof and Amy L. Russell, Western Michigan University, Kalamazoo, MI; Grand Valley State University, Allendale, MI

Documented fatalities of bats at wind turbines have raised serious concerns about the future impacts of increased wind power development on populations of migratory bat species. To understand whether mortalities at wind power developments pose a serious risk to bat populations we need to have a greater understanding of current population size and trends of affected species, whether populations of these species are differentiated geographically, and whether different populations may utilize non-overlapping migratory pathways. We utilized multiple genetic markers (microsatellites, mitochondrial DNA, nuclear intron) to examine population structure and differentiation in the eastern red bat (*Lasiurus borealis*), one of the most strongly affected migratory bat species by turbine-related mortality in the eastern United States. We also used genetic data to estimate effective population size of this species to provide a baseline estimate that can be used for future genetic population monitoring, and to estimate historical population trends. Our data have important implications for the long-term management of populations of migratory bat species, and provide context for understanding the potential impact of increasing wind power development on the persistence of affected species.

Heritability and Reproductive Skew in Wild Bats
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Bats are long-lived, show extended maternal care, and often live in complex societies. Yet virtually nothing is known about the extent to which traits in bats are determined by genetic inheritance versus non-genetic determinants (environmental factors and/or maternal effects). To assess the heritability of morphological, life-history, and behavioral traits in wild greater horseshoe bats (*Rhinolophus ferrumequinum*) we used microsatellites to infer the parentage of 924 pups born at a United Kingdom colony since 1993. We built highly resolved pedigrees spanning 10 generations, and applied a mixed-effects 'animal model' to estimate the genetic variance components of a range of traits. Our preliminary analyses suggest that forearm and digit length are both highly heritable and also strongly correlated with each other, indicating that they are controlled by the same gene(s). Inspection of breeding patterns based on the parentage results reveal that a small minority of males contribute massively to the gene pool; in fact just 4% males ($n = 6$) fathered 25% ($n > 170$) of all colony pups ($n > 700$) born during a 19-year period. We discuss these and our related findings, and their implications for future work.

The Discovery of a Breeding Population of the Eastern Small-footed Myotis (*Myotis leibii*) in Illinois
Michael Whitby, Timothy Carter, Rod McClanahan, Scott Bergeson, and Stephanie Rutan, Ball State University, Muncie, IN; Shawnee National Forest-Hidden Springs, Vienna, IL

The only record of eastern small-footed bats (*Myotis leibii*) in Illinois was from a 2005 discovery of two individuals under a rock at the Fink Sandstone barrens of Shawnee National Forest. The Illinois Department of Natural Resources lists *M. leibii* as a species of possible occurrence but it is not considered a resident species. In 2011, the Fish and Wildlife Service found "substantial information indicating that listing a species may be warranted" and requested information on the species in order to complete the review. In response to this request the Shawnee National Forest initiated a survey of likely areas of *M. leibii* occurrence. A survey of likely roosting habitat for the rock-dwelling species was conducted in July and August 2011. Twenty-six individuals, including post-lactating females and juveniles, were discovered by surveying rock outcroppings around the original site of discovery. Although the extent of *M. leibii* occurrence in Illinois is still poorly understood, this survey indicates that a resident breeding population occurs within the southern tip of the state.

Does Diversifying Selection in Big Brown Bats (*Eptesicus fuscus*) Maintain Phylogeographic Structure at *β*-globin Loci?
Aryn P. Wilder, Thomas H. Kunz, and Michael D. Sorenson, Boston University, Boston, MA

A recently published phylogeographic study of big brown bats (*Eptesicus fuscus*) in North America found highly divergent and geographically restricted mtDNA lineages but little geographic structure at two nuclear loci, suggesting that male-mediated gene flow homogenizes the nuclear genome across the species' continental range

(Turmelle et al. 2011, *Mol. Ecol.*). In contrast, Neubaum et al. (2007, *J. Mammal.*) reported that *E. fuscus* from New York and Arizona are fixed for divergent alleles at a nuclear *β*-globin intron. We tested the hypothesis that contrasting patterns for nuclear genes in these two studies were attributable to diversifying selection at *β*-globin loci, which code for components of embryonic, fetal, and adult hemoglobin. We designed primers to independently amplify each of the four *β*-globin loci in big brown bats, and sequenced 517 bp of the two 3' loci (corresponding to the genes expressed in adult mammals) from a representative sample of this species. Our sequences include part of the 5' UTR, exon 1, intron 1, and most of exon 2. Nucleotide diversity was high at both loci and included at least nine non-synonymous substitutions. At both loci, we found strong geographic clustering of haplotypes; at one locus, a haplotype clade restricted to western North America and the Caribbean differed by three non-synonymous substitutions from the common haplotype in eastern populations. Contrasting phylogeographic structure for *β*-globin and other neutral nuclear loci suggest that *β*-globin loci may be under selection strong enough to produce adaptive divergence of populations despite ongoing gene flow.

Availability of Potential Bat Roosts across a Gradient of Agricultural Intensification in Coffee Agroecosystems in Chiapas, Mexico

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Agricultural intensification affects the resources available to bats, including the availability of tree hollows that can serve as roosts. To investigate the abundance and occupancy of tree hollows, I surveyed 1,456 trees in natural forest, diverse high-shade coffee, commercial coffee polyculture, and low-shade coffee monoculture in Chiapas, Mexico for the presence of cavities. The density of trees with cavities ranged from 28.4/ha in high shade coffee to only 2.4/ha in low shade coffee. Tree size was the most important predictor of presence of a tree cavity: the odds of a tree having a hole increased by a factor of 21.644 when trees were large (> 125 DBH) versus small (<50 DBH). To explore occupancy of tree hollows, I netted in front of basal hollows identified during the survey. Of 25 trees surveyed, bats occupied only 3. A roost in the forest fragment housed a small number of *Carollia sowelli*, *Glossophaga commissarisi*, and *Hylonycteris underwoodi*; a group of *Sturnira lilium* was found roosting in an *Alchornia latifolia* in the high-shade coffee; and a small group of *Rhogeessa tumida* roosted in an *Albizia* sp. Although the presence of (apparently) suitable but unoccupied hollows suggests roosts are not currently a limiting factor for bats in this landscape, tree cavity availability clearly declines significantly with intensification in shade coffee. Bat populations could be limited in landscapes dominated by intensified shade coffee production; this study suggests that traditional shade coffee cultivation maintains this critical resource for bats and other wildlife.

The Dehydration Hypothesis—Exploring Evidence from Bats Infected with *Geomyces destructans*

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The cause of mortality from white-nose syndrome (WNS) is still not understood. The influence of evaporative water loss (EWL) on torpor patterns during hibernation, combined with the nature of cutaneous invasion by *Geomyces destructans* (GD), recently led to the hypothesis that GD-infection of wing membranes causes dehydration, which in turn increases arousal frequency during hibernation. This predicts that uninfected individuals of species most susceptible to WNS, like *Myotis lucifugus*, exhibit high rates of EWL compared to less susceptible species. It also predicts that bats infected with GD will spend more time drinking, and exhibit physiological evidence of dehydration (e.g., altered plasma electrolyte profiles), compared to controls. We tested these predictions using data from the literature, new data quantifying EWL in *Myotis nattereri*, a European species sympatric with GD but not affected by WNS, and behavioral and physiological measurements of experimentally inoculated *M. lucifugus*. We found significantly higher rates of normothermic EWL for *M. lucifugus* compared to other bats in general, and *M. nattereri* specifically. Based on a population model, the increase in EWL required to cause the pattern of WNS-mortality observed in the wild was readily plausible, equivalent to a reduction in relative humidity of only 5 to 13% (i.e., reduction from typical near saturation conditions to 87–95%). We also found preliminary evidence of altered plasma electrolyte and hematocrit levels, consistent with dehydration, for bats inoculated with GD. These results suggest that the dehydration hypothesis is worth pursuing as an explanation for mortality from WNS.

Bats in the Undergraduate Curriculum
John Winkelmann, Gettysburg College, Gettysburg, PA

Advertise your scientific identity! At undergraduate institutions like Gettysburg College, opportunities to educate the academic community abound. In addition to department seminars, many colleges have programs like our Friday Faculty Luncheons where free food and intellectual curiosity (in equal measure?) guarantee a large audience. An occasional plea for bat removal is small price to pay for being known as the BMOC. (And your colleagues' recognition can't hurt in the competition for funds and promotion.) No one teaches a course on bat biology at an undergraduate college, but most of us teach courses in which bats can provide relevant examples. In Vertebrate Zoology and Animal Behavior I include sections on energetics and foraging behavior (vampires and nectar bats), reproductive strategies (leks and harems), and mutualism (bats, figs, and fig wasps), for example. In addition, a classroom introduction to echolocation followed by an hour or two in the field recording and displaying bat calls always mobilizes student interest. Talking about our research in class can lead to direct student involvement. Gettysburg College has a well-advertised, campus-wide Individualized Study Program that is backed by in-house funding. This has allowed two students to participate in my bat fieldwork each summer. They receive course credit after analyzing their data, writing a scientific paper, and presenting an oral paper in a student colloquy.

Foraging Resource Selection by Female Indiana Bats during the Maternity Season
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There is little information regarding foraging resource selection for Indiana bats (*Myotis sodalis*) during the maternity season. Existing studies are based on modest sample sizes likely due to the rarity of this endangered species and the difficulty of radio-tracking bats. Our objectives were to determine resource selection by foraging Indiana bats during the maternity season and to compare resource use among pregnant and lactating individuals. We used an information theoretic approach to evaluate support for discrete choice models representing hypotheses that land cover, percent canopy cover, distance to water, and prescribed fire affected the probability a point was used by foraging Indiana bats. We radio-tracked 29 females and obtained 32–208 locations per bat and paired each location with 3 random points. We found evidence of resource selection by all 29 individuals and conducted a population model to determine the effects of season and reproductive condition. Individuals varied in what resources were more important; however, if a resource received support in models the magnitude and the direction were similar for all individuals. In our population models we found no support for differences between reproductive conditions (lactating and pregnancy) or seasonality. Forests in these agricultural landscapes are important habitat for breeding Indiana bats. Managers should consider use of prescribed fire to reduce clutter in the understory while leaving the canopy intact to improve habitat for Indiana bats; however, management practices that greatly reduce canopy cover in forest may reduce habitat quality for Indiana bats.

A Preliminary Study on the Effects of Thermal Gradients on Hibernating Tri-colored Bats (*Perimyotis subflavus*)
Risa Wright and Tom Tomasi, Missouri State University, Springfield, MO

We tested whether tri-colored bats (*Perimyotis subflavus*) use artificial thermal gradients in order to reduce energetic costs during hibernation. One mitigation tactic proposed to counteract the effects of white-nose syndrome involves heating portions of caves so that bats can conserve energy by moving into these warmer areas during arousals; however, only anecdotal observations suggest that hibernating bats naturally use thermal gradients within caves. We hypothesized that bats housed individually in hibernation chambers with an artificial temperature gradient will enter torpor in the coldest temperatures available and will move into warmer areas while aroused. We compared time spent aroused, movement during arousals, and mass lost during hibernation of healthy bats between an experimental group (n = 2) in a thermal gradient (7.7 ± 0.3ºC – 26.6 ± 0.5ºC), and a control group (n = 2) in a uniform temperature (7.6 ± 0.3ºC). Bats in the experimental group lost more mass during the study period and had a greater duration and frequency of arousals than bats in the control group; however, we were unable to test for statistical significance because of the small sample size. Furthermore, the experimental bats with a complete temperature profile preferred temperatures in the middle of the chamber (13.7 ± 1.72°C) and avoided the coldest area of the chamber when aroused and torpid. These preliminary results provide insight into a larger scale study we will conduct this winter on the effects of thermal gradients on hibernating bats.

Sri Lanka's Bat Fauna: Depauperate or Data Deficient?

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Sri Lanka, a 60,000-km^2 island, is inhabited by 30 species of bats compared to 119 for South Asia. All known species were accounted for by British naturalists in the first half of the 20^{th} Century or earlier. Curiously, the 'distributions' of these bats almost exactly match the locations of the plantations where those gentleman-naturalists worked, leading one to conclude that the limiting factor is observational, not real. There has never been a comprehensive and systematic survey of the bat fauna of Sri Lanka. The reasons are complex and relate to the elitism that surrounded nature study on the island, with knowledge of English being a prerequisite to even read the only book available on mammals, which was published in 1935 and was long out of print until revised and released in 1980. A civil war then overran the island making vast swathes of land in the north and east unsafe for researchers. Peace was restored in 2009, and now about the only deterrent to access anywhere are the minefields, which are being quickly cleared. Intriguingly, the distribution of many bat species in India stop 20 km from Sri Lanka, which is the width of the marine straits that separate the two countries. However, there is habitat in Sri Lanka perfectly suitable for these bats, so the suspicion is that they are there but have not been found. Additionally, the life histories of bats on the island are barely known and urgently need to be studied.

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ANNOUNCEMENTS

2012 Renewal Notices — *Bat Research News*

It is once again time for subscription renewals! You should be receiving a renewal notice for the 2012 volume-year very soon, if you have not already. In order to keep subscription rates as low as possible, renewal notices will be sent via e-mail whenever possible (or at least the first and second "friendly reminders" will be!). It would be most helpful if you would kindly set your e-mail filters to allow messages through from the Editor, Margaret Griffiths (margaret.griffiths01@gmail.com). If an e-mail address is not available for you, notices will be sent via the post. If you do not receive a renewal notice soon (and think you should have received one), please let the Editor know. Thank you for subscribing to *BRN* this past year, and I hope you will consider renewing again for 2012. All of us at *Bat Research News* wish you a happy, safe, and productive 2012!

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 (mgriff@illinoisalumni.org). 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 (mgriff@illinoisalumni.org), 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 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 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/.