2011

Bats of Kansas

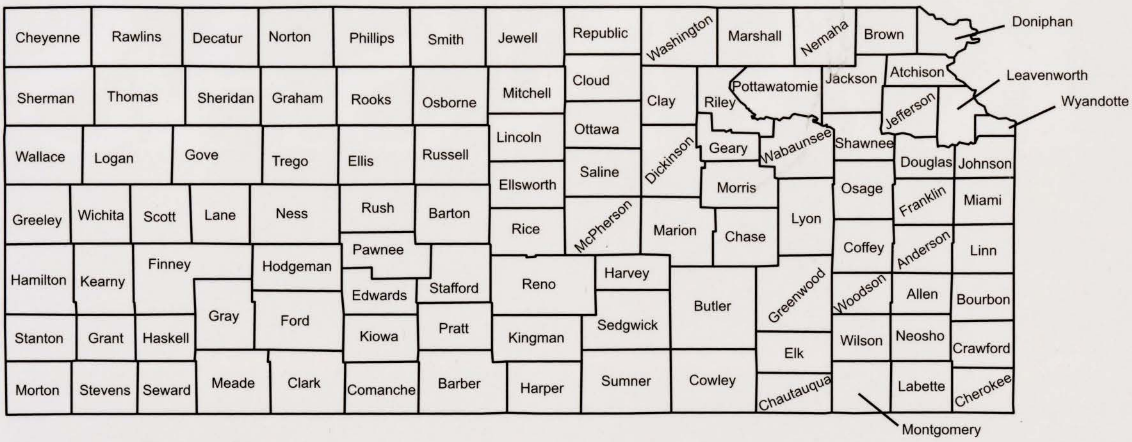
Dale W. Sparks

Curtis J. Schmidt

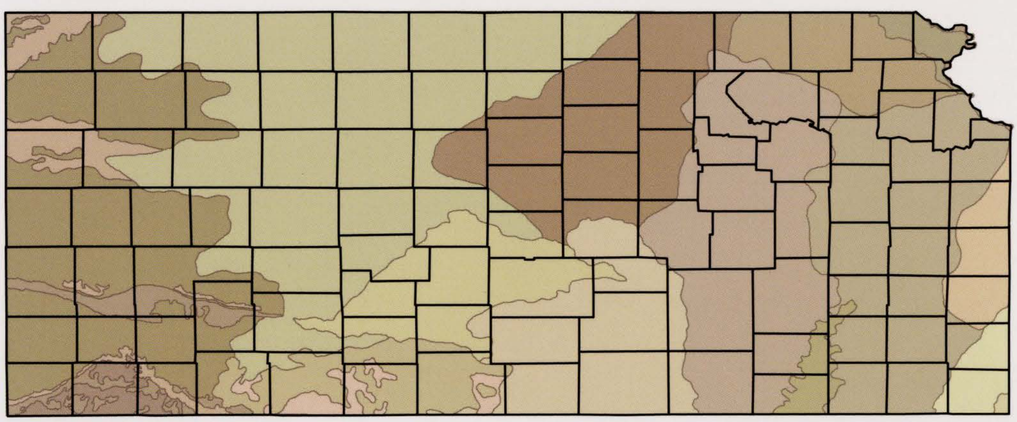
Jerry R. Choate

BATS OF KANSAS

Dale W. Sparks
Curtis J. Schmidt
Jerry R. Choate

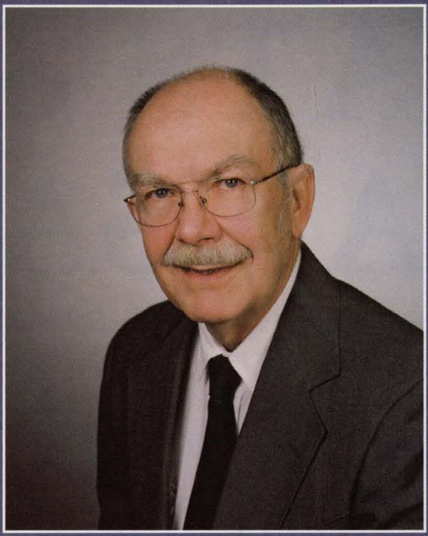


Kansas Counties



Geographic ecoregions of Kansas

- Canadian/Cimarron Breaks
- Canadian/Cimarron High Plains
- Cherokee Plains
- Flat Tablelands and Valleys
- Flat to Rolling Plains
- Flint Hills
- Great Bend Sand Prairie
- Loess and Glacial Drift Hills
- Missouri Alluvial Plain
- Moderate Relief Plains
- Nebraska/Kansas Loess Hills
- Northern Cross Timbers
- Osage Cuestas
- Prairie Tableland
- Rolling Plains and Breaks
- Rolling Sand Plains
- Smoky Hills
- Springfield Plateau
- Wooded Osage Plains



Dedication

Kansas is unique in the number of prominent mammalogists who have worked in the state, often while completing their graduate educations. Many of these biologists were the mentors, classmates, and later students of Dr. Jerry R. Choate who met an untimely death while working on this volume. Jerry was mentor to both of us as we progressed from students to professional biologists, as we absorbed his knowledge and passion for the outdoors and the study of furry critters. For this we are indebted to him. We dedicate this book to Jerry and all others who spend the best days of their lives tending bat nets and climbing into old buildings, mines, and caves.

—DWS and CJS

Printed in the United States of America.

Library of Congress Cataloging-in-Publication Data
ISBN: 978-0-9817096-4-2

BATS OF KANSAS

by

Dale W. Sparks
Environmental Solutions and Innovations
4525 Este Avenue
Cincinnati, OH 45232

Curtis J. Schmidt
Jerry R. Choate (1943-2009)
Sternberg Museum of Natural History
Fort Hays State University
Hays, KS 67601

INDIANA STATE UNIVERSITY
Center for North American
Bat Research and Conservation

Publication Number 5
Indiana State University Center for North American Bat Research and Conservation

TABLE OF CONTENTS

FOREWORD

The Indiana State University Center for North American Bat Research and Conservation was established in September 2005 by the Indiana State University Board of Trustees. Our mission is to conduct and encourage basic and applied research on North American bats by collaborating with students and other scientists, and to make our findings available to the scientific community and the general public through technical and popular publications, teaching, and outreach programs. In keeping with that mission, the Center published *Bats of Indiana* in 2007, *Bats of Michigan* in 2008, *Bats of Missouri* in 2009, and *Bats of Ohio* in 2010.

I am very pleased to present the fifth booklet in that series. It is by Dale W. Sparks, Curtis J. Schmidt, and Jerry R. Choate (1943-2009). Dale completed his Ph.D. at Indiana State University in 2003 and currently has a position at Environmental Solutions and Innovations, Incorporated. Curtis J. Schmidt received his Master of Science degree from Fort Hays State University in 2004 and currently serves as Adjunct Curator of Herpetology and Mammalogy at Fort Hays State University's Sternberg Museum of Natural History, Hays, Kansas. Both Dale and Curtis studied alongside Jerry, a good friend of ours and for many years director of the Sternberg Museum.

Bat enthusiasts, as well as other naturalists, teachers, and wildlife biologists, should welcome *Bats of Kansas* as there is no better resource for the general public on the ecology of Kansas bats. It provides a great deal of information about our only truly flying mammals. Bats are beneficial to humans in many ways (seed dispersal and pollination in the tropics, for example), but bats of our area primarily because of their food habits. All of the bats of Kansas are 100% insectivorous, except that a few spiders are gleaned by some species. Being the only nocturnal flying predators on night-flying insects except for nighthawks and nightjars, they are necessary to retain the balance of nature with regard to these insects. Our bats destroy huge numbers of farm pest insects. This service should allow farmers to reduce our dependence on pesticides and improve crop yields on many of our farm fields. Hopefully this booklet will help educate the public about Kansas bats.

In addition, declines in bat populations, along with frogs and many species of birds, should serve as an indication of major environmental degradation and that we have much to do to reverse these trends and retain this planet in good condition for our heirs. Our human population is now over 6 billion, and still rising. We are developing, polluting, and otherwise damaging our environment at an ever increasing rate. Most of us do not realize, or choose to ignore, that it is human population increase that is driving these worldly problems.

John O. Whitaker, Jr.
Director, Indiana State University Bat Center

ACKNOWLEDGMENTS

First, we are indebted to the dozens of biologists who previously conducted studies on the biology of bats in Kansas. These efforts started when physicians attached to the various army posts scattered throughout the state recorded observations about wildlife including bats. Formal study began in 1886 when Dr. C. Hart Merriam, director of the Bureau of the Biological Society at the Smithsonian Institution, described the first individual of the Western small-footed myotis which had been collected from Banner in Trego County. Starting in the 1930s swarms of graduate students mentored by the likes of E. R. Hall and J. K. Jones, Jr., at the University of Kansas (KU) spread out across the state and focused their attention on determining the distribution and taxonomy of all mammals in the state including bats. Starting in the 1960s, students from what is now Fort Hays State University (FHSU) under the direction of E. D. Fleharty and later J. R. Choate began working extensively on bats, especially in the western part of the state where little was previously known. Finally, one of those students (L. W. Robbins) produced by FHSU is now a faculty member at Missouri State University and frequently works along the Kansas/Missouri border.

The Gypsum or Red Hills located in south central Kansas and adjacent Oklahoma is one of the most important areas in the country for chiropteran biodiversity, and it is no surprise that this area has hosted numerous important studies by some of the most influential biologists of their era. In the 1930s, C. W. Hibbard provided the first detailed studies of the bats native to the caves of this region, and named the species *Antrozous bunkerii* (now *A. pallidus*) from that region. He went on to found the science of micropaleontology which has contributed much to our understanding of the ancient world. By the 1950s J. W. Twente was conducting the first detailed studies of the hibernation physiology of bats by studying temperature preferences of bats hibernating in some of these same caves. In the late 1960s and early 1970s, T. H. Kunz conducted a series of studies into the ecology of bats within this region and later branched out to conduct studies around the state and the world. Today, he is among the most respected chiropтologists (bat biologists) in the world. Today, students of W. E. Jensen at Emporia State University are conducting investigations into the conservation of bats in this region. No discussion of bats in the Red Hills or all of Kansas would be complete without mentioning the enormous and magnanimous effort of S. D. Roth of the Kansas Biological Survey, who has mentored virtually every person interested in Kansas bats for nearly five decades.

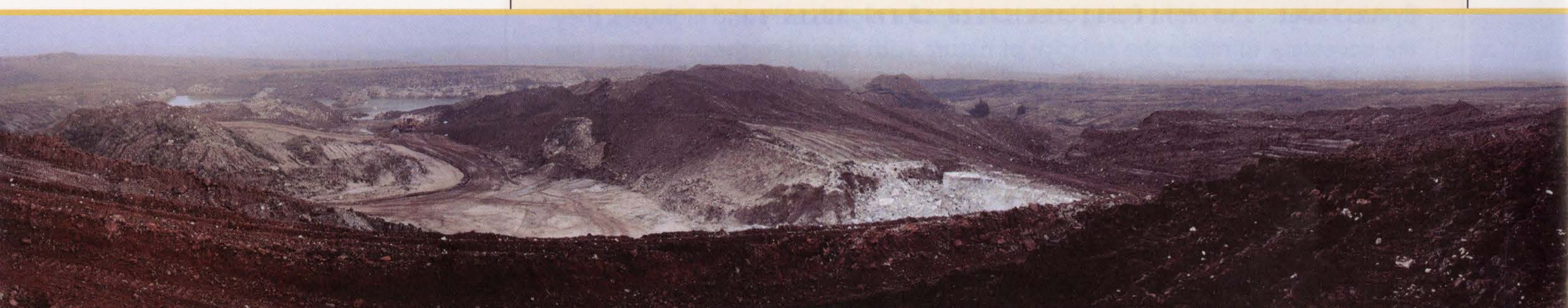
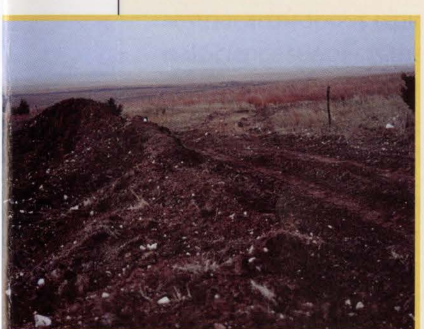


Figure 1. Panoramic View of a Gypsum Mine in the Red Hills of south-central Kansas. This part of Kansas has long been a center of bat research because bats roost in caves and mines in the gypsum and forage in the surrounding prairies. *Photo by Alexis Powell*

Second, we would like to thank all those individuals involved with the Kansas Mammal Atlas Project, a State Wildlife Grant supported project funded by the U.S. Fish and Wildlife Service through the Kansas Department of Wildlife and Parks. This project, granted to J. R. Choate and the Sternberg Museum of Natural History, was responsible for accumulating, verifying, and adding numerous bat records throughout the state. These records have added much to our knowledge of the bats described in this book.

We would also like to thank those who have assisted us in preparing the current manuscript. Ken Brunson with Kansas Wildlife and Parks has graciously persisted through nearly 20 years of seeing variations of this manuscript in draft form and has provided funding to support both field work and publication. Similarly, the Sternberg Museum of Natural History served as our academic home during much of the work and has graciously provided partial funding for the manuscript. We thank E. M. Counihan for reviewing the text from a lay-person's view, as well as three fellow biologists (E. D. Fleharty, K. Geluso, and E. W. Valdez) who aided us in maintaining our accuracy. Environmental Solutions and Innovations provided time and support for the senior author to work on the manuscript. J. O. Whitaker, Jr., L. Castor, L. Bakken, and B. L. Walters of the Center for North American Bat Research and Conservation provided a platform, editorial support, and opportunity to publish the manuscript. Jo Garofalo of Environmental Solutions and Innovations provided editorial assistance. Kelli Cheever designed the publication.

Finally, the senior author would like to thank those who helped him collect the information that was used to develop an earlier and more technical version of this work (Sparks and Choate 2000). Unfortunately, the only people who normally read the acknowledgments section of any paper are those who should be mentioned in it, or folks who are wondering "who funded this." Thus, the general public is often unaware of the vast amount of cooperation that scientists extend each other. For an eye-opening experience one should examine the acknowledgments section of the technical report that preceded the current publication. If you sat down and counted all of those names you would find a total of 81 scientists (including wildlife managers and biology teachers). The average time donated would be over 2 hours if computed. Thus you can see the assistance provided us by other professionals is well over 150 hours. Thanks to all of them.



Additionally this type of work requires that many different people allow us access to their homes, farms, ranches, and businesses. The following persons and agencies provided access to property that they either owned or managed: Trish Briney; Korrie Chapman; Wilmer Dinkle; Toni Eder; Robert Fox; Sherry Gager; Connie L. Griffith; Matt Hall; Becky Hartzell; Kansas Department of Wildlife and Parks; Fred Karlin; Gary Littrell; Sam Maupin; James L. Mc Adam; Helen Metzker; Royce Muir; Robert Quanz; Bud O'Grady; Dave Perry; Sally Peter; Bill Reynolds; Bud Richards; Ben Riddle; Lloyd Schaffer; Allen Schwetzer; Jim Struckoff; Bruce Taggart; H. Tien; United States Fish and Wildlife Service, Flint Hills National Wildlife Refuge; United States Forest Service, Cimarron National Grasslands; A. Voth; L. Voth; Annita Warrington; and dozens more who chose to remain anonymous.

Last, but certainly not least, we'd like to extend heart-felt thanks to our wives, Jodi, Amanda, and Fi and our children Bailey, Jonathan, Avery, and Judd, who have offered continuous support and endured our countless hours away from home.

INTRODUCTION

Invariably, our most feared neighbors on planet earth are the animals that we know the least about. Almost as frequently, when people are exposed to these animals, the fear turns quickly to fascination. Unfortunately, many of these animals are accessible only to the professional scientist. Though science has made great strides in understanding the basic biology and behaviors of many of our least-known animals, this information is generally kept locked away from the general public by the dry, technical language of science. In this publication, it is our hope to open your eyes to the world of perhaps the last great, misunderstood group of animals—the bats. Further, it is our hope, by dispensing (as much as possible) with technical language, to bring across the intense fascination that we share for these animals and to infect you with that same fascination.

In order to accomplish our task we have prepared the book in five sections. Because our main goal is to open your eyes to the fascinating world of bats, we have designed the first section to answer the most often asked questions about bats. The second provides a key to the bats of Kansas so that you can identify any bat you discover. In the third section we introduce you to the sixteen species that are known to occur in Kansas. As is the case for human neighbors, there may be bats in Kansas that we haven't "met" yet. The fourth section describes these "species of possible occurrence" and tells you where to look for them. Unfortunately, we have only a limited amount of space, so the fifth section tells you how to find additional information.

QUESTIONS AND ANSWERS ABOUT BATS

Where do bats fit into the tree of life?

Inside the cover of many a biology textbook is an illustration that attempts to show the relationship between different organisms (living things). Historically, much of the academic work conducted by the museums at KU and FHSU has been in this field (called systematics) and has been aimed at understanding those patterns of relationship. Systematists can often be broken into three groups: paleontologists (who study the remains of past life), phylogeneticists (who study the branching pattern of the tree), and taxonomists (who assign names to the various branches). In a perfect world, taxonomists develop a naming system that is used by all biologists, that perfectly reflects the branching pattern caused by evolutionary history, works well with fossils, and is stable across time. Unfortunately, such a perfect taxonomy requires perfect information, which we do not have. As we discuss the way that bats fit into the tree of life, always remember that scientific names (at any level) are meant to be a tool for communication, and part of the message we are communicating is a snapshot of our current state of knowledge about these creatures.

Now that we know a little more about taxonomy, let's talk about the bats of Kansas and where they fit into the tree of life. The basic premise of this book is that you know very little about bats, but would like to know more. As such, we will illustrate the levels of taxonomy using an animal that is much more familiar to the average Kansan—the dog.

Species: The word "species" has proven to be a difficult word in science to define, especially since the advent of modern molecular (mainly DNA) techniques. There are multiple species "concepts" with their own ideas of what exactly constitutes a species and how they are recognized. This book is no place to get into this conundrum, so we will attempt to keep it simple. When we talk about "scientific names" most people immediately think of the two-part or binomial name by which scientists refer to a particular species. For example, most people are aware that modern humans also go by the name *Homo sapiens*. We see and recognize other species around us all the time. No matter whether we are looking at a German short-haired pointer or a Chihuahua, we realize that both are dogs (*Canis familiaris*). Part of the reason we can readily recognize this relationship is the abundant evidence (provided by hundreds of mongrels) that these and all other breeds of dogs recognize each other as mates, successfully mate, and produce fertile offspring. Thus, all dogs belong to one biological species. Under ideal conditions different species do not mate with other, similar species, or when they do the offspring are not generally fertile. While coyotes, dogs, and wolves have clearly different morphologies and ecologies they share such a recent ancestor that some level of hybridization is almost always present. These animals may be treated as one complex species or three separate species that occasionally hybridize.

In the following sections, we will discuss the 16 species of bats that we know have been found in Kansas since settlement.

Genus: In the example above, we noted that dogs are known by the scientific name *Canis familiaris* while coyotes are known as *Canis latrans*. Both are members of the genus *Canis*, as are wolves and jackals. Thus, a genus is simply a group of similar species with several characteristics in common, and which share a common ancestor (i.e., are monophyletic). Kansas is home to 10 genera (plural form of genus) of bats. The genus with the most species in the state is *Myotis*, six of which have been captured in Kansas.

Family: Every step up the taxonomic ladder should be similar to a step back in time. Thus, a family is simply a group of genera that share certain characteristics because of shared evolution. In our dog example, the family Canidae includes not only the members of the genus *Canis* listed above, but also all the foxes and several lesser-known species. Kansas is home to two families of bats. Fourteen of our species belong to the family Vespertilionidae while two species belong to the free-tailed bat family (Molossidae) which lives mainly in the tropics

Order: An order is yet a broader grouping consisting of families that, again, are similar because of shared characters and evolution. In our dog example, the family Canidae is part of the order Carnivora which also includes the cats (Felidae), skunks (Mephitidae), weasels (Mustelidae), raccoons (Procyonidae), and bears (Ursidae). All bats in the world belong to the order Chiroptera which literally translated means hand-wing in Greek.

Class: All orders of mammals are lumped together in class Mammalia. This includes not only the dogs we have been using as an example but also bats, whales, horses, deer, mice, moles, gophers, elephants, opossum, kangaroos, and people. All mammals share a variety of traits including the presence of hair, highly specialized teeth, four-chambered hearts, and the presence of three ear ossicles, and they feed the young milk. With the exception of three egg-laying species from Australia (two echidnas and the duck-billed platypus), all modern mammals give birth to live young.

Phylum: A phylum is a group of classes that are bound together by deep evolutionary history. The phylum Chordata not only includes bats and other mammals, but also reptiles, amphibians, birds, bony fish, and sharks among others. Almost all modern chordates are also vertebrates which can be easily recognized by having a spinal column protected by bones or cartilage (i.e., a backbone).

Kingdom: Bats are united with other animals (multicellular organisms that move and have to feed) in a kingdom, which historically was called Animalia but is now known as Metazoa. Kingdoms are groups of phyla that contain the most distant relatives that can be recognized as a distinct group. Other kingdoms include the plants (Plantae), fungi, Archeobacteria (strange unicellular creatures that are best known for living in the hot springs at Yellowstone), Monera (blue-green algae and bacteria), and Protista (mostly unicellular organisms including algae and protozoa like *Paramecium*).

From the information above, you can see that bats are their own unique group of mammals despite some common misconceptions. Bats are not birds. The wings of birds (and other flying vertebrates) include the same bones that make up your arm, hand, and fingers. Most of the wing area itself is made up of feathers. Hands and fingers of birds are reduced to that small end section that is all breading and bone on a fried chicken wing. The wings of bats are much different. Bat wings consist of a very thin layer or skin that surrounds the same bones that make up our hands, arms and fingers. Fingers on bats are enormous and are often as long or longer than either section of the arm. Interestingly, Pterosaurs, which were common in Kansas during the Cretaceous, also had fully powered flight. Their wings consisted of skin flaps attached to the back of the arms and a single greatly elongated finger. Bats also are not simply flying mice as the well-known German opera *Die Fledermaus* suggests. Taxonomists agree that mice and bats are very different mammals and appropriately place each in their own orders.

What is special about bats?

Ability to Fly

Probably the first thing that draws young biologists to bats is the presence of powered flight. Bats are the only mammals that can truly fly, while other groups, such as the flying squirrels and sugar gliders, are able to glide. The difference is the ability to sustain an altitude. Gliders are always falling and can only veer upwards for a few short moments before once again returning to a downward angle. Flying animals, however, can move up and down under their own power.

Unusual Anatomy

Flight brings with it a whole series of special modifications to the body. The most obvious of these are the flight membranes. These thin flaps of skin follow and surround the greatly elongated bones of the hand, arm, and finger and also run from the underarm down along the side of the body to the ankles. All of this is commonly known as the wing or propatagium. Similarly, the uropatagium or interfemoral membrane extends from each leg to the tail. The two families of bats found in Kansas can be distinguished by the amount of tail that extends beyond the uropatagium. Fourteen of the 16 species are members of the family Vespertilionidae and have little or no obvious tail extending beyond the membrane. The other two are members of the free-tailed family (Molossidae) and have one half inch or more of tail that extends beyond the uropatagium. Bats of both families use their wing and tail membranes to help capture insects, using them much like a baseball player uses his glove.

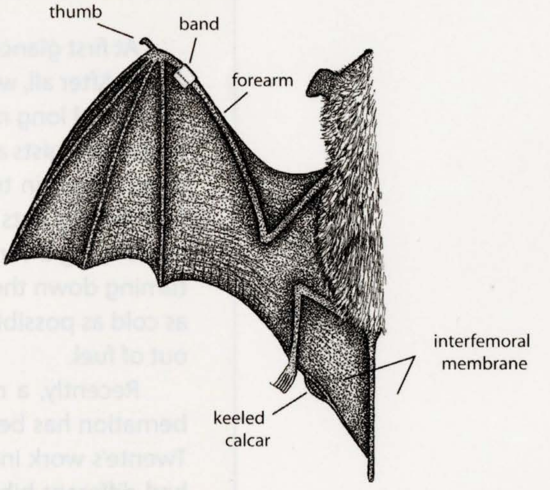


Figure 2. Anatomy of a bat.
Drawing by Linda K. Castor

Anyone who has watched a flying bat has noticed that it flaps its wings a lot and makes sudden short maneuvers. This flapping action results in massive pectoral muscles. It also takes a lot of oxygen to keep the muscles working at peak efficiency. Thus, bats have a large heart and lungs. This constant movement is energetically costly and calls for a high metabolic rate, which is why bats spend so much of their active time devouring prey. Similarly, much of the roosting ecology of bats is driven by their need to find body temperatures that allow them to optimize the physiological relationship between energy use and other needs (such as growth).

Bats have unique and specialized skeletons. Bat bones are thin and hollow as are the bones of birds and pterosaurs. The next time you see a pterosaur bone in one of the Kansas museums, you will note that the long bones are almost always crushed unlike the skeletons of the other Cretaceous reptiles that are excavated from the chalk of western Kansas. Bats have an extra piece of cartilage (called the calcar) extending off the ankle. The calcar helps support and maneuver the tail membrane. Biologists often use the shape of the calcar to help separate similar species.

Hanging Upside Down

All bats hang upside down. The knees of bats face the rear whereas those on all other mammals face the front. This may be an adaptation to maneuvering the tail membrane, and may also have (in conjunction with using the hands as wings) forced bats to hang in their characteristic upside-down position. Other biologists have suggested that hanging upside down is important for seeing predators coming and for allowing bats to drop easily into flight. Regardless, it is another trait that makes bats unusual.

Hibernation

At first glance, hibernation is amongst the least interesting aspects of bat biology. After all, what could be less interesting than animals simply going to sleep for several long months each winter? For many years hibernation was treated by many biologists as a primitive trait that allowed bats to lower their body temperatures, which in turn lowered their energy requirements, which in turn allowed hibernating bats to go long months without feeding. In essence, a hibernating bat is using a very similar approach to a person who lowers their heating bill by turning down the thermostat. As such, the best option for bats would be to get as cold as possible without freezing and thus take the lowest chance on running out of fuel.

Recently, a more balanced and far more interesting understanding of hibernation has begun to appear in the literature. This effort started with Dr. Jack Twente's work in the Red Hills when he demonstrated that each species of bat had different hibernation requirements. Later research indicated that bats periodically emerge from hibernation and become active, and bats hibernating at colder temperatures emerge less frequently. Research also demonstrated that these periodic arousals consumed a large portion of the fat reserves. These data perplexed biologists for many years. If hibernation is all about energy minimization, why would bats periodically emerge and thus waste large amounts of energy?

It turns out that hibernation is a very complex series of physiological interactions and trade-offs. During hibernation bats have effectively no immune system. This is part of why White Nose Syndrome has had such a devastating effect (see below). Similarly, muscle fibers lose their strength, neural function is lost, and animals become sleep deprived. These data suggest that hibernation should be an act of last resort for bats. Several recent studies support the idea that bats do everything they can to limit time spent hibernating. Bats in good condition selectively choose warmer areas (where they will arouse more frequently), whereas bats that are running low on fat hibernate just above freezing. There is also some evidence that bats take steps to reduce the amount of energy they spend during their periodic arousals which may include flying to warm areas of caves and clustering together so they can share body heat when they arouse. Given the threat posed by WNS, we suspect that hibernation physiology will be an area of intense future research.

single greatly elongated finger. Bats also are not simply flying mice as the well-known German opera *Die Fledermaus* suggests. Taxonomists agree that mice and bats are very different mammals and appropriately place each in their own orders.

What is special about bats?

Ability to Fly

Probably the first thing that draws young biologists to bats is the presence of powered flight. Bats are the only mammals that can truly fly, while other groups, such as the flying squirrels and sugar gliders, are able to glide. The difference is the ability to sustain an altitude. Gliders are always falling and can only veer upwards for a few short moments before once again returning to a downward angle. Flying animals, however, can move up and down under their own power.

Unusual Anatomy

Flight brings with it a whole series of special modifications to the body. The most obvious of these are the flight membranes. These thin flaps of skin follow and surround the greatly elongated bones of the hand, arm, and finger and also run from the underarm down along the side of the body to the ankles. All of this is commonly known as the wing or propatagium. Similarly, the uropatagium or interfemoral membrane extends from each leg to the tail. The two families of bats found in Kansas can be distinguished by the amount of tail that extends beyond the uropatagium. Fourteen of the 16 species are members of the family Vespertilionidae and have little or no obvious tail extending beyond the membrane. The other two are members of the free-tailed family (Molossidae) and have one half inch or more of tail that extends beyond the uropatagium. Bats of both families use their wing and tail membranes to help capture insects, using them much like a baseball player uses his glove.

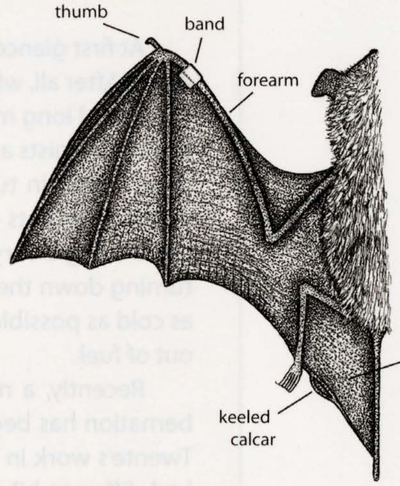


Figure 2. Anatomy of a bat.
Drawing by Linda K. Castor

Anyone who has watched a flying bat has noticed that it flaps its wings a lot and makes sudden short maneuvers. This flapping action results in massive pectoral muscles. It also takes a lot of oxygen to keep the muscles working at peak efficiency. Thus, bats have a large heart and lungs. This constant movement is energetically costly and calls for a high metabolic rate, which is why bats spend so much of their active time devouring prey. Similarly, much of the roosting ecology of bats is driven by their need to find body temperatures that allow them to optimize the physiological relationship between energy use and other needs (such as growth).

Bats have unique and specialized skeletons. Bat bones are thin and hollow as are the bones of birds and pterosaurs. The next time you see a pterosaur bone in one of the Kansas museums, you will note that the long bones are almost always crushed unlike the skeletons of the other Cretaceous reptiles that are excavated

Is it true that bats hunt by radar?

Bats create complex ultrasonic sounds (echolocation calls) used for many purposes, including navigation, prey capture, and communication with other bats. A typical bat call begins at the high end of the species' vocal range, descends rapidly to a breaking point, or "knee," and then levels out near a characteristic low frequency. Many calls are not a single tone, but are similar to a musical chord where there is a prime note that harmonizes with lesser notes.

All bats in Kansas use echolocation (more similar to SONAR than RADAR) as an aid to navigation and food location. The bats produce a call that travels out in the environment, bounces off any object and then returns to the bat. The amount of time the echo takes to reach the bat provides a precise measurement of distance. Distortions in pitch provide the bat information about if and how fast an object is moving as well as the type of surface. Different bats produce different types of calls, and a single bat can produce dozens of different calls depending on its needs. Search phase calls are used when the bats are simply flying around, whether they are looking for food or just simply commuting between hunting and roosting areas. The approach phase calls of most bats in Kansas look a lot like a reverse J. The call starts off at a high pitch and then drops swiftly down to a "knee" and then flattens out. By examining the overall shape of the call, the pitch at which it starts, stops, and reaches its knee, as well as the variability between calls, biologists can often identify which species made the call. When a bat detects an object, then the calls become closer together and become much more steep—this is called an approach phase call. Finally, a bat that is about to capture an insect, or is about to crash into an object, produces a feeding buzz. In this case, the bat is literally bombarding the object with many short calls, which provide it very detailed information. All of these call types can be produced by a single bat within a few seconds.

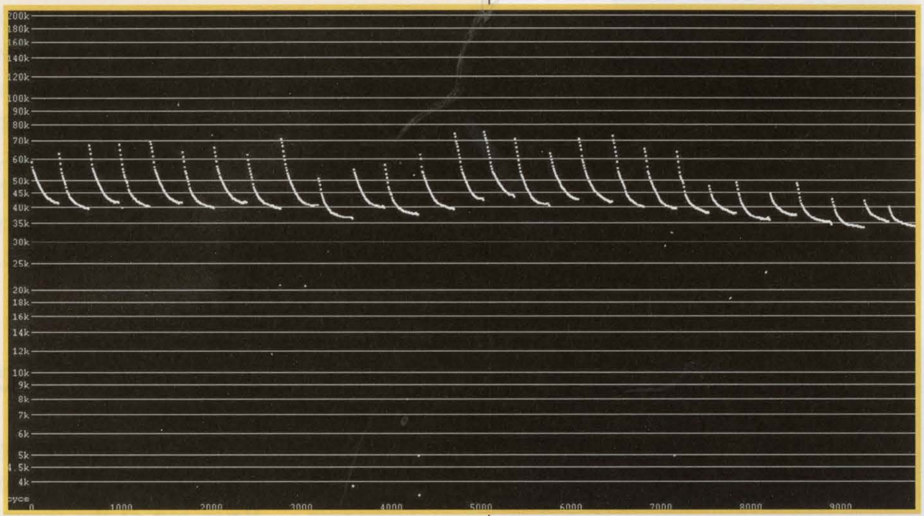


Figure 3. Echolocation call of an Eastern red bat.
Image by C. Ryan Allen

The bats' ears are highly specialized for receiving such acoustic information. Aside from the wings, the large, often intricate ears are probably the most recognizable feature of bats. The external ears, or pinnae, are often large and function in funneling sound waves to the eardrum. A second structure, known as the tragus, aids the bat in determining distances, directions, and sizes of objects. The tragus is a small, fleshy appendage that protrudes from the inside bottom of the ear. The size and shape of the tragus often is unique to a species and aids in its identification.

This ability to echolocate is not unique to bats, as biologists have now discovered that it is also common amongst the shrews, whales, and dolphins. In fact, many blind people have also learned to use echolocation by either producing a click themselves, listening to the taps from their canes, or simply by paying attention to details about how sound changes around them.

How many types of bats are there?

Currently, biologists recognize approximately 1100 species of bats among more than 5400 species of mammals. As such, one in every five mammals is a bat. This diversity is only exceeded by the rodents, which include more than 2200 species. Most people have become aware over the past few years that there are more species in the tropics than anywhere else. This pattern is especially clear with bats, where nearly half the species are found in tropical areas. Here in the United States, bat diversity also tracks the variety of roosting type and is highest in the desert southwest where there are a variety of roosting options, ranging from rock crevices in canyons to broken tree limbs on the taller mountains. Similarly, in Kansas, the Red Hills are an important center of bat diversity as a result of the large and complex cave systems. During a day of fieldwork in this region, biologists may see hundreds or even thousands of bats. Conversely, during the fieldwork that led to this book, it was not unusual to spend a week working on the High Plains and never capture a bat.

Figure 4. The Common vampire bat, *Desmodus rotundus*, is native to central and South America, but not Kansas. *Photo by The Organization for Bat Conservation*

Do vampire bats exist?

Yes. In Central and South America a group of bats exists that eats by cutting the skin of an animal and licking the blood that flows out of the wound. Early explorers named these animals "vampires" after the mythical undead of Europe.

What are the benefits of bats?

As our knowledge about bats increases so does their usefulness to people. For example many tropical fruits rely on bats for pollination including the agave plants that are the source for tequila. Also enzymes from the saliva of vampire bats may someday replace the heparin blocks that are currently used to keep IV lines in hospitals free of blood clots. Although all bats in Kansas eat insects, many tropical species eat fruit. In the process of eating the fruit, the bats also consume many of the seeds. When the bats defecate the seeds come out along with a good dose of fertilizer, which plays an important role in seed dispersal and germination. This information has now become an important consideration in efforts to re-establish or manage tropical forests after they have been harvested. Several studies have now been completed aimed at understanding how to better use this free seed dispersal system. Amongst the discoveries has been that isolated fruit trees left within otherwise open clear cuts can be enough to draw bats from miles around. Bats defecate as they fly, and do so while flying to and from the remnant tree(s). Such minor steps can cut years or even decades off the amount of time it takes for forests to become re-established.

In Kansas, bats are the major predators on nighttime flying insects. Some of the nighttime flying insects on the menu include biting flies (but including very few mosquitoes), cucumber beetles (the adult of one of the corn rootworms), moths (the caterpillars of which are often crop pests), Hessian flies (a major wheat pest) and many other pest species. Biologists have recently teamed with economists to determine that Brazilian free-tailed bats in central Texas save farmers millions of dollars in pesticides by eating cotton pests. This is great news for the farmers of southern Kansas, because a colony of approximately 250,000 of these bats lives just south of the Kansas border in Woods County, Oklahoma. Every summer night, thousands of free-tailed bats cross the border and forage on a large menu of agricultural pests.

In the U.S., bat guano has long been used as a fertilizer. In fact, at one point, there was a commercial effort to mine bat guano from the major Brazilian free-tailed bat colony just south of the Kansas border in Oklahoma. The high nutrient content of bat guano may provide an important clue to nutrient cycling. Rainwater washes nutrients off the higher parts of the landscape and moves it to the lowlands, which is why river bottoms make such good farmland. Very few natural processes move these nutrients back up-slope, and bats are one such process. Recent research has demonstrated that nutrient hot spots occur near large bat roosts.

Figure 5. Guano pellet of a Big brown bat.
Photo by Linda K. Castor

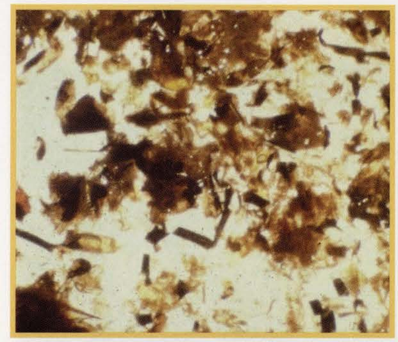


Figure 6. Guano pellet broken up to reveal fragments of spotted cucumber beetle, an important agricultural pest.
Photo by Linda K. Castor

Figure 7. Legs and hind wings of a spotted cucumber beetle recovered from guano.
Photo by Linda K. Castor

What do bats eat?

Unfortunately, there have been few studies of bat diets in Kansas. Every species that occurs in the state has been studied in other states, and we provide a quick overview of these studies within each species account. All bats in Kansas eat night flying insects, including many pest species. Some species such as the Big brown, Evening, and Pallid bats feed primarily on beetles and other hard-bodied insects. Other species such as the Hoary bat and the big-eared bats feed almost exclusively on moths. The remaining species feed on a variety of insects including flies, moths, flying ants, wasps, and beetles, as well as some other terrestrial arthropods (spiders, scorpions, etc.). A newly published paper in the journal *Science* suggests that loss of bats would cost U.S. farmers 3.7 billion dollars per year.

How do bats find food?

Bats hunt by locating areas where there are large numbers of food insects, and flying through these areas to capture insects. Bats then fly back and forth through such areas of high insect density until they either fill their stomachs or until the cost of hunting becomes too low because insects flee the area or get eaten.

We know little about how bats find food sources on a very large scale, and this is an area of ongoing research. Some biologists have suggested that when female bats return to feed pups they are able to see if any of their neighbors have been successful. Unsuccessful bats are thought to follow successful bats to their foraging areas. We must also remember that bats are long-lived social animals. As such, it is possible (even likely) that bats learn places that produce swarms of high quality insects at predictable times. Examples of such places would include small forest wetlands, edges of fields where the wind blows the insects against the tree-row, and agricultural fields. As such, it should not surprise us to find out that bats are able to recognize sites that may eventually provide food, or that individual bats may be able to pass this information to their roost mates. Although long suspected, newly available studies indicate that bats may form long-term associations much like human friendships. These data support the contention that information is being shared amongst roost mates.

While radio-tracking foraging bats, we have observed that some bats may have a set route that takes them past multiple good feeding grounds. We suspect that the bats have learned locations where high quality foods are produced reliably. The bats seem to start at one hunting ground and work their way through the rest in series.

Where do bats live?

If you ask the average person where bats live, they are likely to give you one of two answers. Some people will answer "in caves," while most others will state "in old buildings." In fact, both are classic examples of roosts. Most people are unaware that the majority of North American bats, including most of the species found in Kansas, roost in trees during summer. Some such as Red, Hoary, and Evening bats even hibernate in trees. Hoary, Red, and Tri-colored bats spend their lives hiding amongst the leaves of trees. Evening, and Silver-haired bats and Northern myotis primarily live in hollow trees or under the bark of dead trees. Pallid bats and Yuma and Western small-footed myotis live primarily amongst rock crevices. Modern Big brown bats are associated primarily with people using anthropogenic structures, especially buildings and bridges, during both summer and winter. A few species including Cave myotis, Gray myotis, Brazilian free-tailed bats, and Townsend's big-eared bats spend most of their entire lives in caves, although they occasionally move into an old building. Most species of bats make at least short migrations between their summer and winter quarters. For species such as Red, Hoary, and Silver-haired bats, this can occur at continental scales, whereas species such as Tricolored bats and Cave myotis may only move a few miles. Some of our bats, such as Little brown and Northern myotis, are tree bats in summer and cave bats in winter; and both will use buildings if the conditions are right.

Figure 8. Spotted cucumber beetle.
Photo by John O. Whitaker, Jr.

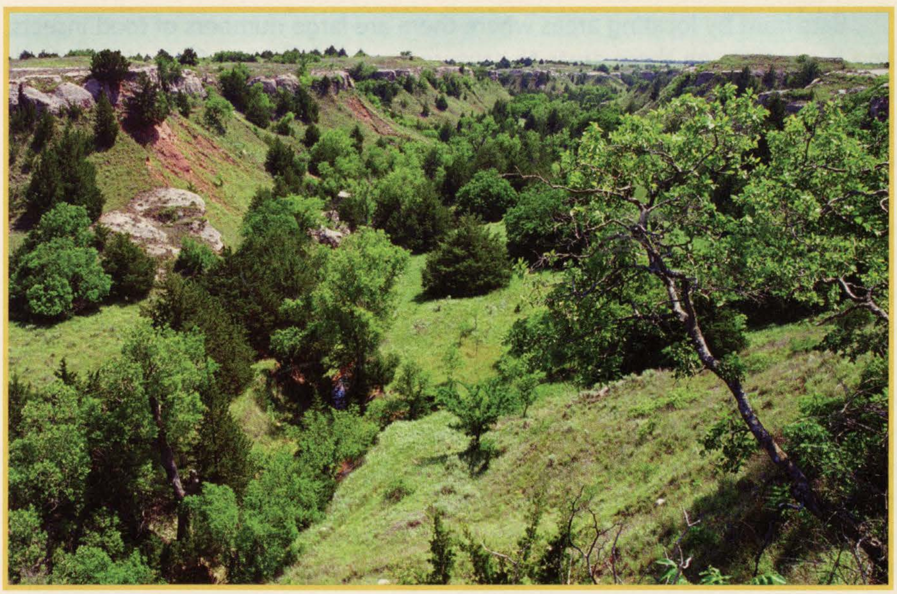


Figure 9. Many bats of Kansas roost in hollows or under the bark of the scattered trees that line streams throughout Kansas.
Photo by Alexis Powell

What are the biggest threats to bats?

Direct Persecution

Bats have few natural enemies, and their entire ecology is based on long lives. During the 20 years we have been compiling information for this book, this section has changed three times as new and greater threats have emerged. In 1996, the biggest concern for bats in Kansas was the interaction between people and bats. The most egregious case was the killing of dozens if not hundreds of Pallid bats beneath the old Natural Bridge in Barber County by a farmhand with a blowtorch. Bats are especially vulnerable to vandalism of caves during hibernation, and as such, most bat biologists are very careful who they tell about known hibernacula. Similarly, hibernating bats that are disrupted and caused to take flight can use up valuable energy reserves during a time when replenishing those reserves is not an option, ultimately succumbing to an untimely death.

In some cases, well-meaning people kill bats in homes because they think they are dangerous or because they do not realize there are options available to encourage bats to leave buildings where they are not welcome. In fact, the senior author's first interaction with bats was to help his father kill several preflight juvenile Big brown bats who, during an extreme heat wave, had moved into the living room of his 91 year-old great-grandfather's house. Like many other people, we were worried about the risk of rabies and we had no idea how to get the bats out of the house. To avoid such senseless killing, we have provided information about the rarity of rabies amongst normally behaving bats and information about how to eliminate unwelcome bats from homes, churches, and other buildings.

Habitat Loss

It's a little ironic to include this section immediately after we tell you that we will later discuss how to encourage bats to leave when they move into our homes, offices, and places of worship. Studies conducted by legendary bat biologists Dr. James Cope, Dr. John Whitaker, and their students discovered that house bats typically survive and return until they are "built-out" by the property owners. If you must exclude bats from an unwelcome address, try providing them with a new or alternate place to live. While many bats live in buildings, the reality is that most bats in Kansas summer in trees. The riparian forests that follow many of the streams in the state date to the late 1800s when the bison had been hunted to extinction, but before ranching was common. When these trees became large enough that some trees had hollows or dead sections where bats could get under the bark, they became bat habitat. Now they are great bat habitat, but over the next 50 years or so, the quality of habitat will begin to decline. Because many of these trees are roughly the same age, we will eventually have a situation where the trees are unsuitable. This can be combated by starting the replacement process now even if we have to sacrifice a few areas of older trees to do so. Artificial roosts such as bat boxes may also help. Kansas has few natural caves and mine shafts deep enough to provide winter shelter for hibernating bats. Protecting those sites is critical to maintaining the bats that are present. Protecting these mines does not just mean keeping people from killing the bats or destroying the caves and mines. It also means limiting the number of visitors to such sites so that the bats are able to hibernate in peace.

Pesticides

It makes sense that when bats prey on insect pests the bats may also be exposed to pesticides that people use to control those same insect pests. There is evidence that banned pesticides, including Dieldrin and DDT, are linked to declines in bat populations. These pesticides, however, were banned not because they immediately killed wildlife, but because they remained active in the environment for many years and the effects of the toxin could easily be passed among species. For example, DDT was banned primarily because it caused thinning of eggshells for species such as Bald Eagles. The eagles were not directly sprayed with DDT; rather, they ate many fish that were contaminated with small (sublethal) amounts of pesticides. The eagles eventually had accumulated enough pesticides so that they caused a negative physiological effect.

Most modern pesticides are nerve agents similar to Sarin and VX. As such, these toxins are extremely toxic, but rapidly break down in the environment. Few data are available, but many biologists are concerned that bats are exposed to these poisons while feeding and either are killed outright or suffer sublethal effects. Sublethal effects can range anywhere from being sick for a few hours to permanent neurological impairment. Even if bats are only affected for short periods of time, they may be eaten by predators or their dependent young may die from a lack of care. This is an area of ongoing research, but evidence is beginning to build that this may be an important source of mortality for bats.

Figure 10. Wind Turbines, such as these near Lincoln, provide clean, renewable energy. Large numbers of bats are killed annually at wind turbines.
Photo by Curtis J. Schmidt

Wind Turbines

Until very recently, wind power in Kansas was primarily used for pumping water into isolated cattle tanks. Now the whole state is sprouting commercial wind turbines. This is a very worrisome phenomenon, because some wind turbines kill bats in large numbers. Recent studies suggest that bats, particularly the migratory tree bats, are actually drawn to these structures where they are killed either by colliding with the blades or by barotrauma (rapid decompression which collapses the lungs). The good news is that concern over these issues has led to a large amount of research throughout the country. In fact, all of the authors have worked with wind power companies to 1) determine if a proposed wind farm has a high likelihood of killing bats and 2) try to find ways to reduce bat mortality at wind farms. The available data indicate that such simple steps as turning off select turbines during periods of low wind (when bats are flying), or during times when bats are migrating, can greatly reduce the problem. Regardless, interactions between bats and wind farms will likely be an important conservation issue for the next several decades.

White Nose Syndrome

In early 2006, biologists and cavers noticed that a few bats in a mine near Albany, New York harbored an unusual white substance. This substance, later identified as a previously undescribed species of fungus, was growing on their muzzles and wings. The fungus is now known as *Geomyces destructans*, and it is associated with a disease called White Nose Syndrome (WNS). By winter 2007/2008, it was clear that WNS was associated with the death of many bats, and by 2008/2009 the disease was causing catastrophic population declines in many species, mostly across the eastern United States. Infected bats that survive the winter emerge with badly scarred wings and many still have active infections. WNS continues to spread rapidly, and in winter 2009/2010 biologists were shocked to discover isolated bats with the characteristic wing scarring and the fungus in both Missouri and Oklahoma. So far, we have been lucky not to see the disease in Kansas, but anticipate that it will likely arrive in the next few years.

Figure 11. The fungus associated with White-Nose Syndrome can invade any bare skin of bats, not just the nose. Diagnostic tests would be required to determine if the white fungus on the ears of this endangered Indiana myotis is evidence of the disease.
Photo by Adam Mann/ Indiana Department of Natural Resources

WNS spreads primarily by bat-to-bat contact, quickly spreading through large hibernating colonies. Bats that emerge from infected hibernacula then migrate to summering grounds where they form maternity colonies that often include individuals from other caves. Spores of the fungus can then be shared among bats within the summer roost and be carried back to new caves. In addition, during autumn migration and swarming, infected bats may visit several hibernacula, infecting each with WNS.

WNS has killed at least a million bats since the winter of 2006-07 and in some caves populations have declined by 99 percent over three winters. Worse yet, research indicates that fungus remains in these caves and mines, infecting bats that attempt to recolonize. Conservation efforts to date have focused on examining the biology of the fungus and understanding how it kills bats. The major cause of mortality is that the fat stored by bats, which is used to maintain the bat through the winter, is depleted before the end of winter. The bat flies about, often out into the winter weather, and often starves to death. Some think that the fungus causes sores and lesions in the wing and tail membranes. This damage disrupts the water balance of the bats, ultimately leading to their death. Another possibility is that hibernating bats have virtually no immune function, thus infected bats have to arouse in an effort to fight off the disease. These arousals use up limited fat stores and the bats effectively starve to death, or fly out into the cold of winter in an effort to feed. There is no known cure for WNS, but infected bats are able to recover if they can find food.

Figure 12. Wing damage consistent with White Nose Syndrome.
Photo by Darwin Brack, ESI

It is possible that so few of the highly colonial species, like Little brown, Northern, Gray, Yuma, and Cave myotis, will survive that summer maternity colonies will no longer be viable. Long-term conservation efforts should focus on determining how to provide the benefits of social living to the few bats that survive and finding ways to ensure that historically important hibernacula are cleaned.

We also predict that bats using dispersed hibernacula, such as Big brown bats, Western small-footed myotis, and Tri-colored bats, will suffer some declines, but will continue to be moderately common. Red and Hoary bats are thought to be mostly unaffected because they rarely enter caves and mines and their solitary lifestyles are less likely to expose them to the disease. Similarly Evening and Silver-haired bats may be spared because they also rarely enter caves. Both species of free-tailed bats migrate south and remain active during winter. As such, these species are unlikely to be affected in large numbers (although they may spread the disease long distances). We also are unsure how to predict the impact of the disease on Pallid or Townsend's big-eared bats in the Red Hills. The largest winter group of Virginia big-eared bats (*Corynorhinus townsendii virginianus*) is in Hell Hole Cave, West Virginia, which has been infected since winter 2009/2010. So far, these bats do not appear to suffer from WNS. The population of Pallid bats shared by Kansas and Oklahoma will likely be the first population exposed to WNS. If the species has any unique behavioral or biological adaptations that protect it from WNS then that discovery will probably be made in Kansas.

How common is rabies among bats?

In most cases the rate of infection in North American bats is less than 1%. Sometimes outbreaks do occur and the number can climb much higher, but this is extremely unusual. Newly available research indicates that many bats catch rabies when they are pups. Some pups die, but others recover and then have a level of immunity to the disease. Advances in molecular biology have now made it possible to examine the genetics of rabies. Biologists used to think of this disease as a single entity. We now know that there are different strains of rabies associated with raccoons, dogs, skunks, and with some of the many species of bats. Research into these strains and how they are maintained and occasionally passed among populations will continue to be an important area of study for the future. It is extremely difficult, if not impossible, to visibly determine whether or not a bat has rabies. Odd behaviors, such as daytime activity, could indicate infection, but could also be an indicator of a variety of diseases or stress factors as well.

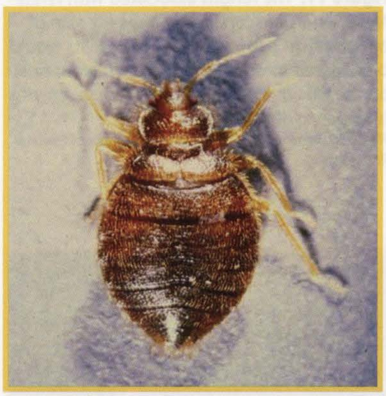


Figure 13. Bat bedbug (Family Cimicidae).
Photo by Christopher M. Ritzi

Do bats have any predators?

Most bats have few natural predators other than man. A combination of small size, the ability to fly, nocturnal activity, and roost selection of bats all serve to reduce predation. On occasions, a wide variety of predators have opportunities to take bats. In the case of cave-roosting bats, any animal capable of taking

Figure 14. The orange spots in the ears of these Cave myotis are parasites.
Photo by Alexis Powell

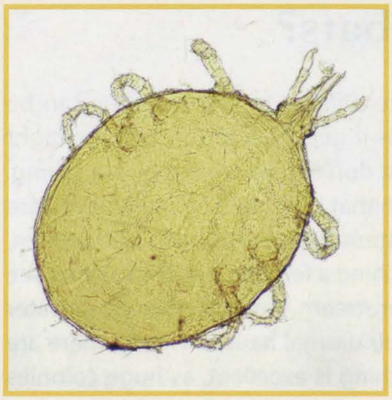


Figure 15. Bat tick (*Ornithodorus kelleyi*).
Photo by Christopher M. Ritzi

Figure 16. Bat tick (*Ornithodorus* sp) attached to a Pallid bat in Kansas.
Photo by Jeff Miller

bats and found within a cave containing bats may occasionally take bats. Bats that roost in buildings, crevices, or trees are particularly vulnerable to climbing snakes such as rat and corn snakes. When bats are grounded or use low roosts, they fall prey to many ground-dwelling predators. Finally, birds of prey occasionally take bats both on and off the wing. The speed and killing power of birds are probably the main reason bats are nocturnal.

Figure 17. Bat flea.
Photo by Christopher M. Ritzi

What other causes of death are known among bats?

We know little about the causes of death among bats. All of our information stems from accidental observations. Thus, without data from actual studies, we really do not know how most bats die. We do know that some die each year from accidents. Some common accidents include becoming entangled in barbed wire, crashing into buildings, being hit by wind turbines, and drowning in flooded caves. Many bats may be killed each year by pesticides and other chemical poisons. Until recently biologists knew that there were occasional outbreaks of disease (especially rabies), but these were of relatively minor importance to bats. Unfortunately, as we write this book, we dread the next e-mail or phone call because it may very well tell us that WNS has now arrived in Kansas.

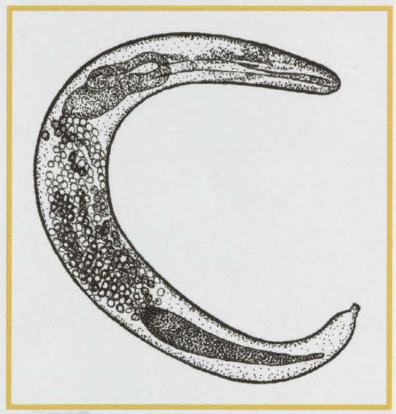


Figure 18. Nematode (Roundworm).
Redrawn by Linda K. Castor from Rausch 1983

What parasites afflict bats?

Externally mites, batbugs, ticks, fleas, and two specialized families of flies often parasitize bats. Bat bugs are close relatives of the bedbugs that attack people. Internally, bats are often infected with flukes; although tapeworms, roundworms, and a variety of other animals are also found.

Where can I go to see bats?

Unfortunately, in most of Kansas bats are difficult to see, but they can be found. First, go out into your back yard just as it gets dark and watch the night sky. Many people see bats all the time and just don't know what they are seeing. The flight of bats is usually more "fluttery" than that of birds. If the animal you are watching begins to fly a roughly circular pattern with occasional, but sudden, changes in course then you are probably watching a feeding bat. If you don't see bats in your yard, try going to a nearby pond or stream. Bats will often fly to water to drink immediately after emerging from their diurnal haunts. Finally, there are several places in other states where bat watching is excellent, as huge colonies emerge simultaneously from their shared roosts. Texas has two well known bat attractions: 1) Bracken Cave and 2) Congress Ave. Bridge in Austin—directions to either site can be obtained from Bat Conservation International (see the last section of this book for details). Also Carlsbad Caverns National Park in New Mexico is home to a large summer colony of bats. Alabaster Caverns and Merrihew Cave, just south of Kansas in Oklahoma, provide good opportunities to see emerging bats.

Figure 19. Brazilian free-tailed bats emerging from Merrihew Cave, Oklahoma.
Photo by Alexis Powell

Are there any fossil bats from Kansas?

Yes, we know of four. Three are extinct forms. A Hoary bat (*Lasiurus cinereus*) also has been recorded in the fossil record of Kansas.

How are bats doing?

The best information that science has to offer suggests that many species of bats are declining in numbers throughout the world. Everybody has opinions, but we really don't know what has caused the problem. As with most groups of animals, major declines are typically caused by a mixture of problems, from climate change to environmental contamination and habitat alteration. The two most common explanations for bats have been loss of habitat and pesticide poisoning. In North America, the major concern now is trying to find a way to stop the spread of WNS, help infected bats recover, or protect the small number of survivors.

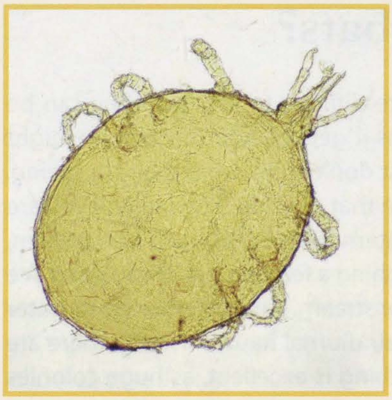


Figure 15. Bat tick (*Ornithodorus kelleyi*).
Photo by Christopher M. Ritzi

Figure 16. Bat tick (*Ornithodorus* sp) attached to a Pallid bat in Kansas.
Photo by Jeff Miller

bats and found within a cave containing bats may occasionally take bats. Bats that roost in buildings, crevices, or trees are particularly vulnerable to climbing snakes such as rat and corn snakes. When bats are grounded or use low roosts, they fall prey to many ground-dwelling predators. Finally, birds of prey occasionally take bats both on and off the wing. The speed and killing power of birds are probably the main reason bats are nocturnal.

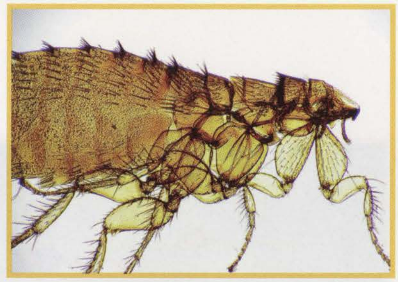


Figure 17. Bat flea.
Photo by Christopher M. Ritzi

What other causes of death are known among bats?

We know little about the causes of death among bats. All of our information stems from accidental observations. Thus, without data from actual studies, we really do not know how most bats die. We do know that some die each year from accidents. Some common accidents include becoming entangled in barbed wire, crashing into buildings, being hit by wind turbines, and drowning in flooded caves. Many bats may be killed each year by pesticides and other chemical poisons. Until recently biologists knew that there were occasional outbreaks of disease (especially rabies), but these were of relatively minor importance to bats. Unfortunately, as we write this book, we dread the next e-mail or phone call because it may very well tell us that WNS has now arrived in Kansas.

Figure 18. Nematode (Roundworm).
Redrawn by Linda K. Castor from Rausch 1983

What parasites afflict bats?

Externally mites, batbugs, ticks, fleas, and two specialized families of flies often parasitize bats. Bat bugs are close relatives of the bedbugs that attack people. Internally, bats are often infected with flukes; although tapeworms, roundworms, and a variety of other animals are also found.

What are some of the techniques used to study bats?

Capturing Bats

Figure 20. In wetter areas of Kansas multiple mist nets are stacked on top of each other to cover flyways such as streams. These can be as much as 60 feet wide and 30 or more feet tall. *Photo by Dale W. Sparks, ESI*

The methods used to study bats depend greatly on the type of question we are trying to answer. Most of the time we need to capture the bats, and we'll try just about anything. The most common technique used to capture bats throughout North America is to place delicate mist-nets in areas where bats are likely to fly. These nets are fine enough that we keep a net seven feet high and eighteen feet long rolled up in a quart Ziploc® sandwich bag. Throughout much of Kansas, the most successful technique is to use a series of pulleys and ropes to stack 2-4 nets on top of each other. These high nets can then be used to seal off corridors where bats fly when moving between their roosting and foraging areas. If we are lucky, bats flying down the corridor (usually a stream or a roadway passing through a woodlot) fail to detect the net and become entangled. Although, there are occasional exceptions, most streams in Kansas are small enough that a large mist-net consists of two 18 foot nets stacked on top of each other. Most often, we simply use a single net placed across the smaller streams and ponds. In states further east, however, it is common to use mist-nets that are as large as 60 feet long and 40 feet tall.

In western Kansas, there simply are not enough streams to use this technique. In that type of habitat, we take single nets and stretch them across stock tanks or tail-water pits. Bats often fly across hilly terrain by flying just above the ground. Thus, we can sometimes catch bats by placing mist nets across a saddle between two high points.

Figure 21. In arid portions of Kansas single mist-nets are often set across small ponds such as this. *Photo by Curtis J. Schmidt*

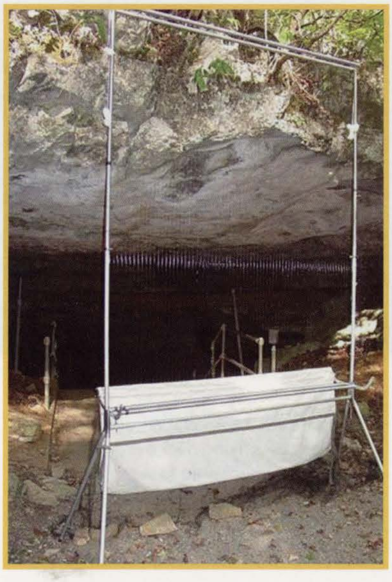


Figure 22. Harp trap placed to capture bats at the entrance of an abandoned mine. This technique has all but disappeared since the arrival of White Nose Syndrome. *Photo by Adam M. Mann, ESI*

In cases where we expect to capture a lot of bats in a short period we use specialized traps that look like a pair of harps placed back-to-back. These harp traps are usually placed across the entrance of caves and mines. When bats try to enter or exit the cave or mine, they detect the strings on the first harp, hit the second, and fall into a waiting bag.

We also capture them by hand and in hand-nets at both day and night roosts. Many times people ask us to come get them out of buildings. When we are doing distribution or parasite work in areas where no endangered species occur, we occasionally shoot them with shotguns. We have recently gained some significant distributional information for bats in southwest Kansas by using guns to collect, the only collecting method that the bats did not elude.

Bat Detectors

As mentioned above, bats use complex ultrasonic calls for a wide variety of purposes including navigation. For some time, biologists have been trying to use these calls to study bats. The simplest bat detectors would alert the user (usually by producing a popping sound) any time a sound of a particular frequency was detected. These detectors were widely used, although they were good for little more than getting a general idea of how often bats were flying past a particular site. We often used detectors of this type to determine if an area was worth returning to after an unproductive night of netting, although a few biologists with well-trained ears learned to recognize some species based on the interval between calls. Conversely, if a biologist was interested in studying the details of bat calls, they had to carry a small sound studio into the field with them. In the mid-1990s, a new tool known as AnaBat™ became available to bat biologists.

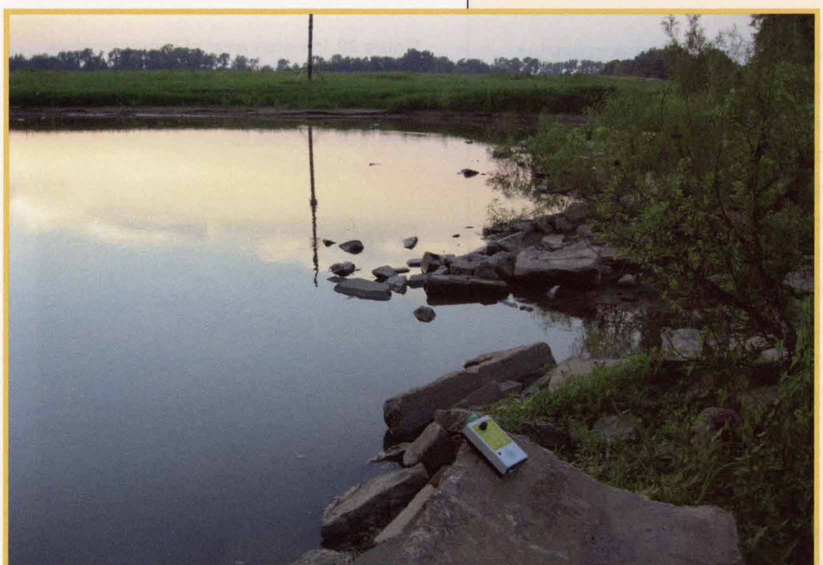


Figure 23. An AnaBat detector placed to record bats flying over deep pond that is impossible to sample with nets. *Photo by Dale W. Sparks, ESI*

AnaBats were designed specifically to be an intermediate approach with an eye toward allowing biologists to record and identify calls at the specific level. At first, AnaBat allowed biologists to either record calls to either a tape recorder or a laptop. The most recent version allows the detector to be placed at a remote site, and it will then turn itself on and off and record calls directly to a flash drive. There is even an option to have the device essentially phone in the data. Once in the lab, these calls could then be pulled up on a computer screen and analyzed. By examining the overall shape of the call; the pitch at which it starts, stops, and reaches its knee; as well as the variability between calls, biologists can often identify which species made the call.

AnaBat is not without competition, however. Continuing advances in technology have now made it possible to get much of the data that used to require a mobile sound studio into a small package. Much like AnaBat, these devices are now relatively affordable, easy to transport, and have the ability to monitor remote locations almost on their own. As such, both AnaBats and full spectrum detectors are frequently used to monitor bat activity at proposed wind farms and other sites. This has been a great help in developing a greater understanding of not only where some species occur, but also how they make use of the landscape.

For example, the work of Jeff Miller in the Red Hills has used bat detectors to remotely monitor bat activity at several sites while he was also attempting to capture bats near their roosts.

Radio-telemetry and Similar Techniques

In the late 1980s, radio transmitters became small enough that biologists were able to conduct radio-telemetry studies on bats. In these studies, a transmitter, which emits a pulse on a particular frequency, is attached to each bat. Using a radio-receiver and a directional antenna, biologists are able to determine the direction from which the signal is coming. Once the proper direction is determined, the biologists can then follow the signal as it gets stronger and stronger, eventually locating the animal.

To date, most radio-telemetry studies have focused on obtaining detailed information about the types of roosts used by bats. In fact, without the recent use of radio-telemetry, we would still think Pallid bats were restricted to a single crack in Kansas. Much information in the subsequent species accounts comes from such studies. Radio-telemetry is also widely used to obtain detailed information about the nocturnal behaviors of bats including addressing issues of habitat selection and time allocation. Locating roosts requires only a single biologist and set of equipment. However, tracking a moving bat at night requires two or more times as much equipment because each location must be obtained by having two or more observers simultaneously record their location and the direction the tagged bat is moving. When available, this approach can provide a massive amount of data within a short period of time, but can be rather costly.

Figure 24. A Townsend's big-eared bat captured and radio-tagged in the Red Hills of southern Kansas.
Photo by Jeff Miller

Older Remote Monitoring Techniques

Prior to the widespread use of radio-telemetry and remote bat detectors, biologists tried a variety of techniques to obtain information about what bats do when they leave their roosts. Some species such as Pallid and Big-eared bats have distinct flight patterns that allow biologists to recognize the species on the wing. This ability to recognize a species (or even an individual bat) can be greatly enhanced by adding a visual mark to the bat(s). Examples of this approach include wing bands, reflective tape as used by Decher and Choate to study Gray myotis in Kansas, and attaching small chemical lights to the backs of bats. Because most of these techniques require biologists to see the bats, you must consider the limitations caused by changes in terrain or simple visual obstructions such as a windbreak. One should also remember that radio-telemetry data includes a higher level of error. For example, using radio-telemetry it is often impossible to say for sure if a bat is foraging along the edge between a field and the riparian forest or if the bat is just barely in one habitat or the other. Visual data, however, can record that level of detail. We suspect that within the next 10 years, these older techniques will be joined by newer approaches such as Global Positioning System (GPS) tags. Just like GPS in many modern smart phones, these tags can record the precise coordinates of an animal at a particular time. Unfortunately, at present there are no tags small enough for bats to carry.

Figure 25. Radio-tracking bats in the Red Hills of Kansas.
Photo by Jeff Miller

Banding and Marking

Bat marking remains an important yet controversial technique. At one time, the US Fish and Wildlife Service widely distributed wing bands and biologists throughout the country were encouraged to take every opportunity to band bats. With time, however, it became clear that those early bands were causing damage to the wings, and thus were producing misleading results. As such, banding was limited to those studies that needed to identify and recapture specific bats. Over the years bands have changed, and wing bands now are designed specifically to avoid some of the earlier problems. Additional marking techniques have been developed including tattooing bats and the use of Passive Integrated Transponder (PIT) tags, which are the same microchips that are commonly implanted in pets. Studies based on these very simple marking techniques provided the first evidence that bats were long-lived (some live more than 30 years). Tracking migrating bats between summer and winter roosts has provided the evidence that most bats return to the same summer habitats throughout most of their lives.

Museum Specimens

The authors of this book met as a result of working on the curatorial staff of the Sternberg Museum of Natural History. Most people who visit the museum are used to seeing the upstairs section that is open to the public. Most of the public section of the Sternberg is built around the museum's world class collection of fossils. Within the basement of the Sternberg, however, are tens of thousands of preserved specimens of modern wildlife, including bats that were collected as part of the field work associated with this book. The idea behind these specimens is that they are maintained forever, and can be used for a wide variety of studies into issues as diverse as patterns of wildlife diseases, interactions between parasites and their hosts, patterns of evolution, and the physics of flight. These specimens and their associated collection data act as a history book, possessing information from a snapshot in time. These collections hold vast amounts of historical information that can help us to understand the evolving world in which we live.

Figure 26. Bats collected during this study and preserved at the Sternberg Museum of Natural History in Hays. *Photo by Curtis J. Schmidt.*

Bat Guano

Until very recently, bat guano has had two real uses. Historically, it was an important fertilizer, and it remains important for home gardeners. Biologists, of course, viewed guano as a record of what bats had been eating. By breaking up the individual pellets, biologists could often recognize the parts of different insect types. This technique is still commonly used. Advances in molecular biology, however, have now made it possible to extract both DNA and hormones from these pellets. DNA provides a way to capture the same bat time after time without ever touching the animal. This will provide a new way to study the longevity of bats. This also gives us the ability to follow these bats through their life span and even tell which bats are closely related. From those data we can determine which bats are successful at producing and rearing young.

One of the most difficult challenges facing biologists is when we are asked to evaluate the long-term effects of a human activity when we cannot demonstrate that any wildlife is directly killed. For example, what is the effect of harvesting timber in a forest if we know that no bats are in the trees that are cut? In these cases, biologists have traditionally been forced to speculate on the potential indirect effects or lack of effects on the wildlife. A more modern approach has been to measure the hormones (known as corticosteroids), that are secreted when an animal is under stress. Techniques have been developed to measure stress hormones in the feces of larger mammals, but they are just now being developed for bats.

Figure 27. Bat boxes such as this can be easily built or purchased.
Photo by Dale W. Sparks, ESI

Taking Data from the Field to the Desktop

Science is about answering questions, and no discussion of bat biology would be complete without at least acknowledging what happens to field data once it comes back into the office. We use a wide variety of analytical techniques depending on the type of question being answered. Some of the techniques that we use include the extraction and sequencing of DNA, computer mapping, and mathematical modeling. For example, a biologist tasked with determining and reducing the impacts of a new roadway on a colony of bats may start off with a survey of the site using netting and bat detectors. If enough bats are captured, some may be radio-tagged in an effort to locate where the bats roost. Using computer mapping we can see where the bats live and where the road will be located. If there is concern about how the road will impact the movement of the bats we can use radio-telemetry to locate areas of activity. Finally, we may take all of those data into a virtual world where we can vary the types of stream crossings (bridges versus culverts), speed limits, exit designs, and lighting to see which version has the least impact on the bats.

What can I do to help bats?

The most important things we need are public appreciation of bats and additional scientific research. By reading this book you have started working on the first problem. Take that one step further by sharing what you have learned, and aid us in trying to educate the public about the facts and helping people conquer their fears. If an animal is understood, it is more likely to be respected and, in turn, protected. Baba Dioum, a wise Senegalese poet, said it perfectly when he said, "In the end, we will conserve only what we love. We will love only what we understand. We will understand only what we are taught."

Of particular importance is finding funding to support ongoing efforts to either slow WNS or at least protect the resulting small populations of bats. Artificial roosts may be part of the eventual response to WNS. Bat boxes come in a variety of shapes and sizes. By designing roosts that attract bats, but also provide some of the thermal benefits bats usually get from sharing roosts, we may be able to maintain small populations of bats that survive the disease. We have not provided any bat house designs because there are a large number of designs available on-line. In general, we recommend putting up several artificial roosts in a relatively small area. If you are in an area that includes forest, try placing one box in the open, one at the edge, and one within the woodland so the bats have a variety of roosting options. Also, don't get disappointed if you don't immediately see bats. Most species of tree-roosting bats frequently change roosts, and thus may only occupy a box for one or two days at a time. It may also take time for bats to find the roost.

Excluding Bats When They Are Not Welcome

Sometimes bats move into areas where they are not welcome. The best answer to this problem is to build out or exclude the bats. There are two major approaches to excluding bats. The first is to wait until the bats leave for winter, and then seal their entrance. We have had a great deal of success doing this with expanding foam insulation, which is available at any hardware store. In some cases, there is no time to wait for the bats to leave for winter. In these cases, it's best to use a device that allows the bats to leave, but not return. There are some very fancy one-way gates that work very well, or this can be done relatively cheaply using bird netting. All you need to do is locate the place where the bats are exiting. Using a staple-gun, tack a piece of bird netting over the entrance, but leave the bats enough room to push their way out. Bats will be able to push out, but will not be able to return. You will then need to build the bats out. If faced with a bat problem keep three things in mind. First, bats have an amazing ability to squeeze through tight spaces, so leave no hole unplugged. Second, there are no pesticides that can legally be used to exterminate bats. Their biology is so similar that anything that kills bats also kills people. Third, if you have a maternity colony (mothers and babies) you will want to wait until the baby bats can fly (end of July), otherwise you will have little starving bats moving and dying throughout the building. A final consideration is to simply leave them alone. Most bats come and go unnoticed, and actually provide a valuable pest management service. The accumulation of guano is only a minor problem and can easily be removed periodically and used or sold as a high quality fertilizer. Most people will find that bats and humans can easily cohabitate.

Figure 28. St. Fidelis Church, the Cathedral of the Plains located in Victoria, is used year round by Big brown bats. Recent restoration work was conducted in such a way as to encourage the bats to continue to use the church.
Photo by Curtis J. Schmidt.

One of the most difficult challenges facing biologists is when we are asked to evaluate the long-term effects of a human activity when we cannot demonstrate that any wildlife is directly killed. For example, what is the effect of harvesting timber in a forest if we know that no bats are in the trees that are cut? In these cases, biologists have traditionally been forced to speculate on the potential indirect effects or lack of effects on the wildlife. A more modern approach has been to measure the hormones (known as corticosteroids), that are secreted when an animal is under stress. Techniques have been developed to measure stress hormones in the feces of larger mammals, but they are just now being developed for bats.

Figure 27. Bat boxes such as this can be easily built or purchased.
Photo by Dale W. Sparks, ESI

Taking Data from the Field to the Desktop

Science is about answering questions, and no discussion of bat biology would be complete without at least acknowledging what happens to field data once it comes back into the office. We use a wide variety of analytical techniques depending on the type of question being answered. Some of the techniques that we use include the extraction and sequencing of DNA, computer mapping, and mathematical modeling. For example, a biologist tasked with determining and reducing the impacts of a new roadway on a colony of bats may start off with a survey of the site using netting and bat detectors. If enough bats are captured, some may be radio-tagged in an effort to locate where the bats roost. Using computer mapping we can see where the bats live and where the road will be located. If there is concern about how the road will impact the movement of the bats we can use radio-telemetry to locate areas of activity. Finally, we may take all of those data into a virtual world where we can vary the types of stream crossings (bridges versus culverts), speed limits, exit designs, and lighting to see which version has the least impact on the bats.

What can I do to help bats?

The most important things we need are public appreciation of bats and additional scientific research. By reading this book you have started working on the first problem. Take that one step further by sharing what you have learned, and aid us in trying to educate the public about the facts and helping people conquer their fears. If an animal is understood, it is more likely to be respected and, in turn, protected. Baba Dioum, a wise Senegalese poet, said it perfectly when he said, "In the end, we will conserve only what we love. We will love only what we understand. We will understand only what we are taught."

Of particular importance is finding funding to support ongoing efforts to either slow WNS or at least protect the resulting small populations of bats. Artificial roosts may be part of the eventual response to WNS. Bat boxes come in a variety of shapes and sizes. By designing roosts that attract bats, but also provide some of the thermal benefits bats usually get from sharing roosts, we may be able to maintain small populations of bats that survive the disease. We have not provided any bat house designs because there are a large number of designs available on-line. In general, we recommend putting up several artificial roosts in a relatively small area. If you are in an area that includes forest, try placing one box in the open, one at the edge, and one within the woodland so the bats have a

A KEY TO SKINS AND LIVING RECENT BATS OF KANSAS

(Including Species of Possible Occurrence)

1a. Tail extending at least 3/8" beyond end of tail membrane .... Family Molossidae

1b. Tail not extending more than 1/8" beyond end of interfemoral membrane..Family Vespertilionidae

Key to Molossidae

1a. Small bat (total length 4" or less), ears not joined at bases, live animal often with a strong musty (ammonia) odor....................*Tadarida brasiliensis*

1b. Large bat (total length 4 1/4" or longer), ears strongly joined at base, only slightly smelling of ammonia..........................*Nyctinomops macrotis*

Key to Vespertilionidae

1a. Ears large (over 1 1/4")..2

1b. Ears smaller (less than 1") 4

2a. Large lump-like gland present on nose, hair of back unicolored, ears not joined at the base, eyes relatively small ....*Corynorhinus* (3)

2b. No large lump on nose, hair of back primarily cream colored with dark tips, ears joined at base, eyes relatively large......................*Antrozous pallidus*

3a. Belly noticeably paler than back, hairs extending beyond tips of toes..*Corynorhinus rafinesquii**

3b. Belly apparently same color as back, hairs on feet not extending beyond the tips of the toes ....*Corynorhinus townsendii*

4a. Tail membrane fully covered on back by fur...*Lasiurus* (5)

4b. Tail membrane either furred only for anterior one-half of length, or naked 6

5a. Large animal (forearm longer than 1 3/4"), back brownish with gray or white frosting, face noticeably darker than rest of body, defensive call highly "metallic"...*Lasiurus cinereus*

5b. Medium-sized animal (forearm less than 1 3/4"), adult male bright red color, female reddish with gray frosting on back, face similar in color to body, defensive call not "metallic".......................*Lasiurus borealis*

6a. Tail membrane furred (sometimes only thinly) for about 1/3 of length.......................(7)

6b. Tail membrane, if furred at all, only slightly furred for less than 1/3 of its length.......(8)

7a. Hair of back when blown upon is distinctly tricolored, small bat (total length, less than 3 1/2"), tragus bluntly pointed .... *Perimyotis subflavus*

7b. Dark colored, hair of back black or dark brown with silver tips, medium-sized bat, part of ear pink .... *Lasionycteris noctivagans*

8a. Tragus long, tapering to a distinct, pointed tip .... *Myotis* (9)

8b. Tragus rounded, folded, or otherwise shaped, but not distinctly pointed 17

9a. Medium-sized bat (forearm greater than 1 1/2") 10

9b. Small bat (forearm smaller than 1 1/2") 12

10a. Fringe of fur extending along back edge of tail membrane .... *Myotis thysanodes*

10b. No fringe of fur along edge of tail membrane 11

11a. Wing membrane attaching to ankle, fur of back a uniform gray color .... *Myotis grisescens*

11b. Wing membrane attaching at base of toes, fur of back when blown bicolored tan above with dark base .... *Myotis velifer*

12a. Ears when laid forward extending beyond end of nose, tragus 1/4" or longer and sharply pointed .... *Myotis septentrionalis*

12b. Ears when laid forward not extending beyond end of nose, tragus shorter than 1/4", tragus pointed but not sharply 13

13a. Dark facial mask present 14

13b. No dark facial mask 15

14a. Animal captured in extreme southeastern Kansas .... *Myotis leibii**

14b. Animal captured in western half of Kansas .... *Myotis ciliolabrum*

15a. Calcar strongly keeled, hair on toes sparse, hairs not extending beyond tips of toes, overall color appears gray, hair strongly bicolored to weakly tricolored, tips of hairs not glossy, nose pinkish in life .... *Myotis sodalis**

15b. Calcar if keeled only weakly so, hairs on toes dense and several extending beyond tips of toes, overall appearance is brown or bronze, hair of back with glossy tips, nose brownish in life 16

16a. Hair of belly tan in color, base color of back is brown with glossy tips as if highlighted, forehead does not rise abruptly .... *Myotis lucifugus*

16b. Hairs of belly distinctly white, color of back a light, golden brown, forehead sharply angled .... *Myotis yumanensis*

17a. Large bat (forearm greater than 1 1/2"), calcar distinctly keeled, tragus 1/4" or greater and roundly pointed .... *Eptesicus fuscus*

17b. Medium-sized bat (forearm less than 1 1/4"), calcar not keeled, tragus 1/4" or less and shaped like a printed comma .... *Nycticeius humeralis*

* = *Species not yet documented in Kansas*

BAT SPECIES OF KANSAS

Family Vespertilionidae

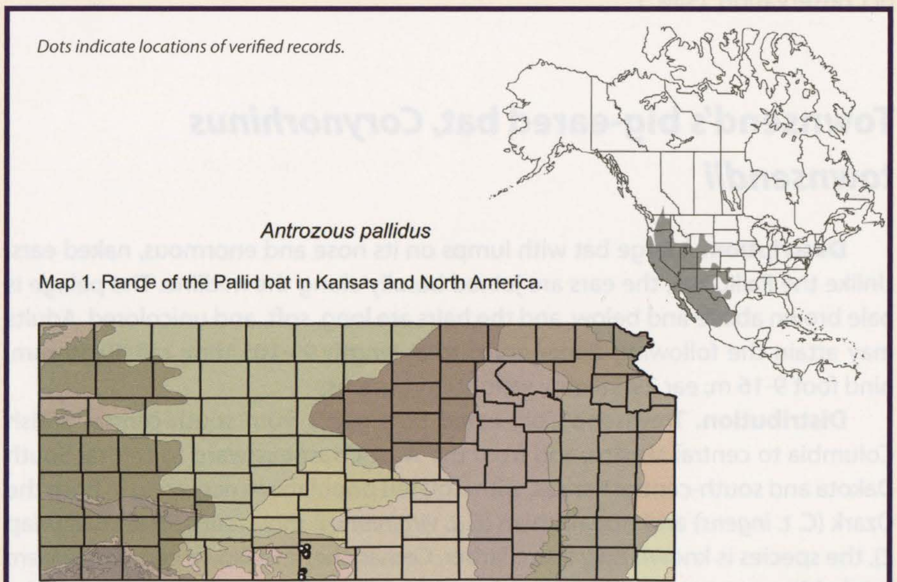
Pallid bat, *Antrozous pallidus*

Description. A large pale bat, creamy to beige above, nearly white below, with large dark eyes, a blunt nose with no lump, and long ears (more than 1 inch long). The ears are not joined medially as in Townsend's big-eared bat. The pelage is pale yellowish and even paler below. Adults may attain the following dimensions: total length 115-135 mm; length of tail 40-53 mm; length of hind foot 12-16 mm; length of ear 26-31 mm; weight 16-22 grams.

Figure 29. A radio-tagged Pallid bat from the Red Hills.
Photo by Jeff Miller.

Distribution. The Pallid bat has a wide distribution in western North America, ranging from south-central British Columbia in the northwest, south along the coast to central Mexico, reaching its northeastern limit in Barber County, Kansas. The Kansas population is isolated from the rest of the species and may eventually prove to be a separate species, *Antrozous bunkeri*. Most historic Pallid bat locations in Kansas have not been occupied in many years. The lone exception is a group of rock crevices near the former Natural Bridge in Barber County. Recently Jeff Miller, under the direction of Dr. William Jensen at Emporia State University, has succeeded in capturing this species in other nearby canyons and also used bat detectors to record echolocations of this species throughout the surrounding prairies.

Natural History. The Pallid bat usually spends summer in cracks in rocks, and that behavior has recently been confirmed via radio-telemetry in Kansas. In Kansas, these bats have also been found roosting in buildings and caves. They



Map 1. Range of the Pallid bat in Kansas and North America.

readily accept bat boxes as summer habitat in other states, and the attachment of artificial roosts to canyon walls appears to be a viable option for managing this species in areas where it is limited by the availability of roosting habitat. Pallid bats also hibernate in rock crevices, where their large size may allow them to use warmer roosts than other bats.

Pregnant females form maternity colonies beginning in early April, and all currently known maternity sites in the Red Hills are in rock crevices. Pallid bats typically give birth to two pups in late June or early July. Young are on the wing by six weeks of age.

Pallid bats emerge after full darkness. They are slow fliers and feed primarily by capturing insects and other arthropods on the ground, and occasionally in the air. Prey items are located and attacked on sound alone. Pallid bats take a wide variety of prey including Jerusalem crickets, grasshoppers, scarab beetles, ground beetles, scorpions, and centipedes. They will eat the occasional lizard or other small vertebrate. After capturing prey items, Pallid bats fly to a night roost, where they hang apart from other bats and protect their food with their wings and body while they consume it. In Kansas, echolocation calls of this species have been recorded in the numerous pastures that surround the deeply incised canyons.

Figure 30. In Kansas, Pallid bats roost in rocky canyons such as those seen in the background and forage in the surrounding prairies. *Photo by Jeff Miller.*

Conservation. Pallid bats have always been rare in Kansas. Unfortunately, in 1964, about 200 of these bats were intentionally burned out of a crevice in Barber County by ranch hands. The only other locality where these bats were occasionally found was a barn near the town of Aetna that has not been occupied by Pallid bats since the early 1960s. By 1990, they had all but disappeared from the state, although the best data indicate that about a dozen of these bats continued to occupy the rock crevice near the former Natural Bridge (which was dynamited at the same time). Currently, researchers at Emporia State University are completing a detailed study of this species. Data from this study indicate that Pallid bats are more abundant than previously thought, with bats occurring in several of the rocky canyons in Barber County. The Pallid bat is among the rarest bats in the state and is listed by the KDWP as a "Species in Need of Conservation" (SINC).

Townsend's big-eared bat, *Corynorhinus townsendii*

Description. A large bat with lumps on its nose and enormous, naked ears. Unlike the Pallid bat, the ears are joined basally along the midline. The pelage is pale brown above and below, and the hairs are long, soft, and unicolored. Adults may attain the following dimensions: total length 95-105 mm; tail 40-50 mm; hind foot 9-16 m; ear 29-38 mm; weight 8-11 grams.

Distribution. Townsend's big-eared bats occur from south-central British Columbia to central Mexico, and from the West Coast eastward to central South Dakota and south-central Kansas, with isolated populations occurring in both the Ozark (*C. t. ingens*) and Appalachian (*C. t. virginianus*) mountains. In Kansas (Map 2), the species is known only from Barber, Comanche, and Kiowa counties, where it inhabits caves, mines, and abandoned buildings. The three disjunct populations are currently recognized as subspecies of a single species, but likely represent distinct species because of their geographic isolation and morphological differences. Further study is necessary to confirm this, but if true, the species in Kansas likely would be known as *Corynorhinus pallescens*.

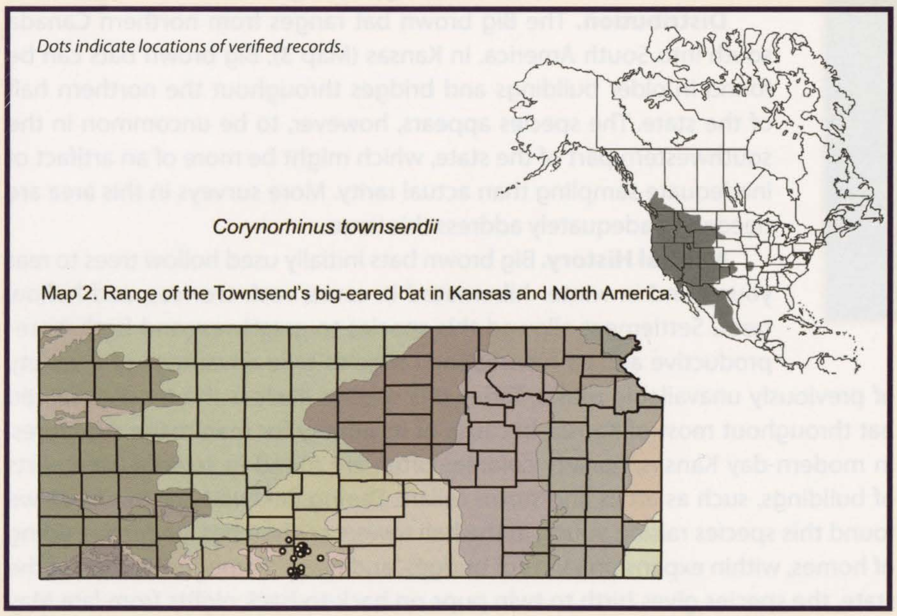
Natural History. Townsend's big-eared bat needs caves. In all parts of its range, it relies primarily on caves for shelter, although we have observed several of these bats in man-made habitats. The majority of such instances were bats located in partly lit basements, storm cellars, and in one case a 1950s-era fallout shelter. Individuals have recently been observed roosting in a dimly lit attic of a dilapidated farm house, and in June a maternity colony was found roosting in a root cellar that had been dug into a bluff behind the house.

Figure 31. Hibernating cluster of Townsend's big-eared bat. Note that some bats have their ears rolled up while others are erect. *Photo by Alexis Powell.*

Nursery colonies in Kansas are formed near the openings of caves with low ceilings in early May. Pups are born in June, and are on the wing by the end of July.

As in most other North American species, males are widely scattered during summer, and most big-eared bats captured in man-made dwellings are males. Though they have not been reported to occupy bat houses, those wishing to provide such roosts should consider building relatively large, open structures.

Winter groups include all sex and age classes, and hibernacula often are in the coldest parts of caves. Hibernating individuals tend to keep their large ears coiled behind the head in a way that is visually reminiscent of a big-horned sheep, whereas animals in a group tend to keep at least one ear uncoiled. These bats seem to be much more sensitive to disturbance during winter than other species, which may indicate that they do not hibernate as deeply as other cave bats. Upon approaching a cluster of these bats, biologists often find ears moving toward them in a way reminiscent of a missile targeting system. Unfortunately, this sensitivity has contributed to population declines in other parts of its range. By not hibernating as deeply as the *Myotis* and similar species, this bat may have some level of protection from WNS.



Map 2. Range of the Townsend's big-eared bat in Kansas and North America.

Townsend's big-eared bat emerges after it is completely dark. In flight, big-eared bats have a characteristic "head down" appearance because they extend their large ears nearly directly out in front of them. Townsend's big-eared bats feed primarily by capturing flying insects close to, or by gleaning resting insects from, dense vegetation. The diet consists primarily of moths. Often the bats land to feed. A night roost used frequently by this species may be littered with moth wings.

Conservation. Both eastern populations (presently listed as separate subspecies) of this animal currently are listed as endangered by the United States Fish and Wildlife Service (USFWS). The Kansas subspecies is currently listed by Kansas Department of Wildlife and Parks (KDWP) as a Species in Need of Conservation (SINC). Long-term population monitoring by Stan Roth and colleagues indicates that this species has remained relatively stable through time.

Big brown bat, *Eptesicus fuscus*

Description. The Big brown bat is one of the largest bats in Kansas, with a large head and broad nose. The ears are short and rounded, the tragus is broad and blunt, the wings are short and broad, and the calcar is keeled. The pelage is soft and somewhat oily in texture. Pelage color depends on location, ranging from light tan to rich brown dorsally, somewhat paler ventrally. Hairless areas of the face, ears, wings, and tail membrane are almost black. This species can be distinguished from the smaller evening bat by having two rather than one upper incisor. *Myotis* differs from *Eptesicus* by having 2 tiny teeth behind the canine (creating the appearance of a space), whereas the Big brown bat has a series of larger teeth behind the canine. Adults may attain the following dimensions: total length 110-130 mm; length of tail 39-54 mm; length of hind foot 9-13 mm; length of ear 14-20 mm; weight 16.5-33 g. As in many other species of bats, females average larger than males. Weight is greater in autumn than in spring because of the layer of fat accumulated during summer for use as metabolic energy during winter.

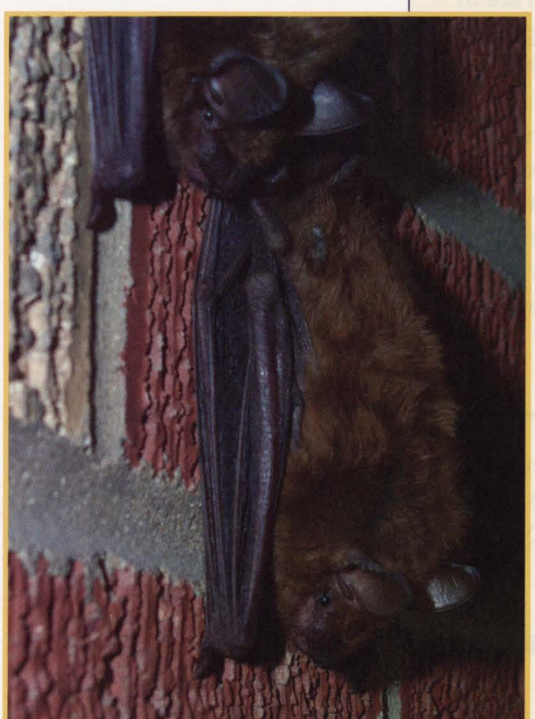
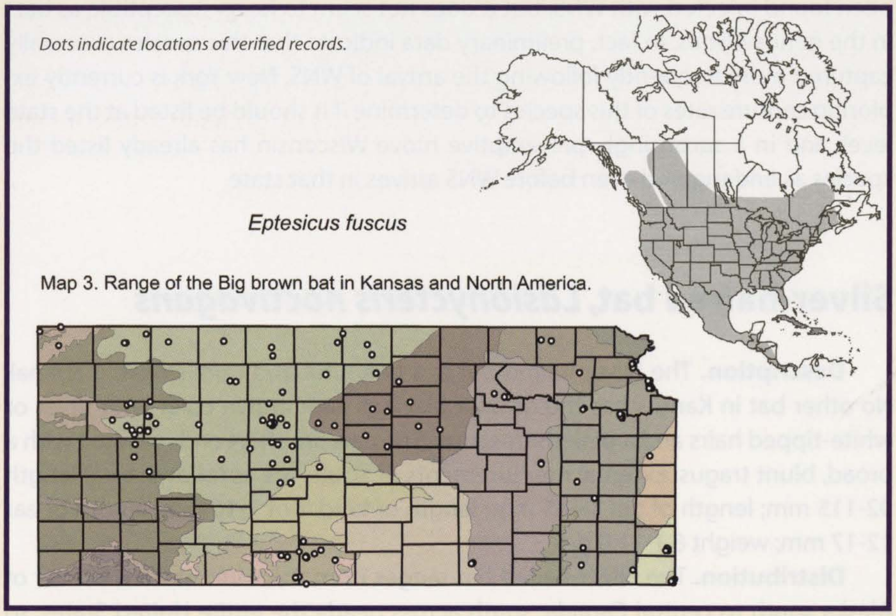


Figure 32. In Kansas Big brown bats share many buildings with people. *Photo by Dale W. Sparks*

Distribution. The Big brown bat ranges from northern Canada south into South America. In Kansas (Map 3), Big brown bats can be found in older buildings and bridges throughout the northern half of the state. The species appears, however, to be uncommon in the southwestern part of the state, which might be more of an artifact of inadequate sampling than actual rarity. More surveys in this area are needed to adequately address this issue.

Natural History. Big brown bats initially used hollow trees to rear young and in winter hibernated in caves, rock crevices, and hollow trees. Settlement allowed this species to greatly expand both its reproductive and its hibernating range to take advantage of a variety of previously unavailable roosts. Today this species likely is the most observed bat throughout most of Kansas because of its affinity for man-made structures. In modern-day Kansas, nursery colonies often are found in seldom-used parts of buildings, such as attics and storm cellars. During fieldwork for this book we found this species raising young in the bell towers of churches, under the siding of homes, within expansion joints of bridges, and barns. Throughout most of the state, the species gives birth to twin pups on back-to-back nights from late May to mid June with most juveniles being volant by the middle of July.



Map 3. Range of the Big brown bat in Kansas and North America.

As with other Kansas bats, male Big browns are widely scattered during summer. Males may be found roosting either in small groups, mixed in with females in a maternity colony, or as isolated individuals in a variety of structures. Male roosts are typically under shutters on the sides of buildings, or under bridges, and occasional males are seen roosting during the day on the sides of buildings with little or no apparent protection. Individual adult males also may be found within maternity colonies.

Figure 33. A Big brown bat ensnared in a mist net.
Photo by Andrew Knioski

Big brown bats are among the most hardy of North American bats and use a wide variety of hibernacula. Most hibernate in buildings, but they are also commonly found in caves, bat houses, rock crevices, and a variety of other roosts. Although some individuals hibernate in their summer quarters, most migrate short distances to hibernacula. In Ellis County we have observed hundreds, if not thousands, of bats of this species hibernating in the attic of the Saint Fidelis church, also known as the Cathedral of the Plains, in Victoria. In mid-winter we heard the vocalizations of this bat coming from expansion joints under a bridge in Yocemento.

At emergence, Big brown bats follow a nearly direct path toward their feeding areas and may use the setting sun as an orientation cue. These bats fly straight paths with fewer wing beats than most other species. Big brown bats living in cities may commute several miles to reach more rural foraging areas. These bats often forage around lights, even in urban settings. In other Midwest states, Big brown bats eat mostly beetles, although they also eat ichneumon wasps, ants, stinkbugs, and other hard-bodied insects. Because Big brown bats eat many pest species, are common, readily inhabit human structures, and tolerate extreme climatic conditions, they are among the most important species to farmers in Kansas.

Conservation. The settlement of Kansas allowed the Big brown bat to increase in both distribution and numbers in Kansas. This is probably the most numerous bat in the state, and as such is not in need of special protection, other than being protected from wanton destruction. In the northeast, this species has been found infected with WNS, but it does not seem to be as susceptible as bats in the genus *Myotis*. In fact, preliminary data indicate that this species is actually captured more frequently following the arrival of WNS. New York is currently exploring capture rates of this species to determine if it should be listed at the state level, and in a surprisingly pre-emptive move Wisconsin has already listed the species as endangered even before WNS arrives in that state.

Silver-haired bat, *Lasionycteris noctivagans*

Description. The Silver-haired bat is a beautiful and unmistakable animal. No other bat in Kansas has the distinct black or dark brown color with silver or white-tipped hairs and a pink-rimmed ear. The ears are short and rounded with a broad, blunt tragus. External measurements of adults are as follows: total length 92-115 mm; length of tail 35-45 mm; length of hind foot 7-10 mm; length of ear 12-17 mm; weight 8.1-11.0 g.

Distribution. The Silver-haired bat ranges from the southeastern border of Alaska south to central Canada, south across nearly the entire United States, to northern Mexico. The Silver-haired bat is migratory within this range, and can occur anywhere in Kansas (Map 4) during this migration.

Figure 34. Silver-haired bat captured during spring migration along Bow Creek in Rooks County, Kansas. *Photo by Dale W. Sparks*

Natural History. These bats are migratory. They inhabit upper slopes of mountains and northern latitudes during summer. In autumn, they migrate to southern North America. In Kansas, captures of Silver-haired bats peak during the months of May in spring and September in fall. It is possible that males and females have different migratory paths through the state.

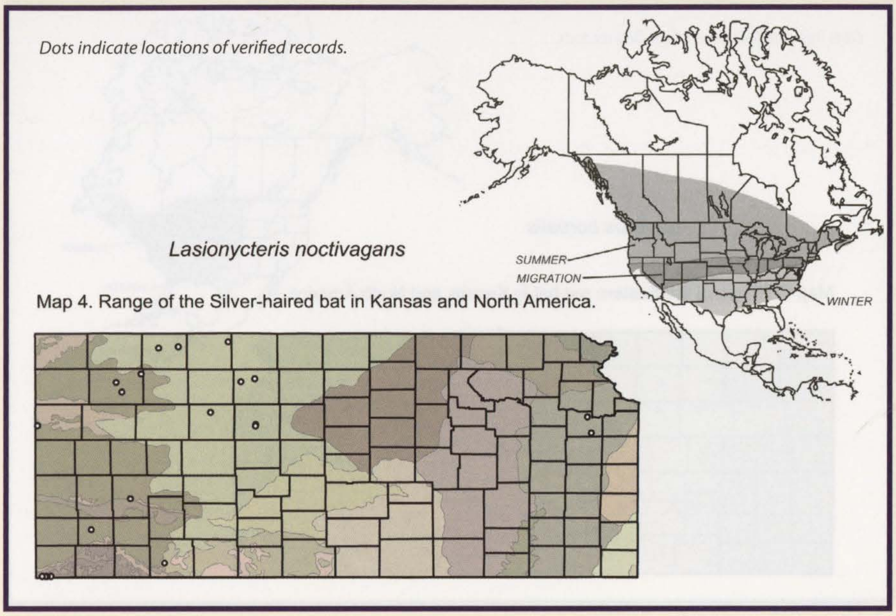
Though the species is not known to produce young in Kansas, one of the females we captured contained a very small fetus. Small maternity colonies are formed in hollow trees and females give birth to twins between late May and early July. In Iowa, juveniles were flying as early as 22 July, and milk production ceased by early September.

Winter range of the Silver-haired bat appears to be defined by temperature gradients. Occasional hibernating individuals are found in trees, rock crevices, caves, and buildings. One Silver-haired bat was captured roosting in a hole in the ground; such unusual roosting habitats may be used as migratory stopovers. Most migrating Silver-haired bats appear to roost under the exfoliating bark of trees.

Even the time of emergence of the Silver-haired bat is open to question. Although they emerge early in the evening over much of their range, the time of emergence varies with time of year, weather, and the presence of competitor species. The flight is slow, often close to the ground, and the same circuit may be followed several times in succession.

Silver-haired bats feed heavily on caddisflies, moths, flies, and true bugs with other types of insects being consumed less frequently.

Conservation. Until the widespread development of commercial wind farms, there was little that would indicate that Silver-haired bats faced any real threats in Kansas because the species is present only as a migrant. Migration, however, is the time when this species is most frequently killed at wind energy facilities. At present, there are no data about mortality rates at wind farms in Kansas.



Map 4. Range of the Silver-haired bat in Kansas and North America.

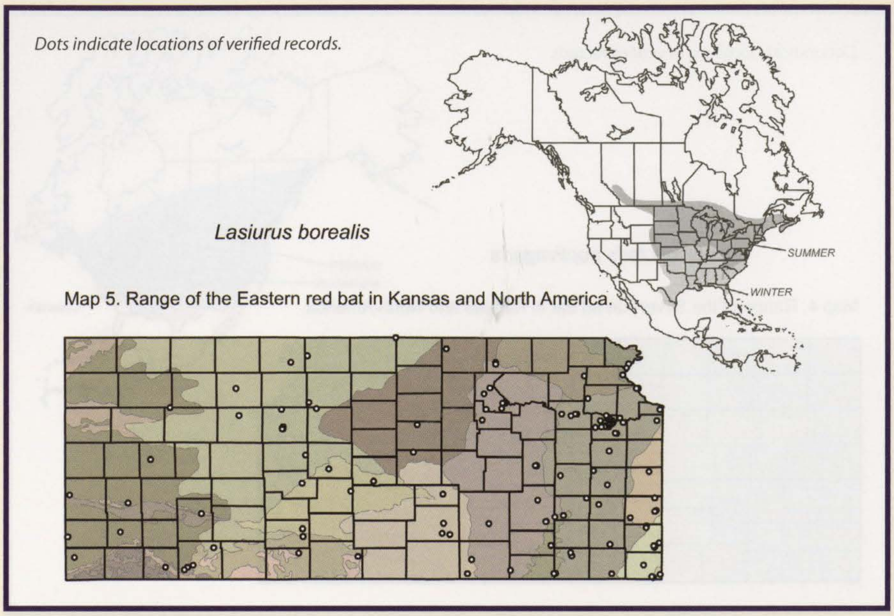
Eastern red bat, *Lasiurus borealis*

Description. Males and females are different colors. Males are a bright red color, whereas females tend to be reddish with gray or silver tinted hair tips. However, both sexes have a buffy white patch on each shoulder. Eastern red and Hoary bats are the only bats in Kansas to have fully furred tail membranes. Adults may attain the following dimensions: total length 103-124 mm; length of tail 43-60 mm; length of hind foot 8-10 mm; length of ear 10-14 mm; weight 6-14 g.

Distribution. The Eastern red bat occurs throughout eastern North America from central Florida to western Texas and from the Gulf of Mexico to just north of the Canadian border. In Kansas (Map 5), the Eastern red bat occurs statewide, and may be the most common species in the extreme southwestern part of the state.

Natural History. Eastern red bats are summer residents of Kansas, but most probably migrate south for winter. During fieldwork for this book, we encountered a migratory pulse of both this and the closely related Hoary bat during a mid-September trip to Cimarron National Grasslands. We suspect some eastern red bats are year-round residents, particularly in southeastern Kansas because there are known hibernating populations in southwestern Missouri. These are tree bats during all times of the year and spend most of their lives hiding among the leaves at the end of branches. During very cold weather, the bats enter leaf litter where they wrap up in their tail like a blanket. The fur of this species becomes more insulative (probably by increasing the number of hairs) during winter, which may be an important aid to spending the winters exposed. Although occasionally seen flying into the entrance of caves, eastern red bats that enter caves or buildings for extended periods of time seem to become torpid and die.

Figure 35. Male Eastern red bats are bright strawberry blonde in color.
Photo by Andrew Knioski



Map 5. Range of the Eastern red bat in Kansas and North America.

Eastern red bats mate in autumn and mating is initiated in flight. Fertilization is delayed until late spring and one to four pups are born in early June. Unlike most bats, this species has four teats, which allow the mother to feed such large broods. While the mother forages, the juveniles are left at the day roost high in the canopy of trees. Young begin to fly in mid- to late June.

During summer, these bats emerge 20-30 minutes after sunset. In heavily forested landscapes, they make commutes of several miles, although animals roosting within scattered trees in more open land begin foraging almost as soon as they emerge. Foraging Eastern red bats have a straight, rapid flight pattern with occasional sharp turns when they try to capture an insect. Eastern red bats often forage around lights in rural and suburban areas but not in urban areas, and foraging areas are often associated with edge habitat. In Kansas, we have seen many individuals foraging on the field sides of riparian forests and they also routinely forage along rows of trees planted as windbreaks. There is some evidence that this species eavesdrops on the echolocations of other Eastern red bats, and may attempt to capture a particularly desirable food item that another bat has detected. Eastern red bats feed on a variety of insects including true bugs, moths, and beetles.

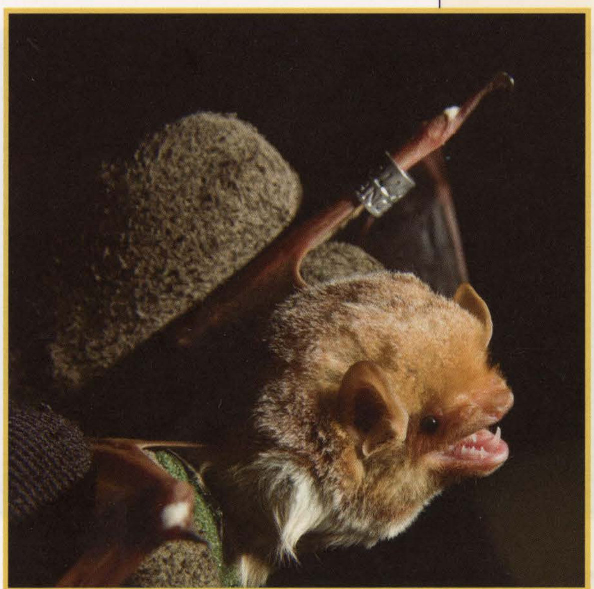


Figure 36. The scattered white hairs on female Eastern red bats make them appear more gray in color than males. *Photo by Andrew Knioski*

The public most often comes into contact with this species when a female and her dependent young are blown out of their roost during storms and come to rest on the sides of trees or houses. When this occurs, the bats must either climb high enough to regain flight, or become prey for a variety of predators.

Conservation. Both the Eastern red bat and the Hoary bat originally occurred throughout Kansas. However, the habitat (trees) of both species has dramatically increased since the state was settled. Presumably, both of these species are now far more common than prior to settlement, and currently neither is in need of special protection in Kansas. There is no evidence that this bat gets WNS. Because these bats are solitary, an infected bat is most likely to die before passing the disease to other bats. However, this and the closely related Hoary bat are the two species most commonly killed at commercial wind turbines. To date, there are no data available about mortality of this species in Kansas. At wind farms throughout North America, most mortality occurs during migration, and this is likely to be the case in Kansas as well.

Hoary bat, *Lasiurus cinereus*

Description. Its white-tipped or frosted (hoary) fur and heavily furred tail membrane readily identify the largest common bat in Kansas. The ears are short and rounded and edged in black. The wings are noticeably long and pointed. Adults may attain the following dimensions: total length 133-150 mm; length of tail 46-65 mm; length of hind foot 11-14 mm; length of ear 17-20 mm; weight 19.5-34.5 g.

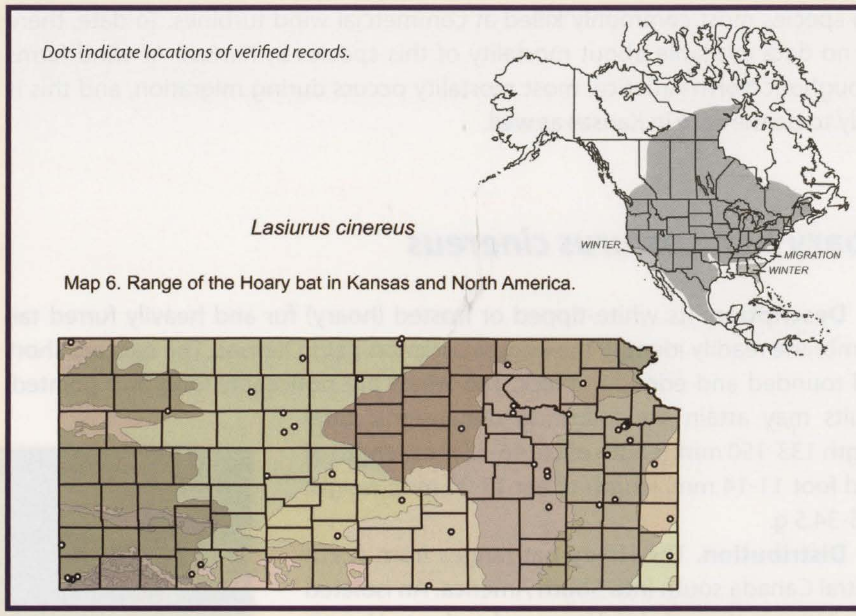
Distribution. The Hoary bat ranges from north central Canada south into South America. An isolated population is the only land mammal native to Hawaii. These bats are strong flyers and occasional bats are known to alight on ships at sea and have been found in islands off the coast of Scotland. In Kansas (Map 6), the Hoary bat is found statewide during summer and it may be super-abundant during migration. The recent discovery that the closely related Eastern red bat hibernates in adjacent areas of Missouri raises the question as to whether this species hibernates in Kansas.

Figure 37. Hoary bat captured in Brown County, Kansas.
Photo by Dale W. Sparks

Natural History. Like the Eastern red bat, the Hoary bat is a migratory tree bat. Roosts of Hoary bats can be located in either deciduous or coniferous trees. Some have suggested that most roosts are found 15-21 ft off the ground and observable only from directly beneath. However, radio-tracked bats have been tracked to the tips of cottonwood limbs more than twice the height of those previously reported. Occasional individuals are found in buildings, but the species does not regularly roost in or even on buildings. There is evidence that this species is at least partly sexually segregated during summer, and we found nearly twice as many females as males in Kansas.

Hoary bats generally produce twins, which are born from late May to early July and are volant approximately one month later. Like the Eastern red bat, female Hoary bats with attached juveniles often are knocked out of trees and cannot take flight.

Hoary bats emerge late in the evening after darkness in near total darkness. During migration, Hoary bats emerge earlier. In fact, one of the authors (CJS) captured an individual in a mist net as it emerged from a nearby tree as the sun had just set, well before complete darkness. This was so unexpectedly early that it was first thought to be a bird. Their flight is bird-like, consisting of wing flaps and short glides. They frequently fly at elevations in excess of 180 ft, which makes them extremely difficult to capture using traditional netting techniques. In summer, Hoary bats generally are solitary although several may be seen hunting in the same area, particularly over water in otherwise dry areas. Groups of Hoary bats, presumably migrating together, have been seen and captured. During work



Map 6. Range of the Hoary bat in Kansas and North America.

for this book we were surprised to encounter such a migration during mid-September on the Cimarron National Grasslands. For two nights, every net yielded at least one Hoary bat. Accoustical surveys associated with development of wind farms promise to yield a much more detailed understanding of the migratory behavior of this and other similar species. In Ontario, they are most active over forest edge sites and sites with cover. They also may feed on insects around lights.

Hoary bats detect prey items at greater distances than do other bat species. The diet of Hoary bats includes mostly large moths, but other insects also are eaten. Hoary bats occasionally attack smaller bats, but these may be cases of bats infected with a furious strain of rabies, bats defending territories, or actual predation events.

Conservation. Both the Eastern red bat and the Hoary bat originally occurred throughout Kansas. Likewise, the habitat (trees) of both species has dramatically increased since the state was settled. Presumably, both of these species are now far more common than prior to settlement. Unfortunately, these are the two species most commonly killed at wind turbines. Because mortality is most common during migration, there is some hope that modification in how wind farms operate, including discontinuing operations at low wind speed during the time when bats migrate, may reduce mortality events.

Western small-footed myotis, *Myotis ciliolabrum*

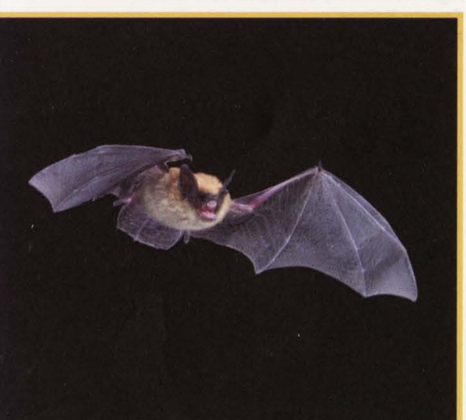


Figure 38. Western small-footed myotis in flight. *Photo by Bruce D. Taubert*

Description. A small blonde bat with dark wings and a dark (raccoon-like) face mask. Adults may attain the following dimensions: total length 80-99 mm; length of tail 37-49 mm; length of hind foot 6-9 mm; length of ear 12-16 mm; weight 3.3-5.9 g.

Distribution. The Western small-footed myotis ranges from central Alberta southward and westward along the Cascades and Sierra Nevadas into central Mexico and north into central Nebraska. In northwest Kansas (Map 7), the species inhabits outcrops of the Niobrara Chalk and similar substrates, where it is currently known from only four counties (Trego, Gove, Logan, and Cheyenne).

Natural History. The Western small-footed myotis is among the most poorly known species of bat in North America. This species inhabits cracks in rocky bluffs. In summer, these hang singly in the open on cliff faces and may form small colonies in cracks or crevices. Day roosts may be in old buildings, and even in abandoned swallow nests, and are typically small, dry, and hot. In other parts of the country Western small-footed myotis hibernate in caves and mines, but no such structures are available inside the known range of the species in Kansas. Thus, we suspect Western small-footed myotis in Kansas hibernate in rock crevices near those occupied in summer. Night roosts may be found in caves, crevices, and man-made structures. We suspect that this bat would benefit from artificial roosts that are attached to naturally existing rock faces that otherwise offer no roosting opportunities.

Figure 39. Western small-footed myotis in Kansas are closely associated with outcroppings of the Niobrara Chalk including Monument Rocks in Gove County.
Photo by Jodi Farrell Sparks

A single pup usually is born in early to mid-June, although one record of twins exists. Nursing females are solitary or form small colonies. The first young are volant by the end of July, and all young can fly by early August.

Western small-footed myotis emerge from day roosts slightly later than eastern red bats and tri-colored bats but before complete darkness. Flight is erratic, typical of the genus *Myotis*, but is distinctive because of the small size of these bats. They feed on moths, true bugs, and flies.

Conservation. The Western small-footed myotis inhabited Kansas prior to settlement. Its current status in Kansas is poorly known, but it probably has declined because of disturbance during the breeding season and destruction of habitat. Studies in other states also suggest that the species is declining.

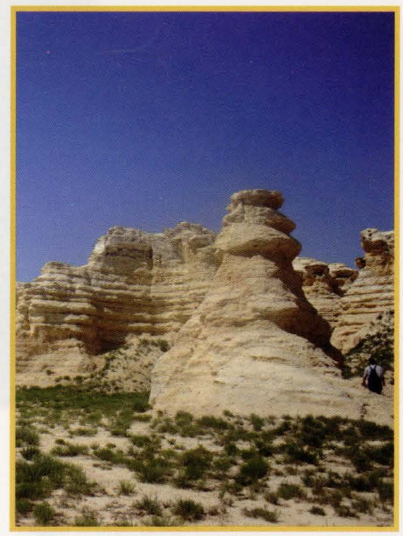
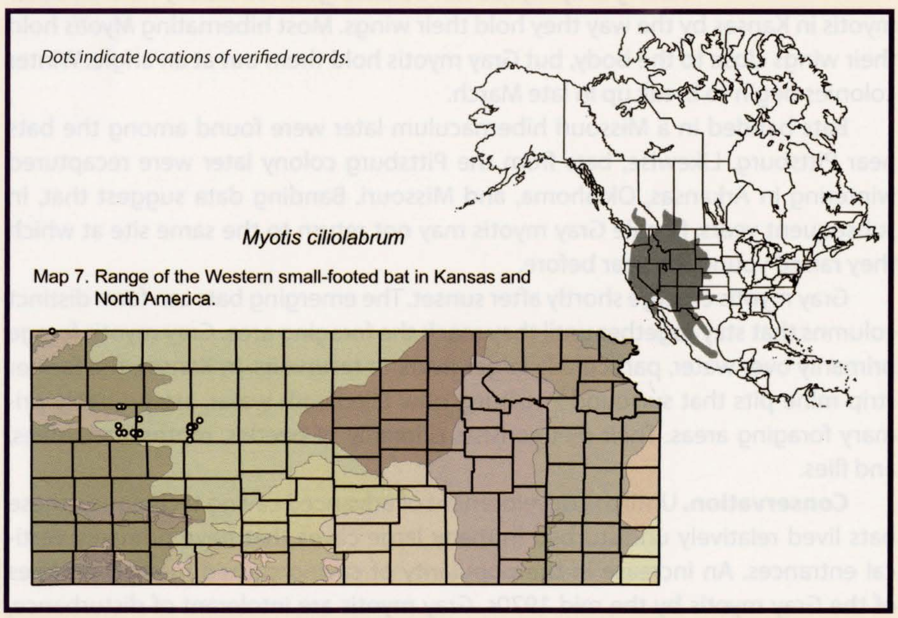


Figure 40. One of the authors searches the area near Castle Rock in Gove County for western small-footed myotis.
Photo by Jodi Farrell Sparks



Map 7. Range of the Western small-footed bat in Kansas and North America.

Gray myotis, *Myotis grisescens*

Description. A medium sized bat with uniformly gray fur, and the wing membrane attaching at the ankle rather than the base of the toes as it does in most other *Myotis*. Another unique feature is the presence of notches on the claws of the hind feet. Adults may attain the following dimensions: total length 88-107 mm; length of tail 32-45 mm; length of hind foot 9-13 mm; length of ear 12-16 mm; weight 8-16 g.

Distribution. The Gray myotis ranges from east-central Oklahoma northward to central Missouri, eastward to western Virginia, and southward to near the Gulf Coast in Alabama. In Kansas (Map 8), the Gray myotis has been recorded only from Crawford and Cherokee Counties. A colony has been located in the Pittsburg area since the 1950s.

Natural History. Although a variety of temporary roosts may be used on occasion, Gray myotis typically are cave bats. They also are gregarious, forming large colonies that may range from a few hundred to a quarter-million individuals.

Figure 41. A gray myotis roosting in the storm sewer of Pittsburg, Kansas. *Photo by Travis W. Taggart*

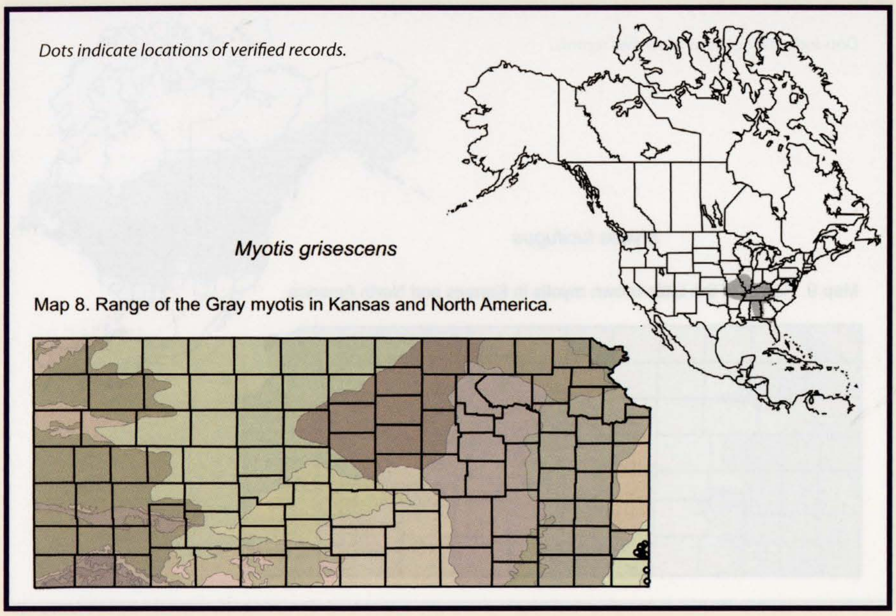
Females arrive at the maternity sites in April. The colonies are typically in large caves that have a stream flowing through them. Females give birth to a single pup in June. Young are flying by July, when the large maternity colonies begin to disband. The colony in Kansas follows this same pattern, but on a smaller scale.

Adult female Gray myotis are the first animals to arrive at the hibernacula, followed shortly by juvenile females, then juvenile males, with adult males being the last to arrive. During winter, the species forms some of the largest colonies of bats in the United States. Most Gray myotis winter in six caves in the southeastern United States. Hibernacula often are in excess of 100,000 animals but can range from fewer than 10 to 300,000. Clusters are large and can be several tiers of bats deep. Hibernating Gray myotis can be distinguished readily from all other myotis in Kansas by the way they hold their wings. Most hibernating *Myotis* hold their wings close to the body, but Gray myotis hold them out at an angle. Winter colonies begin to break up in late March.

Bats banded in a Missouri hibernaculum later were found among the bats near Pittsburg. Likewise, bats from the Pittsburg colony later were recaptured wintering in Arkansas, Oklahoma, and Missouri. Banding data suggest that, in subsequent years, female Gray myotis may not return to the same site at which they raised young the year before.

Gray myotis emerge shortly after sunset. The emerging bats can form distinct columns that stay together until they reach the foraging area. Gray myotis forage primarily over water, particularly larger rivers or reservoirs. In Kansas, the former strip mine pits that surround Pittsburg, now filled with water, are probably primary foraging areas. Their diet consists primarily of beetles, moths, caddisflies, and flies.

Conservation. Until the development of advanced caving techniques, these bats lived relatively undisturbed in many large caves that have primarily vertical entrances. An increase in the popularity of caving caused marked declines of the Gray myotis by the mid 1970s. Gray myotis are intolerant of disturbance, and any individual who enters a cave known to contain the species (particularly during summer) is doing so at a substantial risk of causing the destruction of the



Map 8. Range of the Gray myotis in Kansas and North America.

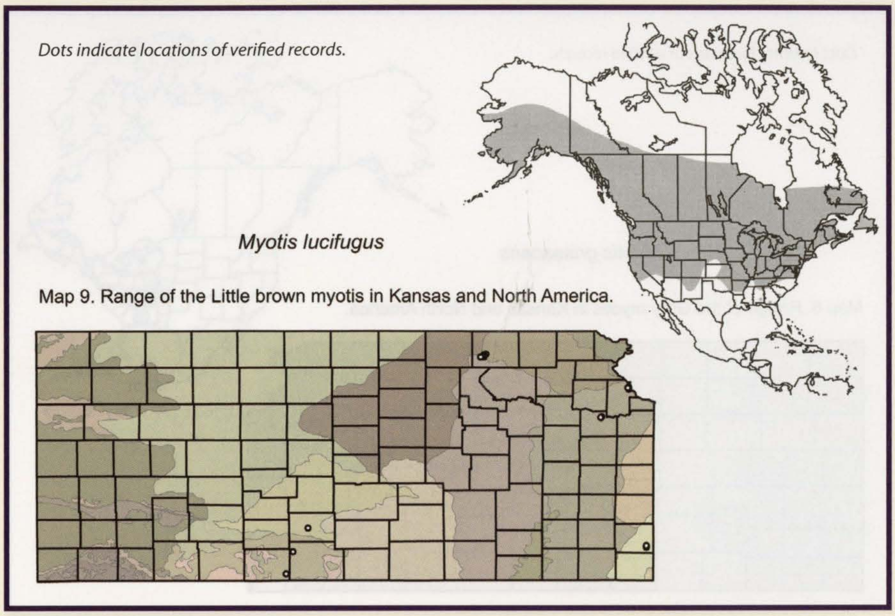
colony. Extensive management of caves (including cave gating) resulted in rapid population increases during the 1990s and an effort was underway to remove the species from the federal endangered species list, when White Nose Syndrome became a national crisis.

The only known colony of this species in Kansas is near Pittsburg. During the 1960s, estimates of the size of the colony ranged between 5,000 and 6,000 bats. It was estimated in the early 1980s that only about 2,400 Gray myotis remained in that colony. The Gray myotis is categorized as endangered at both the state and federal level, and every attempt should be made to protect the future of this species in Kansas. In spring 2010, Gray myotis in Missouri were found with wing scarring characteristic of WNS. DNA markers for the fungus that presumably causes WNS were recovered from these same bats. Given the extreme gregariousness of the species, it seems reasonable that WNS infected Gray myotis will arrive in Kansas by spring 2011.

Little brown myotis, *Myotis lucifugus*

Description. A small bat with hair that is brown at the base with shiny upper parts. The calcar is not heavily keeled, hairs on the toes project beyond the tips of the toes, and the ear when laid forward reaches only to the end of the nose. The tragus is blunt. Identification of this species should be verified by a person with experience identifying bats. Adults may attain the following dimensions: total length 85-100 mm; length of tail 33-40 mm; length of hind foot 8-11 mm; length of ear 14-16 mm; weight 5.5-8.5 g.

Distribution. The Little brown myotis ranges from central Mexico northward to central Alaska and eastward to the Atlantic Coast. In Kansas (Map 9), historic records are scattered throughout the eastern half of the state. Because of the lack of recent records, the present distribution of the species in the state is unknown. Little brown myotis were never common in Kansas, but now they are either very rare or extirpated. Efforts should be made to determine if the species still occu-



Map 9. Range of the Little brown myotis in Kansas and North America.

pies caves and abandoned mine shafts, particularly along the Kansas/Missouri border.

Natural History. Prior to the arrival of settlers, Little brown myotis probably used dead trees as summer roosts. As is the case with Big brown bats, most colonies of Little brown myotis now are found in buildings. Winter roosts are located in caves and mines.

Maternity colonies of Little brown myotis often occur in man-made structures and can contain several thousand individuals. There are no known Little brown myotis maternity colonies in Kansas. If they occur, such colonies are most likely to occur in the attics of buildings within a few miles of the Kansas/Missouri border. As with other species of bats that frequently inhabit buildings and other structures, Little brown myotis often use bat boxes.

In Ontario and adjacent areas of Quebec and New York, young are born between 7 June and 5 July. Births occur earlier in Indiana and Illinois, and presumably occur increasingly early in more southern parts of the range. Young develop quickly and are on the wing less than three weeks later. Juvenile bats in Indiana are born much smaller than juvenile bats in New Hampshire, although they reach approximately the same adult size. Flight skill also develops quickly, with first flights short in duration and occurring when conspecifics are not flying in the area. Some young then proceed to hunting insects from a perch and, at an age of 24-27 days, the flight of juveniles is indistinguishable from that of adults. The young and some adults may use a scent post near the maternity colony as an orientation cue. Other than scent posts, communication is limited to vocalizations and a simple social structure exists.

Figure 42. Little brown myotis may still occur in the caves and mines of eastern Kansas. This type of loose, linear cluster is typical of the species.
Photo by Erin Basiger, ESI

Adult males occasionally are found living within a maternity colony, but most adult males spend summer apart from females. Male roosts, like maternity colonies, often are in man-made structures. However the structures are less roomy than those chosen by females and include structures such as creases in tents, space behind window shutters, and even areas beneath the eaves of porches.

After foraging, an individual may fly to a night roost, often under a bridge with concrete I-beam support. Communal night roosting in this species may serve as a thermoregulatory aid that allows more rapid growth of the fetus.

These bats primarily hibernate in caves in winter. They rarely form large clusters, but occasionally up to several hundred to several thousand individuals. They often consist of loose, often linear groups. A single chamber may contain several hundred representatives of this species. Previously a large number of these bats hibernated in a gypsum mine that was located near Blue Rapids just south of the Kansas/Nebraska border. All entrances of this mine are now closed. Some movement occurs between hibernacula. Even when they emerge from the hibernacula for several hours during winter, they do not feed.

Little brown myotis emerge to forage late in the evening just before complete darkness. The relatively broad wings permit extreme maneuverability. Flight often is described as being "fluttery" because these bats frequently swoop to capture insect prey. These bats frequently forage over water. The diet of the Little brown myotis consists of moths, mayflies, flies, and beetles.

Conservation. The Little brown myotis has benefited from man-made habitats in much of the country. In Kansas, however, the species has never been common, except in an abandoned and now closed gypsum mine near Blue Rapids. Occasional individuals and small clusters were sometimes found in the abandoned mines and caves that occur along the Kansas/Missouri border. Studies of the bats of eastern Kansas turned up no individuals of this species, although echolocation calls consistent with the species were recorded. As recently as 2007, this bat was among the most common mammals in the Northeast, but the arrival of White Nose Syndrome has led to massive population declines. As a result, USFWS has been petitioned to use emergency authority to immediately list the species as endangered.

Figure 43. The long ears and tragus of this northern myotis are clearly visible.
Photo by Andrew Knioski

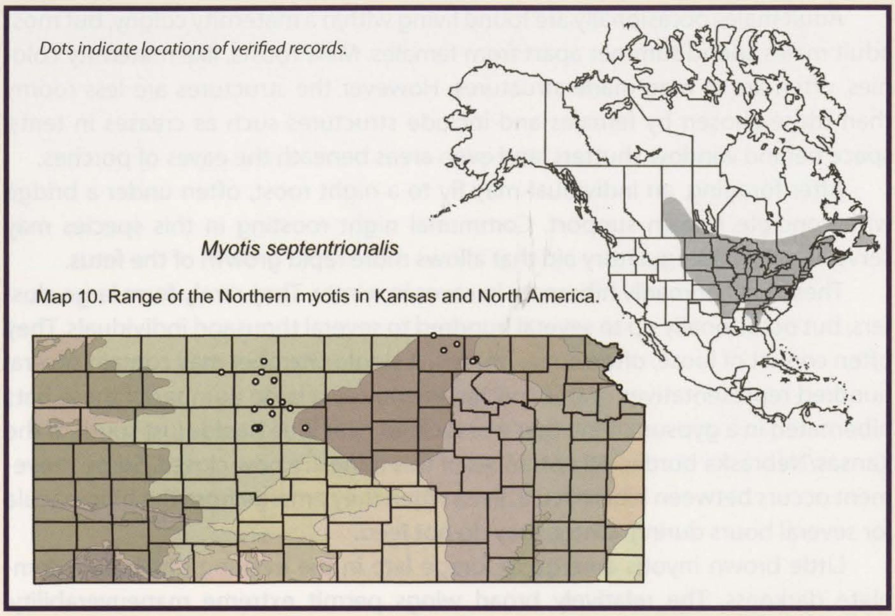
Northern myotis, *Myotis septentrionalis*

Description. A small bat with ears that extend beyond the tip of the nose when laid forward, a weakly keeled calcar, and gray fur with a golden wash. The ears are long and rounded, with a distinctively long and sharply pointed sometimes curved tragus. Adults may attain the following dimensions: total length 86-99 mm, length of tail 36-43 mm, length of hind foot 8-10 mm, length of ear 16-18 mm, weight 5.2-8.4 g.

Distribution. The Northern myotis ranges from easternmost Quebec west to central Saskatchewan and south to northern Florida. In Kansas (Map 10), this species currently is known from only eight northeast and north-central counties. We suspect the species occurs in many riparian woodlands throughout the northern half of the state. More thorough sampling is needed to confirm this.

Natural History. This is a true forest bat, although it occasionally roosts in buildings and in bat boxes. Bats of this species are found in a variety of roosts, but usually form maternity colonies in hollow trees, although exfoliating bark is often used.

In late spring, bats leave hibernacula and individuals may migrate long distances in order to reach summer areas. Females form breeding colonies that ap-



Map 10. Range of the Northern myotis in Kansas and North America.

pear to average about 30 adults, although larger colonies have been reported. Mating occurs prior to hibernation. Most young are born in June and probably are volant by late July. Earlier authors assumed the Northern myotis was present in Kansas primarily as a migrant, but this bat is one of the species most often captured along riparian corridors in north central Kansas.

Males spend summer either alone or in small groups and summer roosts may be shared with other species. Roost locations are varied, including bridges, bat boxes, and abandoned buildings.

Northern myotis winter in caves, mines, and other such structures. Hibernation lasts from October to March in eastern Missouri. Although several hundred may inhabit a given cave, often very few individuals can be found. Individuals often hibernate separately, often in broken stalactites, cracks, and crevices. We strongly suspect that Northern myotis in Kansas hibernate in rock crevices in the state's many rocky outcrops. They do not feed during winter even though they may emerge from time to time.

Northern myotis emerge about half an hour after sunset. They tend to forage in forested areas, even if these woodlands are only a few acres. Their diet includes moths, true bugs, ichneumons, and flies. These animals appear to feed on insects both by capturing prey on the wing and by gleaning prey from surrounding structures which explains the regular presence of spiders in the diet. Some animals occupy a night roost and re-emerge to forage a second time immediately before dawn.

Conservation. The Northern myotis has probably migrated across the state for many years, with some small breeding populations also being present. However, we suspect that the species has been increasing in both range and numbers since at least the 1960s. Unfortunately, this species is susceptible to White Nose Syndrome. USFWS has also been petitioned to list this species as federally threatened or endangered.

Figure 44. Northern myotis resting on a tree.
Photo by Andrew Knioski

Cave myotis, *Myotis velifer*

Figure 45. Historically cave myotis were restricted to the caves of the Red Hills region in Kansas. This photo includes bats that range in age from newborn to approximately 2 weeks of age.
Photo by Shauna Marquardt

Description. The Cave myotis is a medium sized bat with fur that is dull brown or tan on top with a darker base. The forearm of adults is always longer than 1 3/4 inches. The ears are short and rounded and the nose appears to be "stubby." Adults may attain the following dimensions: total length 97-115 mm; length of hind foot 10-13 mm; length of ear 15-17 mm; weight 9-17 g.

Distribution. The Cave myotis ranges from Honduras north to the California/Nevada border and east to Kansas. In south-central Kansas (Map 13), the Cave myotis is known from the Oklahoma border north to Rush County, east to Harper County, and west to Meade County. The species likely is restricted to the Red Hills during winter, with individuals dispersing into many surrounding counties during summer.

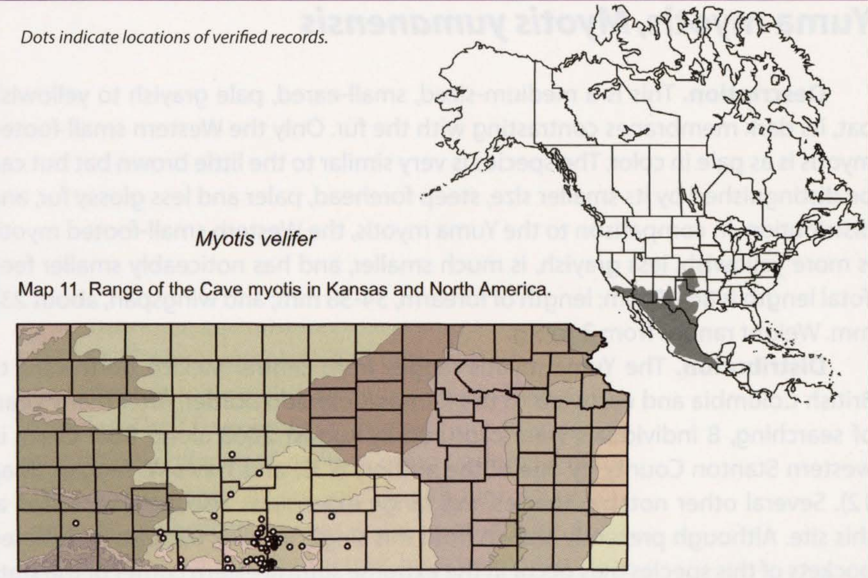
Natural History. Hibernacula begin to break up in April, and males follow females to the maternity colonies. Summer colonies of the Cave myotis are in caves, mines, and buildings. Most males leave the females in late spring and become more widely scattered.

Female Cave myotis probably ovulate from late March to early April. Yearling females are sexually mature. Most females give birth to a single pup in mid to late June. Nursing peaks in mid-afternoon and after the females return from their foraging trips. Young begin to fly at about three weeks and are weaned at about six weeks.

In males, testicular size increases after leaving the hibernaculum and maximum size is reached in August. In Arizona, matings are initiated in August or September, but probably occur slightly later in Kansas.

Winter colonies of the Cave myotis are primarily in caves. These bats typically form large, tight, and partially sexually segregated clusters in the most humid areas of caves. Colonies in Kansas began to form about mid-October and break up in mid-April.

Figure 46. Barns and other buildings have allowed the cave myotis to expand throughout much of southern Kansas. These nearly volant juveniles are waiting for their mothers to return from foraging.
Photo by Shauna Marquardt



Map 11. Range of the Cave myotis in Kansas and North America.

Cave myotis emerge well before full darkness. Foraging occurs primarily over water at heights of 18-35 ft. Adults show a bimodal pattern of foraging, with most activity occurring early in the evening and a second period of activity just before dawn although individuals may be active throughout the night. Juveniles develop this pattern by early August. Adults may make use of night roosts. Beetles and moths are the most common food item for Cave myotis in Kansas. Although they inhabit very different thermal regimes, cave bats using both building and cave roosts eat essentially the same food.

Conservation. In Kansas, Cave myotis probably originally were restricted to the Gypsum Hills of Barber, Comanche, and Kiowa counties, but are now widely distributed in south-central Kansas. We suspect the species will continue to expand until the arrival of WNS in the Red Hills leads to population declines.

Figure 47. Although able to use buildings during summer cave myotis remain reliant on the caves of the Red Hills for hibernacula.
Photo by Alexis Powell

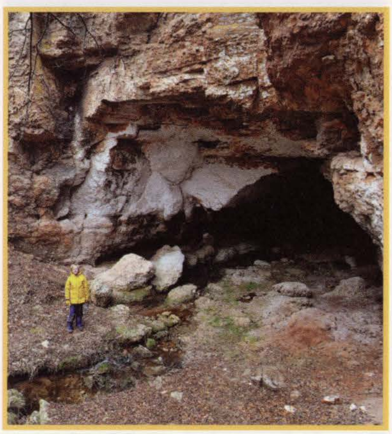


Figure 48. Eli Powell at the entrance to Big Gyp Cave in the Red Hills of southern Kansas.
Photo by Alexis Powell

Yuma myotis, *Myotis yumanensis*

Description. This is a medium-sized, small-eared, pale grayish to yellowish bat, its dark membranes contrasting with the fur. Only the Western small-footed myotis is as pale in color. The species is very similar to the little brown bat but can be distinguished by its smaller size, steep forehead, paler and less glossy fur, and distribution. In comparison to the Yuma myotis, the Western small-footed myotis is more yellowish, less grayish, is much smaller, and has noticeably smaller feet. Total length is 86-88 mm; length of forearm, 34-38 mm; and wingspan, about 235 mm. Weight ranges from 3 to 5 g.

Distribution. The Yuma myotis ranges from central Mexico northward to British Columbia and eastward to the Kansas/Colorado border. After many years of searching, 8 individuals were captured in August 2008 along Bear Creek in western Stanton County by one of the authors (CJS) and Travis W. Taggart (Map 12). Several other notable species and range extensions also were recorded at this site. Although presently known from this single locality, we suspect isolated pockets of this species may occur in the extreme southwestern corner of the state where there have been only limited bat surveys. This species probably wanders into Kansas from nearby roosts in eastern Colorado or during migration. We made several trips to both the Morton and Stevens County sections of the Cimarron National Grasslands during preparations for this book. We were unsuccessful in capturing Yuma myotis during those trips, but on several occasions we did observe flying *Myotis* which likely were this species. In addition, on several occasions we received reports of historic bat colonies in the area that no longer exist.

Natural History. This western species is associated with riparian habitat throughout its range, and thus is rarely found far from water. Colonies of this species are most frequently located in buildings, although some are located in warm caves, mines, and rock crevices. This bat somewhat frequently is found in swallow nests. In many cases, this bat shares roosts with the very similar Little brown myotis. We suspect a maternity colony of this species occurs in either an isolated building or more likely rock crevices along the Kansas/Colorado border. In winter this bat hibernates in caves and mines. In California, some bats are active during winter.

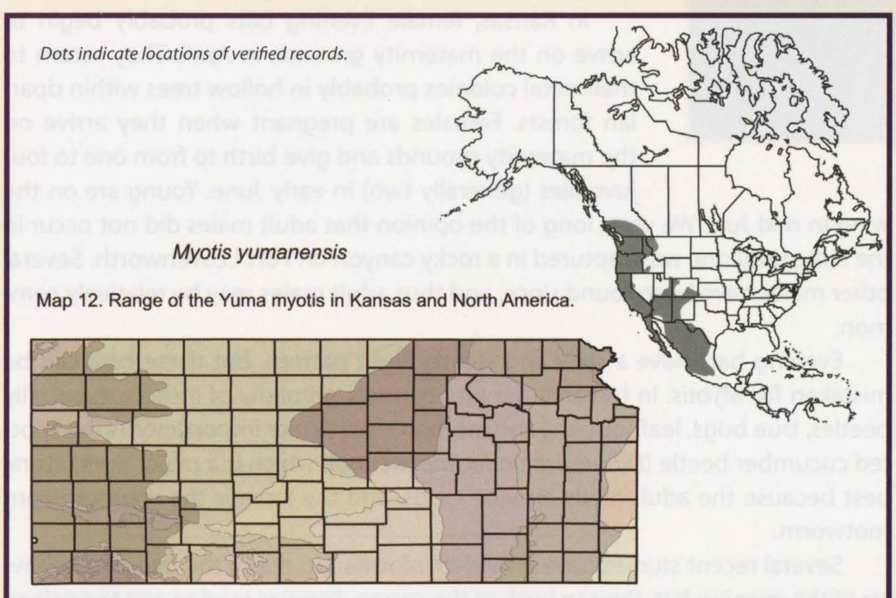
Although poorly documented, we suspect reproduction in this species is similar to other species of *Myotis*. As such, single pups would be born in late May and early June, be flying by early-to-mid July, and be fully independent by August.

Yuma myotis emerge shortly after sunset and forage on a variety of insects including moths, flies, and ground beetles. Because the species is closely associated with riparian zones, it is no surprise that the diet often includes a number of aquatic flies. Much like the Little brown myotis, this species has a complex flight that included frequent swoops to capture insect prey.

Conservation. Present data suggest that the Yuma myotis is a very rare resident of southwestern Kansas. An effort should be made to locate and protect any roosts that occur in the state. Unfortunately, the Yuma myotis is expected to be highly susceptible to WNS when the disease arrives; therefore, the species may have a short future in Kansas.

Figure 49. Yuma myotis in flight.
Photo by Breuce D. Taubert

Figure 50. Habitat of the Yuma myotis along Bear Creek in Stanton County, Kansas.
Photo by Curtis J. Schmidt



Map 12. Range of the Yuma myotis in Kansas and North America.

Evening bat, *Nycticeius humeralis*

Description. A medium-sized dark, chocolate-brown colored bat with a blunt, rounded tragus, an unkeeled calcar, and a forearm shorter than 1 3/4 inches. Perhaps the most distinguishing character is the presence of only a single pair of upper incisors. Adults may attain the following dimensions; total length 83-99 mm; length of tail 35-39 mm; length of hind foot 8-9 mm; length of ear 12-14 mm; weight 9-14 g.

Distribution. Evening bats range from southern Pennsylvania west to western Kansas and Nebraska and south to Mexico. They are to be looked for in and along riparian woodlands throughout Kansas (Map 13).

Natural History. The roosts of Evening bats during summer often are found in hollow trees, although these bats have been known to use abandoned buildings. The Evening bat migrates south for the winter, although it is likely some hibernate in hollow trees in eastern Kansas as is the case in southwest Missouri.

In Florida, mating begins in October and apparently continues throughout the winter. Of particular interest is the role played by newly volant males. In Kansas the testes of juvenile males are descended and enlarged. We dissected one of these animals and found the testes to be not yet functional.

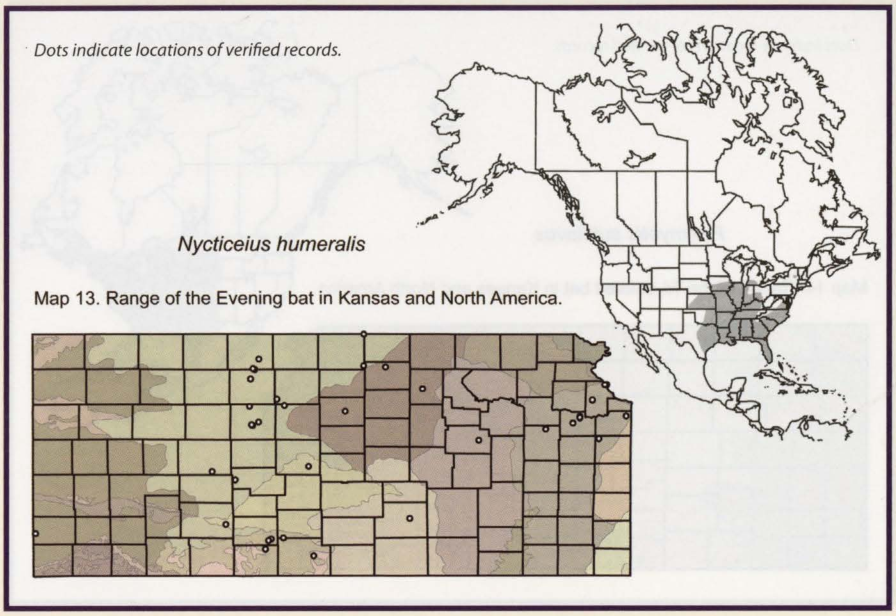
In Missouri, female Evening bats arrived at the roost by mid-May. All were pregnant and gave birth to an average of 2.3 juveniles each in mid-June. Females recognize their own young during the first two weeks, and then may nurse the other young. Recognition is at least partially based on vocalizations, but probably also includes odor. Apparently indiscriminate nursing does not occur, as the females do not nurse unrelated males but will nurse unrelated female pups. Interestingly, male mortality is higher at this time, possibly due to starvation. Young begin to fly after about three weeks of growth. Juvenile males are the first bats to leave, having left by late August. The last bats left a Missouri roost near the Kansas border on 17 September. This pattern is similar to the pattern of captures we encountered while working with a colony of this species that inhabits Bow Creek in Rooks County.

Figure 51. The tragus of an Evening bat is small and curved like a printed comma.
Photo by Jeff Miller

In Kansas, female Evening bats probably begin to arrive on the maternity grounds in April. They return to their natal colonies probably in hollow trees within riparian forests. Females are pregnant when they arrive on the maternity grounds and give birth to from one to four juveniles (generally two) in early June. Young are on the wing in mid July. We were long of the opinion that adult males did not occur in the state until one was captured in a rocky canyon on Fort Leavenworth. Several other males have been found since, and thus adult males may be relatively common.

Evening bats have a slow and steady flight pattern, but these bats can be mistaken for *Myotis*. In Indiana, the diet consists primarily of insects, especially beetles, true bugs, leafhoppers, and moths. Of particular importance is the spotted cucumber beetle (*Diabrotica undecimpunctata*), which is a major agricultural pest because the adult feeds on vine crops, and the larva is the southern corn rootworm.

Several recent studies have provided information about the foraging behavior of the evening bat. Prior to birth of the young, females tend to exit the colony



Map 13. Range of the Evening bat in Kansas and North America.

shortly after dusk and return just before dawn, but this changes to a bimodal pattern after the young are born. Evening bats apparently are affected by inclement weather and may not forage for several days until better conditions are available. Alternative roosts also may be used to "wait out" storms. This species rarely goes farther than a mile from its roost and foraging bouts are relatively short compared to the otherwise similar Big brown bat.

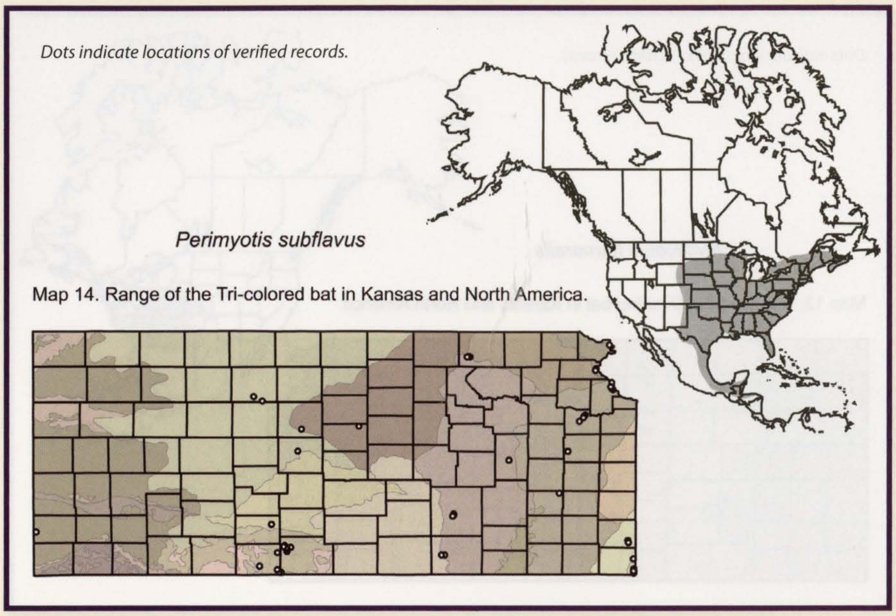
Evening bats do occasionally make use of properly placed bat boxes. Considering the importance of the spotted cucumber beetle as an agricultural pest, studies should be directed at assessing the value of Evening bats in an integrated pest management plan.

Conservation. The Evening bat has expanded its range westward into western Kansas in historic times by taking advantage of the increase in woodlands that occurred following settlement. They are continuing to spread west and thus are not in need of special protection in Kansas. Because this species does not hibernate in caves, we suspect that it may not be severely impacted by WNS.

Figure 52. Evening bat.
Photo by Lynn W. Robbins

Tri-colored bat, *Perimyotis subflavus*

Description. The smallest bat in Kansas is readily identified by its reddish forearms and namesake tri-colored fur that has a dark base followed by a broad band of lighter color with dark tips. The ears are noticeably longer than wide with a short, blunt tragus. A total of 34 teeth also distinguish this bat from others in Kansas. The first tooth behind the canine is reduced in size. Adults may attain the following dimensions: total length 75-90 mm; length of tail 33-45 mm; length of hind foot 7-10 mm; length of ear 12-14 mm; weight 4-8 g.



Perimyotis subflavus

Map 14. Range of the Tri-colored bat in Kansas and North America.

Distribution. The Tri-colored bat ranges from Nova Scotia to Minnesota and southward to the Yucatan Peninsula. It recently has been found as far west as central Wyoming, Colorado, and New Mexico. The species occurs throughout Kansas (Map 14) wherever there are both scattered trees for summer roosts and shallow caves (or similar structures) for hibernation.

Natural History. Males and an occasional female can be found in caves, mines, and similar structures throughout the year in Kansas. Additionally, they are commonly found hanging on the sides of buildings during migration. For example, on the campus of Fort Hays State University, they are frequently encountered in and around doorways during migration.

Maternity colonies of Tri-colored bats are most often in clusters of dead leaves, although colonies have also been found in fairly open areas such as under awnings and duck blinds. Tri-colored bats give birth to between one and three (usually two) young in summer (earlier in the south than in the north), and females are reproductively mature as yearlings. A study in New England found that young began to fly at 20 days of age. Short first flights preceded foraging trips. When young first left the roost to forage, their emergence was more fluttery and occurred later than the adults. Young had an adult-like flight by 25 days of age.

Figure 53. In summer, Tri-colored bats often roost in clusters of dead leaves.
Photo by Brianne L. Walters

Males achieve sexual maturity during their second year of life. Testes are at maximal size in August. Mating probably begins in late August or early September, and continues until at least February, but spermatozoa remain present in males until as late as early June. There may be some additional mating as the bats emerge from hibernation.

In winter, Tri-colored bats frequently are found in caves and cave-like openings. In the hibernaculum, males are more common. In Kansas, hibernacula include not only natural caves but also man-made structures such as storm sewers and mines. Perhaps the most typical hibernacula in western Kansas are natural openings which settlers enlarged. These sites are rarely used by other species. In hibernation, Tri-colored bats are usually amongst the easiest species to recognize. They have a hunch-backed appearance and usually are covered in condensation.

Tri-colored bats emerge shortly after sunset, and their small size and slow, erratic, moth-like flight makes them easy to recognize. In Oklahoma, foraging most often occurred over streamside vegetation at a height of 6-15 m. In Indiana, radio-tagged Tri-colored bats foraged above and within a variety of habitats including woodlands, agricultural fields, and even the grassy area associated with an interstate exit. The diet of Tri-colored bats consists primarily of true bugs, leafhoppers, flies, beetles, and moths.

Conservation. The Tri-colored bat has expanded its range by taking advantage of underground voids such as mines, and dug-out shelters, buildings, and the expanded forest of modern-day Kansas. In the east, this species is rapidly declining due to WNS, but mortality is much less than that seen in Little brown myotis.

Figure 54. Tri-colored bats such as this resident of Russell County Kansas are often covered by water droplets during hibernation.
Photo by Dale W. Sparks

FAMILY MOLOSSIDAE

Big free-tailed bat, *Nyctinomops macrotis*

Description. A very large bat with a mouse-like projection of its tail projecting beyond the tail membrane. Dorsal fur ranges from reddish brown to dark brown, with white at the base of each hair. The large, rounded ears are joined basally and appear to point forward. Adult measurements of Big free-tailed bats are total length 120-160 mm, length of tail 40-57 mm; length of hind foot 7-11 mm; length of ear 25-32 mm; weight 22-30 g.

Distribution. The Big free-tailed bat ranges from western Utah to southern Kansas and southward to central Mexico. In Kansas (Map 15), the Big free-tailed bat is known only from Morton County in the southwest and Crawford County in the southeast corner of the state.

Natural History. Big free-tailed bats presumably migrate south to spend the winter in southwestern Texas, Arizona, and southern California. After returning to their summer haunts in April, Big free-tailed bats form summer colonies of approximately 100 bats in rock crevices. One pup is born in June and apparently does not become volant until August. When the summer colonies break up, Big free-tailed bats, like the related Brazilian free-tailed bat, wander widely. In fact, the records in Kansas probably are the result of such wandering.

Figure 55. Only two Big free-tailed bats have been found in Kansas.
Photo by Ernest W. Valdez

Big free-tailed bats emerge well after dark. They feed primarily on large moths, leaf hoppers, ants and wasps. The presence of ground dwelling insects in the diet of some of these bats suggests that some insects are gleaned from canyon walls. Flight, as in other molossids, is rapid and direct.

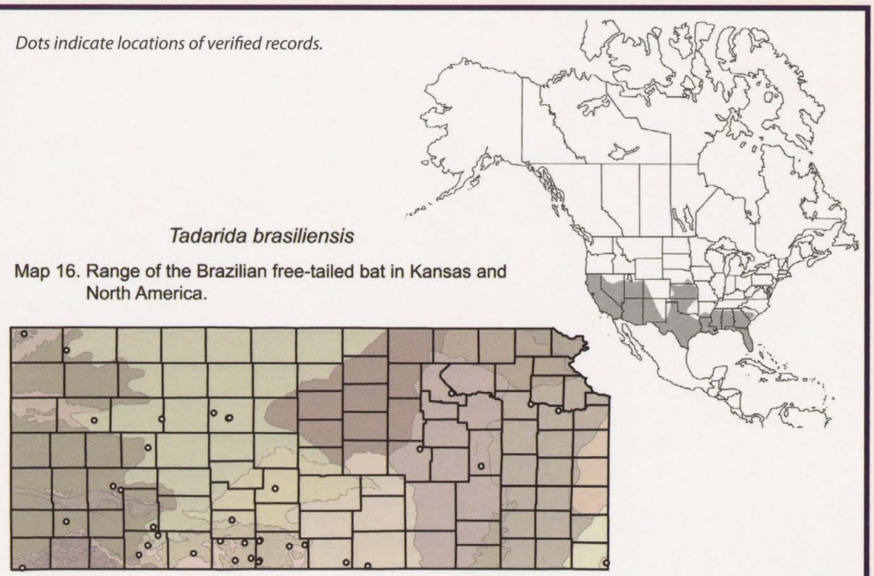
Conservation. In Kansas, the Big free-tailed bat is a rare visitor and state efforts toward conservation would be a poor investment.

Brazilian free-tailed bats are unable to tolerate the winters in Kansas and migrate south annually to escape them. Bats from Merrihew Cave migrate to areas between the Gulf of Mexico and the interior of the Mexican Plateau. Many temporary roosts are used during migration and it is possible that the route south is marked by scent. Individuals begin to return to bordering areas in Oklahoma in late April, and the northward migration continues until large maternity colonies form in mid-May. These colonies may be in caves, buildings, bat houses, and under bridges.

Brazilian free-tailed bats emerge about 15 minutes after sunset. Flight is swift, strong, and resembles that of a chimney swift (*Chaetura pelagica*). Where large colonies occur, the bats appear to exit in a long, continuous column that can be visible for a long distance. The Brazilian free-tailed bat feeds primarily on moths and beetles. Because these bats forage on agricultural pests and form massive colonies, they are among the most economically valuable species on earth in terms of rendering ecological services (pest control).

Figure 57. Brazilian free-tailed bats have a distinct tail.
Photo by Nickolay Hristov and Tatjana Hubel

Notes. Brazilian free-tailed bats are unusual among North American bats in having been exploited commercially. Guano from large colonies occasionally is mined for use as a nitrogen-rich fertilizer. Additionally, the large colonies of bats present at Carlsbad Caverns, New Mexico, Congress Avenue Bridge in Austin, Texas, and in Bracken Cave, Texas, serve as tourist attractions. Several efforts have been made to use this bat to control insects over agricultural fields. Finally, during World War II, bats of this species were part of a weapons development project called project X-ray. The bats were fitted with harnesses, which included a small incendiary device. A timer allowed the bat time to be released and fly to a roost



Map 16. Range of the Brazilian free-tailed bat in Kansas and North America.

before igniting. Development of the weapon was halted after the development of the atomic bomb, and trials set fire to an observation site during testing.

Conservation. Brazilian free-tailed bats have benefited from man's activities in the Red Hills. Brazilian free-tails are known to reproduce in Kansas inside man-made structures. The continued existence of the Brazilian free-tailed bat in Kansas is reliant upon the continued existence of the colonies in Merrihew and Alabaster caves, Oklahoma. Unfortunately, a cave bat in Woodward County, Oklahoma (south of Comanche County, Kansas) was DNA-positive for the fungus associated with WNS. To date, we are aware of no evidence that the free-tailed bats within that same cave have been affected. While we do not expect this non-hibernating bat to be sensitive to WNS, the possibility should be considered.

Figure 58. Most Brazilian free-tailed bats captured in Kansas likely originate in Merihew Cave, Oklahoma. *Photo by Jeff Miller*

SPECIES OF POSSIBLE OCCURRENCE

Four additional species of bats occur in other states near the Kansas border, and potentially may occur in the state. These are discussed below in order of likelihood of capture.

The Indiana (or social) myotis (*Myotis sodalis*) is a north-central species that occurs in portions of Missouri, Arkansas, and Oklahoma near the Kansas border. This federally endangered species almost certainly once occurred in southeastern Cherokee County on the Ozark Plateau. Additionally, the species may have occurred anywhere else along the Kansas/Missouri border. Populations of the Indiana myotis have been drastically reduced in Missouri, and now are also infected with WNS. Because Kansas is at the extreme western end of the species's range, it is unlikely that Indiana myotis will be captured in the state unless the species is able to rebound from its currently precarious condition. Nevertheless, riparian woodland in eastern Kansas should be surveyed for this species. Further, caves and mines in eastern Kansas should be monitored for this species.

The occurrence of the Eastern small-footed myotis (*Myotis leibii*) in Kansas is possible. The closest population of these bats is in the southern Ozarks of Arkansas and Missouri. Here the species seems to be associated with glades. The Eastern small-footed myotis is rare within its range and appears to be relatively sedentary; thus, we do not expect this animal to be captured in Kansas.

Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) occurs in portions of Missouri and Oklahoma near the Kansas border. If this species occurs in Kansas, it is no more than an occasional visitor on the Ozark Plateau in southeastern Cherokee County.

The Fringed myotis (*Myotis thysanodes*) occurs throughout much of the southwestern United States and reaches its easternmost limit in Baca County, Colorado. Although it is possible that an individual might be blown into Kansas from the Black Mesa and Mesa de Maya areas, it is not likely.

WHERE TO GO FOR MORE INFORMATION

The guide you are reading is the second in a series about the bats of Kansas that we have published. The first (Sparks and Choate, 2000) is a technical guide intended for either the advanced naturalist or the professional scientist. As you read through the current guide it is our hope that you will become more interested in the bats of Kansas and would like more information. In order to make this book more readable, we have deleted most of the references that were used to obtain the information necessary to prepare this guide. These resources are cited in the earlier publication.

An excellent resource for all mammal species that occur in Kansas is the Kansas Mammal Atlas website (http://webcat.fhsu.edu/ksfauna/mammals). The Atlas contains information on all known occurrences of mammals in Kansas. Continuously updated distribution maps are provided for each mammal species known to occur (or potentially occur) in the state. Each species account has text descriptions summarizing the taxonomy, recognition features, distributions, ecology, reproduction, and behavior for each species.

Two organizations that specialize in providing the public information about bats are the Organization for Bat Conservation and Bat Conservation International. Both have well-designed web pages (www.batconservation.org and www.batcon.org respectively), which offer a variety of resources ranging from bat-related merchandise, to educational information, to bat house plans.

Several other publications are available that contain accounts of the species of bats that occur in Kansas. Perhaps the best are previous accounts of the bats in Kansas (Jones et al., 1967; Sparks and Choate, 2000). Also of use are several general guides (Barbour and Davis, 1969; Bee et al., 1981; Whitaker and Mumford, 2009; Jones et al. 1985; Tuttle, 1988; Armstrong et al., 1994) that contain generalized accounts of the bats. If one is interested in a particular species the best place to turn is the series of Mammalian Species accounts published by the American Society of Mammalogists (Watkins, 1972; Jones, 1977; Fenton and Barclay, 1980; Fitch and Shump, 1979; Harvey et al., 1999; O'Farrell and Studier, 1980; Fitch et al., 1981; Kunz, 1982; Kunz and Martin, 1982; Shump and Shump, 1982a; 1982b; Thompson, 1982; Hermanson and O'Shea, 1983; Fujita and Kunz, 1984; Wilkins, 1989; Kurta and Baker, 1990; Milner et al., 1990; Decher and Choate, 1995).

BIBLIOGRAPHY

Armstrong, D. M., R. A. Adams, and J. Freeman. 1994. Distribution and ecology of bats of Colorado. Natural History Inventory of Colorado, 15:1-83.

Barbour, R. W., and W. H. Davis. 1969. Bats of America. University Press of Kentucky, Lexington, 286 pp.

Bee, J. W., J. Glass, R. S. Hoffmann, and R. R. Patterson. 1981. Mammals in Kansas. University of Kansas Publications, Museum of Natural History, Public Education Series, 7:1-300.

Choate, J. R., J. K. Jones, Jr., and C. Jones. 1994. Handbook of mammals of the south-central states. Louisiana State University Press, 304 pp.

Choate, J. R., C. J. Schmidt, and T. W. Taggart. 2011. Kansas Mammal Atlas: An On-line Reference. Electronic Database accessible at http://webcat.fhsu.edu/ksfauna/mammals. Sternberg Museum of Natural History, Fort Hays State University, Hays, Kansas, USA.

Decher, J., and J. R. Choate. 1995. *Myotis grisescens*. Mammalian Species, 510:1-7.

Fitch, J. H., and K. A. Shump, Jr. 1979. *Myotis keenii*. Mammalian Species, 121:1-3.

Fitch, J. H., K. A. Shump, Jr., and A. U. Shump. 1981. *Myotis velifer*. Mammalian Species, 149:1-5.

Fitzgerald, J. P., C. M. Meaney, and D. M. Armstrong. 1995. Mammals of Colorado. University Press of Colorado, Niwot, xii + 467 pp.

Fujita, M. S., and T. H. Kunz. 1984. *Pipistrellus subflavus*. Mammalian Species, 228:1-6.

Harvey, M. J. 1992. Bats of the eastern United States. Arkansas Game and Fish Department. 46 pp.

Harvey, M. J., J. S. Altenbach, and T. L. Best. 1999. Bats of the United States. Arkansas Game and Fish Department. 64 pp.

Jones, C. 1977. *Plecotus rafinesquii*. Mammalian Species, 69:1-4.

Jones, J. K., Jr., D. M. Armstrong, and J. R. Choate. 1985. Guide to mammals of the Plains States. University of Nebraska Press, Lincoln, 371 pp.

Jones, J. K., Jr., D. M. Armstrong, R. S. Hoffman, and C. Jones. 1983. Mammals of the northern Great Plains. University of Nebraska Press, 379 pp.

Jones, J. K., Jr., E. D. Fleharty, and P. B. Dunnigan. 1967. The distributional status of bats in Kansas. Miscellaneous Publications, Museum of Natural History, University of Kansas, 46:1-33.

Kunz, T. H. 1982. *Lasionycteris noctivagans*. Mammalian Species, 172:1-5.

Kunz, T. H., and R. A. Martin. 1982. *Plecotus townsendii*. Mammalian Species, 175:1-6.

Kurta, A., and R. H. Baker. 1990. *Eptesicus fuscus*. Mammalian species, 356:1-10.

Milner, J., C. Jones, and J. K. Jones, Jr. 1990. *Nyctinomops macrotis*. Mammalian Species, 351:1-4.

Shump, K. A., Jr., and A. U. Shump. 1982a. *Lasiurus borealis*. Mammalian Species, 183:1-6.

Shump, K. A., Jr., and A. U. Shump. 1982b. *Lasiurus cinereus*. Mammalian Species, 185:1-5.

Sparks, D. W., and J. R. Choate. 2000. Distribution, natural history, conservation status, and biogeography of bats in Kansas. Pp. 173-228, in Reflections of a naturalist: papers honoring professor Eugene D. Fleharty (J. R. Choate, ed.), Fort Hays State Studies, Special Issue 1, 241 pp.

Thompson, C. E. 1982. *Myotis sodalis*. Mammalian Species, 163:1-5.

Tuttle, M. D. 1988. America's backyard bats. University of Texas Press, Austin, Texas, 96 pp.

Watkins, L. C. 1972. *Nycticeius humeralis*. Mammalian Species, 23:1-4.

Whitaker, J. O., Jr., and R. E. Mumford. 2009. Mammals of Indiana. Indiana University Press, Bloomington, 661 pp.

Wilkins, K. T. 1989. *Tadarida brasiliensis*. Mammalian Species, 331:1-10.

SPONSORS

AD ASTRA PER ASPERA
Kansas
Department of Wildlife, Parks and Tourism

This publication is supported, in part, by the Chickadee Checkoff nongame wildlife improvement program of the Kansas Department of Wildlife, Parks and Tourism. The Chickadee Checkoff is a line appearing on the Kansas Individual Income Tax forms, providing Kansans an opportunity to contribute to non-game wildlife programs.

FORT HAYS STATE UNIVERSITY
Forward thinking. World ready.

FORT HAYS STATE UNIVERSITY'S
STERNBERG MUSEUM
OF NATURAL HISTORY

Funding also was provided by the Sternberg Museum of Natural History at Fort Hays State University. "Bats of Kansas" helps to fulfill the Sternberg Museum's mission of advancing an appreciation and understanding of Earth's natural history and the evolutionary forces that impact it. With an emphasis on the Great Plains, our goals are accomplished through research, publications, collections, interpretive exhibits, and educational programs created by our staff, colleagues, and community.

INDIANA STATE UNIVERSITY
Center for North American
Bat Research and Conservation

ISBN: 978-0-9817096-4-2
51000
9 780981 709642