Mammal Inventory of Obed Wild and

Scenic River, Tennessee

Submitted to:

National Park Service
Appalachians Highlands Inventory & Monitoring Network
199 Hemphill Knob Road
Asheville, NC 28803

Submitted by:

Eric R. Britzke
815 Dillard Street
Forrest City, AR 72335

February 2007

Introduction

The Appalachian Highlands Inventory and Monitoring Network is one of 32 networks established nationwide by the National Park Service (NPS) Natural Resource Challenge initiative to provide park managers with comprehensive, scientifically-based information about the distribution and status of the natural resources occurring within the parks. Unfortunately, many National Parks lack even basic information on species presence/absence (Stohlgren *et al*. 1995). One of the goals set forth by this initiative is to document the occurrence of at least 90% of the species of vertebrates and vascular plants that occur within each National Park unit containing "significant natural resources".

Obed Wild and Scenic River (OBRI) is located on the Cumberland Plateau in Tennessee (Figure 1). It is dominated by the river, associated creeks, adjacent riparian habitat, and steep cliff lines. Presence of river and extensive cliff lines has resulted in numerous recreation opportunities within OBRI. Due to the steep terrain surrounding OBRI and the patchwork of landownership along the rivers, human access to OBRI is concentrated at 4 main access points. During periods of suitable weather, these access points attract large numbers of people.

The objective of this project was to conduct a complete inventory of the mammals of OBRI. Additional information on species distribution and relative abundance was also collected. This information should be useful for future conservation efforts in OBRI.

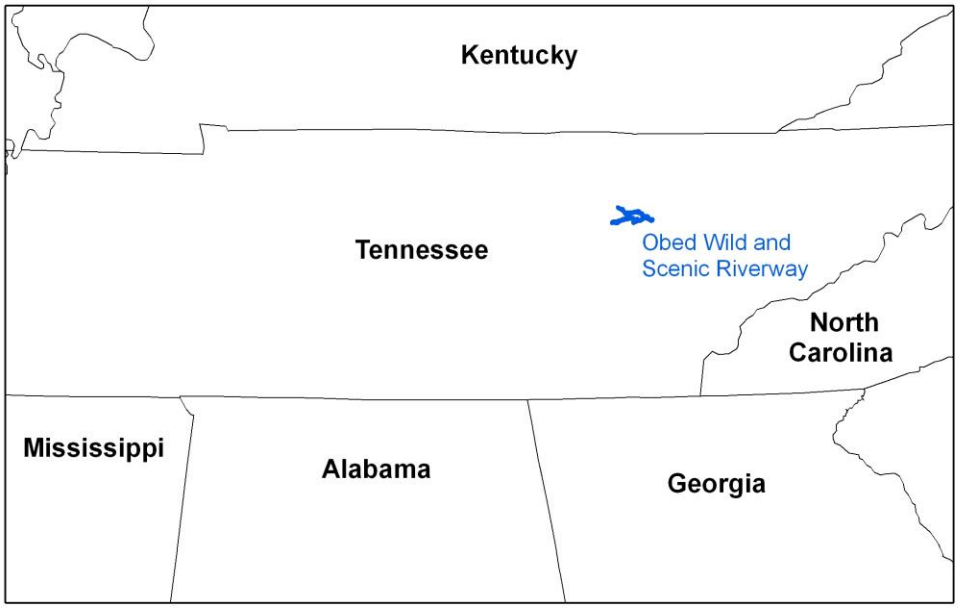

Figure 1. Location of Obed Wild and Scenic River in Tennessee.

Methods

All field work for the current project was conducted from fall 2003 through fall 2004. Before field work was conducted, a list of expected species was developed. This list included the species known or suspected to be present within the boundaries of OBRI. Range maps from Whitaker and Hamilton (1998) were used to develop an initial list, which was further refined through conversations with Dr. Michael J. Harvey (mammalogist at Tennessee Technological University). The expected species list (Table 1) is comprised of species whose ranges included OBRI and for which suitable habitat

occurred within OBRI. This list was viewed as a work in progress, and species were added if additional information suggested their occurrence within OBRI.

Mammals other than bats

A variety of methods was used to document the occurrence of mammals on the OBRI. Traps were used to capture smaller mammals (up to the size of *Mustela* spp.) and spot-lighting, chance observations, and sighting reports from knowledgeable people (National Park Service biologists, state wildlife agency biologists, mammalogists) were used to document the presence of larger species.

Trapping was conducted in common habitats (i.e., mesic hardwood, boulder and talus slopes) first because this allowed compilation of information on large portions of the park. Additionally, these habitats likely contained a large number of species, thereby allowing subsequent work to focus on less common species. Trap type used depended on the target animals. Sherman live traps and snap traps baited with oatmeal, oatmeal mixed with peanut butter, or peanut butter were used to sample small rodents. Mouse snap traps and Victor rat traps were baited with peanut butter and were used in limited areas in an attempt to augment Sherman live trap captures.

Shrews were sampled using pitfall traps made from 32-ounce plastic cups buried so that the top of the cup was just below ground level. Traps were placed along rocks or coarse woody debris to maximize capture. To assess southern flying squirrel presence in an area, Sherman live traps were baited with peanut butter and placed on a tree. Orientation of the traps on the trees was variable (vertical or horizontal) and wire was used to secure the trap to the tree. All traps were checked daily and live animals were

identified, sexed, weighed, marked with a black marker on the base of the tail, and released. Any animals that died during this project were deposited in the collection at the North Carolina Museum of Natural Sciences.

Animals observed during the course of other survey activities were recorded and their locations noted.

Bats

Mist nets were erected and placed in areas expected to have high levels of bat activity (e.g., streams, roadways). Nets varied from a single net (3 m high) to 2 nets stacked on top of each other (6 m high) using a modified system described by Gardner et al. (1989). While attempts were made to mist-net throughout a wide variety of habitat types, locations were selected to maximize capture of bats. Nets were checked every 15–20 minutes, and captured bats were identified, sexed, aged, weighed, forearm measured, and each bat was banded with an individually numbered aluminum-lipped band. Bats were released at the point of capture. Additionally, bridges were checked for bats as time permitted.

In addition to mist netting, Anabat II bat detectors were used to sample habitats that could not be effectively sampled with capture techniques (e.g., open fields) and to complement capture techniques. Recording occurred at stationary points with echolocation calls of bats recorded directly to a laptop computer through a ZCAIM (Zero Crossing Analysis Interface Module), or to a compact flashcard inside a CF storage ZCAIM. Calls recorded to the CF-storage ZCAIM were downloaded using Anabat software (CFREAD) to Anabat files and divided into separate folders for each night.

Frequency division ratio was set to 16 on all systems and the sensitivity of the detector was set to 7-8 unless extraneous noise was too high and the sensitivity had to be lowered.

The Anabat system records each sequence of echolocation calls in an individual file, thus in most circumstances, a file represents an echolocation call sequence of a single bat as it flies above the detector. Recorded files were visually examined and files including only extraneous noise (e.g., setup, insects) were deleted, thereby ensuring that each folder contained only the bat echolocation calls detected at a single site on a specific night. Numbers of files were calculated and used as an index of bat activity. Recorded echolocation calls were also identified using both qualitative and quantitative techniques (Britzke et al. 2002). Because acoustic identifications are probabilistic, multiple calls of a species must be detected in a single night to determine species presence (Britzke 2003).

A habitat description and GPS coordinates (WGS84) were determined for each sampling site as well as sightings of species. Specific coordinates for sampling points are listed in the accompanying database.

Results

Mammals other than bats

A total of 20 sites were sampled for small mammals during the mammal inventory at OBRI resulting in 1,400 trap nights. Pitfall traps (715 trap nights) and Sherman live traps (650 trap nights) were the most commonly deployed types of traps with each trap type being responsible for capture of 4 species (Table 2). A total of 83 animals of 10 species were captured during these trapping efforts. Overall, the most commonly captured species were the white footed mouse (*Peromyscus leucopus)*, cotton

mouse (*Peromyscus gossypinus*), and the smoky shrew (*Sorex fumeus*; Table 3). Sampling in mixed oak-pine and mesic hardwoods resulted in the capture of the greatest number of species and individuals (Table 3).

Twenty-two observations of 9 species were documented through visual observation. Overall 18 of 41 (44%) expected species of non-Chiropteran mammals were documented during this study.

Bats

Mist nets were used to sample 5 sites over 6 nights resulting in the capture of 13 bats representing 6 species. Eastern red bats (*Lasiurus borealis*) were the most commonly captured bat (30.1% of all bat captures). A federally endangered gray bat juvenile male was captured on 9 August 2004 near Barnett Bridge but was not recorded during the acoustic sampling described below. Most bat captures were made over creeks and streams and in mixed oak-pine habitats on OBRI during this study (Table 3). At most of these sites, there was significant pine mortality due to a recent and severe outbreak of southern pine beetles, which created somewhat more open habitats than were previously present. Additionally, 4 big brown bats (*Eptesicus fuscus*) were captured as they day-roosted in Nemo Bridge.

Acoustic sampling was conducted at 14 stationary sampling points during 16 nights for a total of 2,767 minutes. A total of 5,827 echolocation calls of 8 species were recorded with bat activity varying considerably among sampling points (Table 4). Big brown bats, eastern red bats, and eastern pipistrelles (*Pipistrellus subflavus*) were detected at the largest number of acoustic sampling stations (Table 4). Also detected, but less frequently, were little brown and northern long-eared bats. Presence of the previous

five species was also confirmed by physical captures. Acoustic sampling resulted in the detection of 3 species that were not captured: the hoary bat (*Lasiurus cinereus*), the eastern small-footed bat (*Myotis leibii*), and the eastern big-eared bat (*Corynorhinus rafinesquii*). The latter 2 species are listed as Species of Special Concern in Tennessee. Overall 9 of 12 (75%) expected bat species were documented during this study.

Table 1. List of mammal species expected to be present on the Obed Wild and Scenic River.

Order	Family	Species	Common Name
Didelphimorphia	Didelphidae	*Didelphis virginiana*	Opossum
Insectivora	Talpidae	***Scalopus aquaticus***[a]	**Eastern mole**
		Parascalops breweri	Hairy-tailed mole
	Soricidae	*Sorex cinereus*	Masked shrew
		Sorex fumeus	**Smoky shrew**
		Sorex hoyi	**Pygmy shrew**
		Sorex longirostris	**Southeastern Shrew**
		Blarina brevicauda	**Northern short-tailed shrew**
		Cryptotis parva	**Least shrew**
Chiroptera	Vespertilionidae	***Myotis grisescens***	**Gray bat**
		Myotis leibii	**Eastern small-footed bat**
		Myotis lucifugus	**Little brown bat**
		Myotis septentrionalis	**Northern long-eared bat**
		Myotis sodalis	Indiana bat
		Lasiurus borealis	**Eastern red bat**
		Lasiurus cinereus	**Hoary bat**
		Lasionycteris noctivagans	Silver-haired bat
		Pipistrellus subflavus	**Eastern Pipistrelle**
		Eptesicus fuscus	**Big brown bat**
		Nycticeius humeralis	Evening bat
		Corynorhinus rafinesquii	**Eastern big-eared bat**
Xenarthra	Dasypodidae	*Dasypus novemcinctus*	Nine-banded armadillo
Lagomorpha	Leporidae	***Sylvilagus floridanus***	**Eastern cottontail**
Rodentia	Sciuridae	***Tamias striatus***	**Eastern chipmunk**
		Marmota monax	Woodchuck
		Sciurus carolinensis	**Eastern gray squirrel**

Order	Family	Species	Common Name
		Sciurus niger	Fox squirrel
	Castoridae	***Glaucomys volans***	**Southern flying squirrel**
	Muridae	***Castor canadensis***	**Beaver**
		Reithrodontomys humulis	Eastern harvest mouse
		Peromyscus gossypinus	**Cotton mouse**
		Peromyscus maniculatus	Deer mouse
		Peromyscus leucopus	**White-footed mouse**
		Ochrotomys nuttalli	**Golden mouse**
		Neotoma magister	**Allegheny woodrat**
		Microtus pinetorum	Woodland vole
		Ondatra zibethicus	Muskrat
	Dipodidae	*Napaeozapus insignis*	Woodland jumping mouse
Carnivora	Canidae	*Canis latrans*	Coyote
		Vulpes vulpes	Red fox
		Urocyon cinereoargenteus	**Gray fox**
		Canis familiaris	Domestic dog
	Ursidae	*Ursus americanus*	Black bear
	Procyonidae	***Procyon lotor***	**Raccoon**
	Mustelidae	*Mustela frenata*	Long-tailed weasel
		Mustela vison	Mink
		Lontra canadensis	River otter
	Mephitidae	*Spilogale putorius*	Spotted skunk
		Mephitis mephitis	Striped skunk
	Felidae	*Felis catus*	Domestic cat
Artiodactyla		*Lynx rufus*	Bobcat
	Suidae	*Sus scrofa*	Russian wild boar
	Cervidae	***Odocoileus virginianus***	**White-tailed deer**

[a] Species in bold face were documented during this survey.

(Three additional species were on the original "expected species" list – *Oryzomys palustris*, *Sigmodon hispidus*, and *Synaptomys cooperi*. At present there is little or no suitable habitat within OBRI for these wetland/early successional habitat specialists, and none of the three were detected during this survey.)

Table 2. Number of sites sampled, number of trap nights, number of species captured and total number of captures by trap type during mammal inventory in Obed Wild and Scenic River, Tennessee, October 2003 – August 2004.

Trap Type	# of sites sampled	# of trap nights	# of species	# of captures
Sherman	15	650	4	70
Pitfall	7	715	4	11
Sherman – tree	1	10	1	1
Mouse snap	1	20	1	1
Victor rat	1	5	0	0
Total		1400		83

Table 3. Summary of mammals documented during this inventory. # of detections is the total number of events in which the species was captured or seen. The habitat listed is the habitat in which the species was most commonly encountered.

Species	**Common Name**	**# of Detections**	**Habitat Captured**
Scalopus aquaticus	Eastern mole	3	Big rivers and associated floodplain
Sorex fumeus	Smoky shrew	5	Hemlock forest
Sorex hoyi	Pygmy shrew	1	Hemlock forest
Sorex longirostris	Southeastern Shrew	2	Mixed oak-pine
Blarina brevicauda	Northern short-tailed shrew	2	Creek and streams and associated riparian areas
Cryptotis parva	Least shrew	1	Mixed oak-pine
Myotis grisescens	Gray bat	1	Big rivers and associated floodplain
Myotis lucifugus	Little brown bat	2	Mixed oak-pine, Big rivers and associated floodplain
Myotis septentrionalis	Northern long-eared bat	2	Roadside, mixed oak-pine
Lasiurus borealis	Eastern red bat	5	Mixed oak-pine
Pipistrellus subflavus	Eastern pipistrelle	3	Big rivers and associated floodplains
Eptesicus fuscus	Big brown bat	5	Bridge
Sylvilagus floridanus	Eastern cottontail	3	Various
Tamias striatus	Eastern chipmunk	2	Hemlock forest, Big rivers and associated floodplain
Sciurus carolinensis	Eastern gray squirrel	6	Mixed oak-pine

Species	Common Name	# of Detections	Habitat Captured
Glaucomys volans	Southern flying squirrel	1	Mesic hardwood
Castor canadensis	Beaver	2	Big rivers and associated floodplain
Peromyscus gossypinus	Cotton mouse	23	Mesic hardwood
Peromyscus leucopus	White-footed mouse	41	Mesic hardwood
Ochrotomys nuttalli	Golden mouse	5	Hemlock forest
Neotoma magister	Allegheny woodrat	3	Mesic hardwood
Urocyon cinereoargenteus	Gray fox	1	Mixed oak-pine
Procyon lotor	Racoon	2	Big rivers and associated floodplain
Odocoileus virginianus	White-tailed deer	1	Grassland

Table 4. Summary of Anabat recording at stationary sampling points during mammal inventory of Obed Wild and Scenic Riverway, TN in summer of 2004.

Date	Site	Time started	Time stopped	Time recorded	# of files	Bat species detected
17-Apr-04	Lilly Bridge area	20:33	23:54	3:21	112	Big brown, Eastern pipistrelle, Eastern red, Northern long-eared
21-Apr-04	Rock Creek	20:40	21:58	1:18	206	Big brown, Eastern pipistrelle, Eastern red
22-Apr-04	Obed River at Rock Creek	20:30	23:00	2:30	360	Big brown, Eastern pipistrelle, Eastern red
23-Apr-04	Obed River at Rock Creek Campground	20:29	23:06	2:37	258	Big brown, Eastern pipistrelle, Eastern red, Little brown
17-May-04	Rock Creek Campground	20:26	0:40	4:14	73	Big brown, Eastern red, Little brown, Northern long-eared
23-May-04	Jett Access	20:30	21:20	0:50	33	Big brown, Eastern pipistrelle, Eastern red
20-Jun-04	Jett Access	21:03	23:55	2:52	602	Big brown, Eastern pipistrelle, Eastern red, Hoary, Little brown
21-Jun-04	Nemo Access	21:14	21:50	0:36	246	Eastern pipistrelle, Eastern red
14-Jul-04	Barnett Bridge parking area	21:23	22:29	1:06	116	Big brown, Eastern pipistrelle, Eastern red

Date	Site	Time started	Time stopped	Time recorded	# of files	Bat species detected
14-Jul-04	Barnett Bridge 1	20:43	1:01	4:18	1139	Big brown, Eastern pipistrelle, Eastern red, Little brown
14-Jul-04	Barnett Bridge 2	21:03	0:57	3:54	289	Eastern red, Eastern pipistrelle, Little brown
15-Jul-04	Lilly Overlook - northside	20:33	0:50	4:17	233	Big brown, Eastern big-eared, Eastern pipistrelle, Eastern red, Eastern small-footed, Little brown
15-Jul-04	Lilly Overlook - southside	20:23	1:08	4:45	229	Big brown, Eastern big-eared, Eastern pipistrelle, Eastern red, Eastern small-footed
15-Jul-04	River @ Lilly access	20:58	0:58	4:00	631	Big brown, Eastern pipistrelle, Eastern red, Little brown
09-Aug-04	Barnett Bridge 1	20:57	0:01	3:04	1218	Eastern pipistrelle, Eastern red, Little brown,
11-Aug-04	Lilly Picnic Area	20:45	23:10	2:25	82	Big brown, Eastern red

Discussion

Mammals other than Bats

A total of 18 species of non-Chiropteran mammals were documented during this study. Of these, 2 species (cotton mice and white-footed mice) constituted a vast majority of the detections. This was likely due to two factors. First, small mammals, particularly rodents, are easily captured in Sherman traps. Secondly, the presence of larger mammals was underrepresented. Spotlighting was used to document larger animals on the OBRI. However, only a very small part of the OBRI is accessible at night by vehicle, which makes it difficult to conduct spotlighting. Some species such as the opossum and feral hog were expected to occur but were not detected. Several of the non-documented species in this study have been previously documented on OBRI by others (Taylor et al. 1981).

Several factors made conducting the mammal inventory difficult at OBRI:

a) disjunctive ownership
b) park's rugged topography restricts access, which
c) concentrates visitor use at a limited number of developed sites,
d) creating human disturbance and security issues, and
e) the linear nature of the park creates a narrow habitat corridor, making it difficult to survey mammals with larger home ranges.

At OBRI, easy access is limited to a small number of areas where roads cross the river. Additionally, OBRI is not a continuous piece of property but has private ownership interspersed along its reach. Because the OBRI boundary is not well-marked and some landowners have contentious relationships with NPS, care was taken to eliminate the

potential for sampling off of OBRI. Further, the limited number of access points resulted in large numbers of visitors at these points. The human disturbance made it difficult to survey some areas because of concerns about equipment security and disruption of normal mammalian activity. Thus, some areas that could have been sampled were not.

Because there are large tracts of Catoosa Wildlife Management Area adjacent to OBRI, larger mammals may spend the majority of their time there, with only small portions of their time being spent on OBRI, thereby making it more difficult to document their presence on OBRI.

Habitats in which species were most commonly detected provided some basic information on habitat use by these mammals. However, strength of these habitat associations is unknown, as this study focused on documenting species presence. Thus, habitats that were expected to have larger numbers of species or rare species were sampled more heavily than other habitats. For example, mixed oak-pine and mesic hardwoods were extensively surveyed during this study. Therefore it is not surprising that these habitats had the highest number of detections. Additionally, some species were documented through visual observations, so habitat relationships may simply reflect the increased detectability in some habitats. As trapping resulted in a small number of detections for most species, habitat associations should be considered as a subset of all habitats used. Further sampling would provide better delineation of the habitat associations of mammals on OBRI.

Relative abundance of species is commonly inferred from the number of observations of a species. However, relative abundance of species should not be estimated for OBRI as a whole, but simply on a habitat by habitat basis. For example,

mesic hardwood was extensively surveyed so species in these habitats might be over-represented in relative abundances. However within mesic hardwood sampled, cotton and white-footed mice were the most abundant. Habitats that were expected to support more common species were not sampled as extensively. Additionally, because of the difficulty in documenting larger species on OBRI, efforts were focused on surveying smaller species. Thus, species such as the white-tailed deer (*Odocoilelus virginianus*) probably occur more commonly than documented during this inventory.

Bats

With the exception of the gray bat, the eight bat species documented during this survey are representative of the bat community from the upper Cumberland Plateau in Tennessee. Use of the Anabat system resulted in the documentation of 3 species not captured during this survey. These three species included the hoary bat, and the 2 species listed as state Species of Special Concern: the eastern big-eared bat, and the eastern small-footed bat. Presence of these 2 species was not unexpected because both species use rock bluffs and rock outcrops as roost sites, an abundant habitat in OBRI. Despite the limited number of suitable netting sites along OBRI, most bat species expected to occur on the OBRI were documented.

Three species of bats were not documented in this study even though OBRI occurs within or near their ranges: the silver haired bat (*Lasionycteris noctivagans*), the evening bat (*Nycticieus humeralis*), and the Indiana bat (*Myotis sodalis*). The silver-haired bat is migratory and likely occurs on OBRI during spring and/or fall migratory periods. The evening bat is not common in the upper Cumberland Plateau. For example,

only 1 evening bat was captured during a bat survey conducted on Big South Fork National River and Recreation Area, which is only about 30 miles from OBRI.

The federally Endangered Indiana bat was also not documented during this survey. There were a limited number of net sites available for sampling on OBRI, but they were not detected acoustically either. The Anabat system is often able to document species presence (Murray et al. 1999) when species are not captured. Based on my experience with the roosting ecology of the Indiana bats throughout their range and the analysis of habitat during this project, OBRI lacks large tracts of suitable roosting and foraging habitat for this species. Thus, even though not every piece of OBRI was surveyed thoroughly, it is unlikely that Indiana bat maternity colonies occur on OBRI. The habitat on OBRI does provide potential suitable roosting habitat for male Indiana bats. However, males tend to roost in the vicinity of their hibernacula. Since there are no known hibernacula near or adjacent to OBRI, occurrence of male Indiana bats on OBRI would not be likely. Additional survey effort should be used to help determine the distribution of Indiana bats on OBRI.

Capture of a juvenile gray bat at one site was unexpected as there are no known gray bat caves near OBRI. In August, gray bats begin to move from their summer caves to their hibernation caves. During this time a large number of gray bats are present throughout the state. Approximately 1 million gray bats hibernate in caves in the vicinity (i.e., within ~150 km) of OBRI. The timing of capture, the age of the bat, and the lack of other records (capture and acoustical) suggest that this bat was likely dispersing to its hibernaculum. A single juvenile gray bat captured in OBRI likely represents a migratory individual and thus, indicates little relative importance of OBRI for this species.

Management Recommendations

Mammals other than Bats

One of the most apparent features of the OBRI is the long expanse of the Obed River and its tributaries in the park. Because human visitation is focused on access points to the river, efforts should be undertaken to minimize human disturbance impacts on the mammals elsewhere within OBRI. This could be accomplished by focusing future use on those areas that are currently being most heavily used, and restricting human access to sites that are currently not heavily disturbed. Human use-related degradation includes loss of vegetation, presence of trash, high noise and activity levels at inappropriate times or seasons (disrupting hibernation, feeding, roosting or other functions), and other activities that might adversely affect habitat structure or quality, impacting mammals in the OBRI. OBRI contains a wide variety of habitats, but does not have any early successional habitats such as open fields and grasslands within its boundary. Absence of this habitat type in the OBRI may explain the absence of some species from the park. Thus, it might be useful to create or restore native grasslands in OBRI to optimize mammal diversity present on OBRI, if this is compatible with resource management objectives for other taxa and habitats in the park.

Due to the location of the OBRI in the landscape, water sources are not limited. However, care should be taken to minimize impacts on the aquatic habitats that are present. This includes not only the protection of the physical structure of the streams and wetlands, but also the water quality. While a majority of mammals utilize these water resources for drinking, some species such as the beaver, otter, and muskrat depend on

these aquatic habitats for their existence. Therefore, efforts should be made to ensure water quality is high and that the riparian structure associated with the streams is maintained. This includes not only the stabilization of banks, where needed, with smaller shrubs, but also the protection of larger trees along the stream. In addition to helping mammals, efforts to conserve water resources along the OBRI will help countless other species.

Bats

Two bat species of special concern were detected during this study. Both eastern small-footed and eastern big-eared bats have been shown to use cliff lines and rock outcrops for roost sites. Presence of a large amount of this habitat along OBRI is indicative of the potential importance of OBRI for these species. Additionally, these 2 species do not tolerate a lot of human disturbance at roost sites. Unfortunately, some of the rock outcrops at OBRI are heavily used by rock climbers. However, climbing is only permitted in designated locations and these locations do not make up a very large percentage of the cliff lines within the park. Hiking trails and climbing routes should be limited in areas of cliff lines and rock outcrops to minimize impact to these sites, and efforts should be made to discourage off-trail use. Additionally, future efforts should be made so that currently protected rock bluffs remain protected. Minimizing human disturbance will ensure that bats continue to have access to these roost sites.

Bats roost in a variety of different sites including trees, rock shelters, caves, and human structures, with different species preferring different habitat types. Dead trees provide suitable roosting conditions for a number of species, but are generally deemed unsuitable from aesthetic and safety viewpoints and may be taken down. Efforts should

be made to maintain dead trees as long as possible (particularly in remote areas) so that they can provide roost sites for bats. Bats were seen roosting in the Nemo Bridge. Bats utilize bridges because they provide suitable roosting conditions. Therefore, management efforts should focus on conserving the suitability of these structures as bat roosts. Efforts should be made to limit human access below bridges. Additionally, roost temperature profiles and accessibility (to bats) need to be maintained. Maintaining body temperature is important to bats during summer. Roost sites selected by bats are often exposed to sunlight and warm up throughout the day. Presence of warm roost sites allows bats to devote more energy to growth and development rather than expending it to stay warm. Whenever possible, efforts should be made to maintain direct sun exposure on structures (e.g., dead trees, bridges, buildings, etc.) that provide suitable roosting conditions for bats. This may include removal of trees that are shading these potential or actual roost sites, in consultation with experts on bat habitat management, and if there are no conflicts with other resource objectives. Artificial roost structures come in many different styles (see the Bat Conservation International website - http://www.batcon.org/home/index.asp?idPage=47&idSubPage=92 for examples of certified bat house models). In some circumstances, artificial roost structures may provide roost alternatives if bats must be evicted from their roost sites or proper roosting conditions cannot be maintained.

Literature Cited

Britzke, E. R. 2003. Use of ultrasonic detectors for acoustic identification and study of bat ecology in the eastern United States. Unpublished Ph.D. dissertation, Tennessee Technological University, Cookeville, TN.

Britzke, E. R., K. L. Murray, J.S. Heywood, J. S., and L. W. Robbins. 2002. Acoustic identification. Pg. 221-228 *In* The Indiana bat: biology and management of an endangered species (A. Kurta and J. Kennedy, eds). Bat Conservation International, Austin TX.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1989. A portable mist netting system for capturing bats with emphasis on *Myotis sodalis* (Indiana bat). Bat Research News 30:1-8.

Murray, K. L., E. R. Britzke, B. M. Hadley, and L. W. Robbins. 1999. Surveying bat communities: a comparison between mist nets and the Anabat II bat detector system. Acta Chiropterologica 1:105-112.

Stohlgren, T. J., J. F. Quinn, M. Ruggiero, and G. S. Waggoner. 1995. Status of biotic inventories in US national parks. Biological Conservation 71:97-106.

Taylor, C. A., R. S. McKitrick, and M. R. Pelton. 1981. Terrestrial vertebrate inventory of the Obed wild and Scenic River, Tennessee. Unpublished report to National Park Service.

Whitaker, J. O., Jr., and W. J. Hamilton, Jr. 1998. Mammals of the eastern United States. Cornell University Press, Ithaca, NY.