

**Mammal Inventory of Blue Ridge Parkway,
North Carolina and Virginia**

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National Park Service
Appalachians Highlands Network
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Submitted by:

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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”.

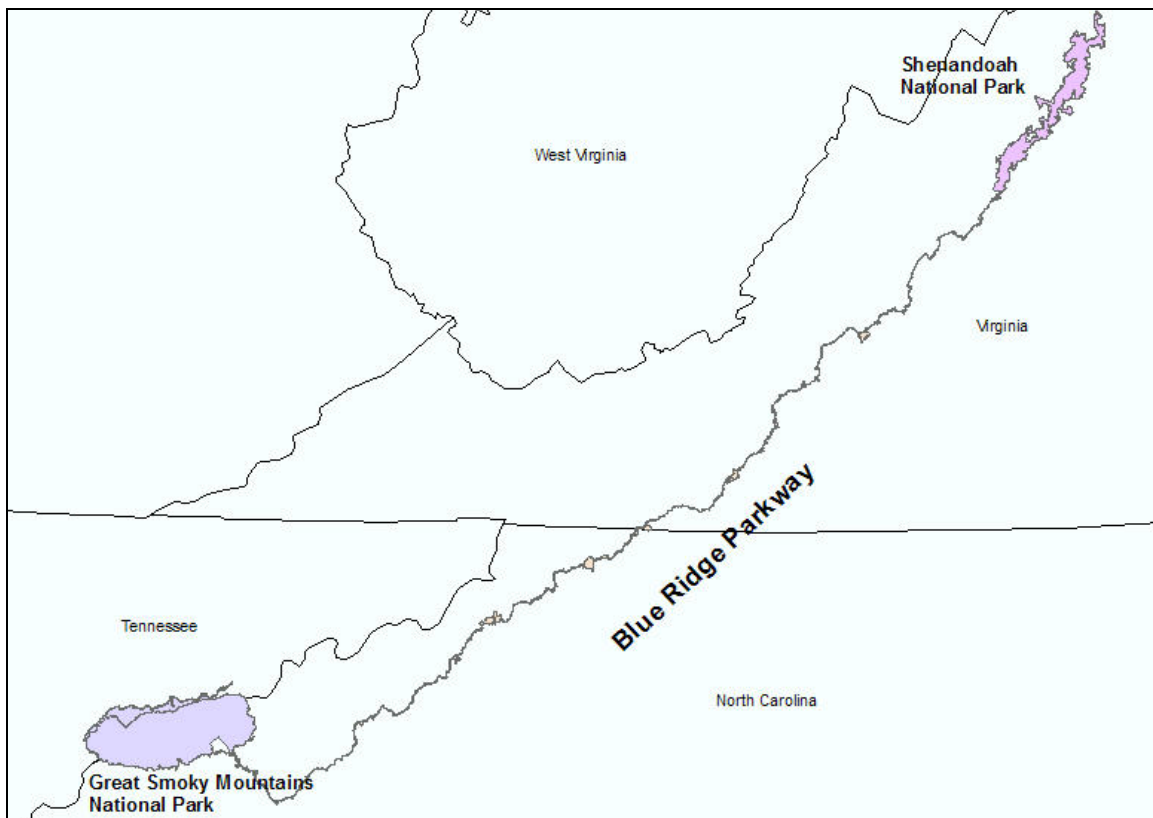
This project was an inventory of the mammals of Blue Ridge Parkway in North Carolina and Virginia. This information will be used for management decisions regarding park resources and protection, as well as education and outreach to the public. Further, inventory information such as this is an important part of the groundwork necessary for managers to develop effective monitoring programs designed to ensure the continued long-term health of Park natural resources.

The Blue Ridge Parkway (BLRI) extends 469 miles from its boundary with Great Smoky Mountains National Park in North Carolina to the southern boundary of Shenendoah National Park in northern Virginia (Fig.1). Elevations along the Parkway range from 198 m in Virginia to 1,843 m in western North Carolina. The 2 ends of BLRI are very different in habitat. The southern end of BLRI is much higher in elevation, has more talus slopes and boulder fields, and has spruce-fir and northern hardwoods, while the northern end is much lower in elevation and is comprised mainly of oak-hickory forest. Previous surveys of rare vertebrate species of the BLRI have been conducted,

primarily in the North Carolina portion (Knowles et al. 1989). However, this work was done in the late 1980's and focused only on a few species.

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

Figure 1. Location of Blue Ridge Parkway, North Carolina and Virginia.



Methods

All field work for the current project was conducted from fall 2003 through fall of 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 BLRI. 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 BLRI and for which suitable habitat occurred within BLRI. This list was viewed as a work in progress, and species were added if additional information suggested their occurrence within BLRI.

Mammals other than bats

A variety of methods was used to document the occurrence of mammals on the BLRI. Traps were used to capture smaller mammals (up to the size of *Mustela* spp.) and spot-lighting, chance observations, sighting reports from knowledgeable people, and road-kill surveys were used to document the presence of larger mammals.

Trapping was conducted in common habitats (i.e., mesic hardwood, boulder and talus slopes, oak-hickory forest) 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. Museum Special 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. Snap traps were not used in potential habitat of northern flying squirrels (*Glaucomys sabrinus*) to eliminate the possibility of collecting this endangered species, or other rare but non-listed species that occupy the same habitat. Tomahawk live traps baited with apple or corn were used to sample medium - sized mammals.

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. Along the southern end of BLRI, additional pitfall trapping was done in conjunction with a survey conducted by Daniel Ray of North Carolina Wildlife Resources Commission on the distribution of rock shrew (*Sorex dispar*) and water shrew (*Sorex palustris*) in western North Carolina using # 10 and # 12 tin cans. Checks of nest boxes set out for northern flying squirrels were conducted by North Carolina Wildlife Resources Commission biologists, so no efforts were focused on this species.

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 added to the collection at the North Carolina Museum of Natural Sciences.

Spotlighting transects were of varying length and passed through a variety of habitat types. Roads were slowly driven while observers scanned for medium and large mammals along the road. Animals observed during the course of other survey activities

were also recorded and their locations noted. Reports of species sightings were gathered from people that were knowledgeable of the area, including a road-kill animal survey conducted by Parkway personnel.

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, structures (bridges, historic buildings) were checked for bats as time permitted. (See page 9).

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 and along transects. Transects were slowly driven (< 20 mph) along predetermined routes to sample extensive areas that could not be sampled otherwise. Once a bat was heard at a location, the vehicle was stopped and recording was conducted for 1-5 minutes, depending on levels of bat activity detected. Echolocation calls of bats were 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 96 sites were sampled for small mammals during the mammal inventory at BLRI resulting in 4,375 trap nights. Sherman live traps (3,390 trap nights) and pitfall traps (685 trap nights) were the most commonly deployed types of traps and the majority of animals were captured in Sherman live traps (Table 2). A total of 401 animals of 15 species were captured during these trapping efforts. Trapping conducted

with the North Carolina Wildlife Resources Commission led to capture of 12 species and 683 captures (Table 3). Overall, the most commonly captured species included the deer mouse (*Peromyscus maniculatus*), smoky shrew (*Sorex fumeus*), and masked shrew (*Sorex cinereus*; Table 4). In addition, several state-listed species were captured including the water shrew (*Sorex palustris*), the long-tailed shrew (*Sorex dispar*), the star-nosed mole (*Condylura cristata*), and the rock vole (*Microtus chrotorrhinus*). Locations of rare species were concentrated along the southern half of BLRI in North Carolina. Sampling in boulder fields / talus slopes and in mesic hardwoods resulted in the capture of the greatest number of species and individuals (Table 4).

Four hundred ninety-six observations of 29 species were documented through visual observation and collections of reports from other people. Overall 42 of the 53 (79%) expected species of non-Chiropteran mammals were documented during this study.

Bats

Mist nets were used to sample 11 sites over 13 nights resulting in the capture of 70 bats representing 7 species. Little brown bats (*Myotis lucifugus*) were the most commonly captured bat (64% of all bat captures). Additionally, eastern small-footed bat (*Myotis leibii*), a species listed in North Carolina and Virginia as a state Species of Concern was also captured during this inventory. Most bat captures were made over creeks and streams on BLRI during this study (Table 4). Bats were observed in 4 man-made structures within BLRI. Big browns (*Eptesicus fuscus*) were observed day roosting in the Apple Barn in Moses Cone Memorial, in a red barn near Price Lake, and night roosting under a bridge over Sims Creek. Seven Virginia big eared bats (*Corynorhinus*

townsendii virginianus), 6 eastern small-footed bats (including at least 1 female with young), and 1 little brown bat were also observed in Linn Cove Viaduct during July.

Acoustic sampling was conducted at stationary sampling points during 28 nights for a total of 5,081 minutes. A total of 10,653 echolocation calls of bats and six species were recorded with bat activity varying considerably among sampling points (Table 5). The big brown bat, the eastern red, and the little brown were detected at the largest number of sampling stations (Table 5). Additionally, 16 transects covering 462 miles were surveyed using the Anabat II bat detector resulting in 2,150 files from 6 species (Table 6). Overall 8 of 11 (73%) expected species of bats were documented during this study.

Table 1. List of mammal species expected to be present on the Blue Ridge Parkway.

Order	Family	Species	Common Name
Didelphimorphia	Didelphidae	<i>Didelphis virginiana</i> ^a	Opossum
Insectivora	Talpidae	<i>Scalopus aquaticus</i>	Eastern mole
		<i>Parascalops breweri</i>	Hairy-tailed mole
		<i>Condylura cristata</i>	Star-nosed mole
	Soricidae	<i>Sorex cinereus</i>	Masked shrew
		<i>Sorex dispar</i>	Long-tailed shrew
		<i>Sorex fumeus</i>	Smoky shrew
		<i>Sorex hoyi</i>	Pygmy shrew
		<i>Sorex longirostris</i>	Southeastern Shrew
		<i>Sorex palustris</i>	Water shrew
		<i>Blarina brevicauda</i>	Northern short-tailed shrew
		<i>Cryptotis parva</i>	Least shrew
Chiroptera	Vespertilionidae	<i>Myotis leibii</i>	Eastern small-footed bat
		<i>Myotis lucifugus</i>	Little brown bat
		<i>Myotis septentrionalis</i>	Northern long-eared bat
		<i>Myotis sodalis</i>	Indiana bat
		<i>Lasiurus borealis</i>	Red bat
		<i>Lasiurus cinereus</i>	Hoary bat
		<i>Lasionycteris noctivagans</i>	Silver-haired bat
		<i>Pipistrellus subflavus</i>	Eastern Pipistrelle
		<i>Eptesicus fuscus</i>	Big brown bat
		<i>Corynorhinus rafinesquii</i>	Eastern big-eared bat
		<i>Corynorhinus townsendii</i>	Virginia big-eared bat
Lagomorpha	Leporidae	<i>Sylvilagus floridanus</i>	Eastern cottontail
		<i>Sylvilagus obscurus</i>	Appalachian rabbit
Rodentia	Sciuridae	<i>Tamias striatus</i>	Eastern chipmunk

Order	Family	Species	Common Name
		<i>Marmota monax</i>	Woodchuck
		<i>Sciurus carolinensis</i>	Eastern gray squirrel
		<i>Sciurus niger</i>	Fox squirrel
		<i>Glaucomys sabrinus coloratus</i>	Northern flying squirrel
		<i>Glaucomys volans</i>	Southern flying squirrel
		<i>Tamiasciurus hudsonicus</i>	Red squirrel
	Castoridae	<i>Castor canadensis</i>	Beaver
	Muridae	<i>Reithrodontomys humulis</i>	Eastern harvest mouse
		<i>Peromyscus maniculatus</i>	Deer mouse
		<i>Peromyscus leucopus</i>	White-footed mouse
		<i>Ochrotomys nuttalli</i>	Golden mouse
		<i>Sigmodon hispidus</i>	Hispid Cotton rat
		<i>Neotoma magister</i>	Allegheny woodrat
		<i>Neotoma floridana haematoreia</i>	Southern Appalachian Eastern woodrat
		<i>Clethrionomys gapperi</i>	Southern red-backed vole
		<i>Microtus pinetorum</i>	Woodland vole
		<i>Microtus chrotorrhinus</i>	Rock vole
		<i>Microtus pennsylvanicus</i>	Meadow vole
		<i>Ondatra zibethicus</i>	Muskrat
		<i>Synaptomys cooperi</i>	Southern bog lemming
	Dipodidae	<i>Zapus hudsonius</i>	Meadow jumping mouse
		<i>Napaeozapus insignis</i>	Woodland jumping mouse
Carnivora	Canidae	<i>Canis latrans</i>	Coyote
		<i>Vulpes vulpes</i>	Red fox
		<i>Urocyon cinereoargenteus</i>	Gray fox
		<i>Canis familiaris</i>	Domestic dog
	Ursidae	<i>Ursus americanus</i>	Black bear
	Procyonidae	<i>Procyon lotor</i>	Raccoon
	Mustelidae	<i>Mustela frenata</i>	Long-tailed weasel

Order	Family	Species	Common Name
		<i>Mustela vison</i>	Mink
		<i>Mustela nivalis</i>	Least weasel
		<i>Lontra canadensis</i>	River otter
	Mephitidae	<i>Spilogale putorius</i>	Spotted skunk
		<i>Mephitis mephitis</i>	Striped skunk
	Felidae	<i>Felis catus</i>	Domestic cat
		<i>Lynx rufus</i>	Bobcat
Artiodactyla	Suidae	<i>Sus scrofa</i>	Russian wild boar
	Cervidae	<i>Odocoileus virginianus</i>	White-tailed deer

^aSpecies in bold face were documented 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 Blue Ridge Parkway, North Carolina and Virginia, October 2003 – August 2004.

Trap Type	# of sites sampled	# of trap nights	# of species	# of captures
Sherman	80	3,390	15	384
Pitfall	13	685	1	3
Sherman – tree	5	85	1	2
Tomahawk	8	75	1	4
Mouse snap	5	110	2	3
Victor rat	2	20	0	0
Museum snap	1	10	1	5
Total		4,375		401

Table 3. Summary of animals captured during pitfall sampling conducted in conjunction with North Carolina Wildlife Resources Commission on and immediately adjacent to Blue Ridge Parkway, North Carolina during 2003-2004. (Coordinates of capture sites were submitted in a separate report to BLRI from the NC Wildlife Resources Commission, and are only partially included in this project's databases)

Species	Common name	# of sites	Total captures
<i>Condylura cristata</i>	Star-nosed mole	1	1
<i>Parascalops breweri</i>	Hairy-tailed mole	1	2
<i>Blarina brevicauda</i>	Northern short-tailed shrew	11	31
<i>Sorex cinereus</i>	Masked shrew	14	187
<i>Sorex dispar</i>	Rock shrew	12	32
<i>Sorex fumeus</i>	Smoky shrew	18	368
<i>Sorex palustris</i>	Water shrew	4	15
<i>Clethrionomys gapperi</i>	Red-backed vole	6	14
<i>Microtus pinetorum</i>	Woodland Vole	1	2
<i>Synaptomys cooperi</i>	Southern bog lemming	3	5
<i>Napaeozapus insignis</i>	Woodland jumping mouse	5	24
<i>Zapus hudsonius</i>	Meadow jumping mouse	1	2
Total			683

Table 4. Summary of mammals documented during this inventory. # of detections is the total number of events in which the species was documented. The habitat listed is the habitat in which the species was most commonly encountered.

Species	Common Name	# of Detections	Habitat
<i>Didelphis virginiana</i>	Opossum	61	Roadside
<i>Scalopus aquaticus</i>	Eastern mole	5	Grassland, Roadside
<i>Parascalops breweri</i>	Hairy-tailed mole	8	Grassland
<i>Condylura cristata</i> ¹	Star-nosed mole	1	Creeks and Streams and associated riparian areas
<i>Sorex cinereus</i>	Masked shrew	191	Boulder fields/ talus slopes
<i>Sorex dispar</i> ¹	Long-tailed shrew	32	Boulder fields/ talus slopes
<i>Sorex fumeus</i>	Smoky shrew	369	Boulder fields/ talus slopes
<i>Sorex hoyi</i>	Pygmy shrew	1	Mesic hardwood
<i>Sorex palustris</i> ¹	Water shrew	15	Creeks and Streams and associated riparian areas
<i>Blarina brevicauda</i>	Northern short-tailed shrew	47	Creeks and Streams and associated riparian areas
<i>Myotis leibii</i> ¹	Eastern small-footed bat	5	Creeks and Streams and associated riparian areas
<i>Myotis lucifugus</i>	Little brown bat	47	Creeks and Streams and associated riparian areas
<i>Myotis septentrionalis</i>	Northern long-eared bat	2	Creeks and Streams and associated riparian areas
<i>Lasiurus borealis</i>	Red bat	10	Creeks and Streams and associated riparian areas
<i>Lasiurus cinereus</i>	Hoary bat	1	Creeks and Streams and associated riparian areas

¹ Species listed as threatened or endangered by the states or the USFWS.

Species	Common Name	# of Detections	Habitat
<i>Pipistrellus subflavus</i>	Eastern Pipistrelle	10	Creeks and Streams and associated riparian areas
<i>Eptesicus fuscus</i>	Big brown bat	6	Mesic hardwood
<i>Corynorhinus townsendii virginianus</i> ¹	Virginia big-eared bat	1	Human Structure
<i>Sylvilagus floridanus</i>	Eastern cottontail	35	Roadside
<i>Sylvilagus obscurus</i>	Appalachian rabbit	4	Grassland
<i>Tamias striatus</i>	Eastern chipmunk	33	Roadside
<i>Marmota monax</i>	Woodchuck	37	Roadside
<i>Sciurus carolinensis</i>	Eastern gray squirrel	113	Roadside
<i>Glaucomys sabrinus</i> ¹	Northern flying squirrel	1	Spruce-fir
<i>Glaucomys volans</i>	Southern flying squirrel	3	Northern hardwood forest
<i>Tamiasciurus hudsonicus</i>	Red squirrel	6	Roadside
<i>Castor canadensis</i>	Beaver	7	Lakes, Wetlands, Creeks and Streams
<i>Peromyscus maniculatus</i>	Deer mouse	171	Boulder fields/ talus slopes
<i>Peromyscus leucopus</i>	White-footed mouse	104	Mesic hardwood
<i>Ochrotomys nuttalli</i>	Golden mouse	15	Mesic hardwood
<i>Neotoma magister</i> ¹	Allegheny woodrat	4	Boulder fields/ talus slopes
<i>Clethrionomys gapperi</i>	Southern red-backed vole	44	Boulder fields/ talus slopes
<i>Microtus pinetorum</i>	Woodland vole	2	Boulder fields/ talus slopes
<i>Microtus chrotorrhinus</i> ¹	Rock vole	2	Boulder fields/ talus slopes
<i>Microtus pennsylvanicus</i>	Meadow vole	48	Grassland
<i>Ondatra zibethicus</i>	Muskrat	1	Roadside
<i>Synaptomys cooperi</i>	Southern bog lemming	7	Creeks and Streams and associated riparian areas

Species	Common Name	# of Detections	Habitat
<i>Zapus hudsonius</i>	Meadow jumping mouse	4	Creeks and Streams and associated riparian areas
<i>Napaeozapus insignis</i>	Woodland jumping mouse	25	Creeks and Streams and associated riparian areas
<i>Vulpes vulpes</i>	Red fox	1	Mesic hardwood
<i>Urocyon cinereoargenteus</i>	Gray fox	5	Roadside
<i>Canis familiaris</i>	Domestic dog	7	Roadside
<i>Ursus americanus</i>	Black bear	2	Roadside, Mesic hardwood
<i>Procyon lotor</i>	Raccoon	49	Roadside
<i>Mustela frenata</i>	Long-tailed weasel	1	Boulder fields/ talus slopes
<i>Lontra canadensis</i>	River otter	1	Roadside
<i>Mephitis mephitis</i>	Striped skunk	15	Roadside
<i>Felis catus</i>	Domestic cat	3	Roadside
<i>Lynx rufus</i>	Bobcat	3	Roadside
<i>Odocoileus virginianus</i>	White-tailed deer	86	Roadside

Table 5. Summary of Anabat recording at stationary sampling points during mammal inventory of Blue Ridge Parkway, NC and VA in summer of 2004.

Date	Site	Time started	Time stopped	Time recorded	# of files	Bat species detected
28-Apr-04	Julian Price Campground	20:16	22:39	2:23	33	Big brown, Hoary, Little brown
25-May-04	BLRI Headquarters	20:30	22:15	1:45	27	Big brown, Eastern red, Hoary
01-Jun-04	Craggy Gardens	20:43	22:15	1:32	51	Big brown, Eastern red, Little brown
07-Jun-04	BLRI Maintenance building at Oteen, NC; Milepost 382.2	20:56	0:00	3:04	9	Big brown, Eastern pipistrelle, Eastern red
08-Jun-04	Tanbark Ridge Tunnel	21:07	0:37	3:30	158	Big brown, Eastern red, Northern long-eared
11-Jun-04	Mt. Pisgah Picnic Area	20:54	23:00	2:06	373	Big brown, Eastern red, Hoary, Little brown
24-Jun-04	James River Visitor Center	20:54	0:50	3:56	510	Big brown, Eastern pipistrelle, Eastern red, Little brown
26-Jun-04	Near intersection of FS road 311 With BLRI (On Little Irish Creek, near where	20:51	0:18	3:27	36	Eastern red, Northern long-eared

Date	Site	Time started	Time stopped	Time recorded	# of files	Bat species detected
	the Appalachian Trail crosses BLRI northeast of Punchbowl Mountain; approx. Milepost 52)					
27-Jun-04	1 st Overlook N of Otter Creek (Otter Creek Overlook; Milepost 59.7)	20:58	0:52	3:54	116	Eastern pipistrelle, Eastern red, Little brown, Northern long-eared
27-Jun-04	Lower Otter Creek Overlook (Milepost 62.5)	20:42	23:12	1:50	33	Eastern pipistrelle, Eastern red, Little brown
27-Jun-04	Otter Lake	20:48	0:50	4:02	49	Big brown, Eastern red, Little brown, Hoary
28-Jun-04	Abbott Lake	21:08	22:54	1:46	495	Big brown, Eastern pipistrelle, Eastern red, Little brown
06-Jul-04	Roanoke River Overlook	20:50	1:00	4:10	186	Big brown, Eastern pipistrelle, Eastern red, Little brown
07-Jul-04	Mabry Mill Pond	20:58	1:00	4:02	165	Big brown, Little brown
19-Jul-04	Stream below Price Lake Dam	20:45	0:36	3:51	1290	Big brown, Eastern red, Little brown
20-Jul-04	Sims Creek	20:45	0:05	3:20	42	Eastern red, Little brown, Northern long-eared
21-Jul-04	Sims Pond	21:01	1:29	4:28	1289	Big brown, Eastern pipistrelle, Eastern red,

Date	Site	Time started	Time stopped	Time recorded	# of files	Bat species detected
						Hoary, Little brown,
21-Jul-04	Price Lake	21:05	0:28	3:23	1028	Big brown, Eastern pipistrelle, Eastern red, Hoary, Little brown
22-Jul-04	Price Lake boat ramp	22:15	0:00	1:45	243	Big brown, Eastern red, Hoary, Little brown
22-Jul-04	Price Lake Picnic Area	20:52	0:08	3:16	784	Big brown, Eastern pipistrelle, Eastern red, Little brown
23-Jul-04	Linville River near Visitor Center	20:55	23:53	2:58	815	Big brown, Eastern pipistrelle, Eastern red, Little brown
24-Jul-04	Bass Lake	20:53	21:32	0:39	46	Big brown, Hoary, Little brown
25-Jul-04	Bass Lake	20:55	0:15	3:20	824	Big brown, Little brown, Hoary, Eastern pipistrelle, Eastern red
05-Aug-04	Little Glade Mill Pond	20:43	0:00	3:17	382	Big brown, Eastern pipistrelle, Eastern red, Little brown
16-Aug-04	Tanbark Tunnel	20:30	23:49	3:19	134	Big brown, Eastern pipistrelle, Eastern red, Hoary, Northern long-eared

Date	Site	Time started	Time stopped	Time recorded	# of files	Bat species detected
18-Aug-04	Linville Falls Visitor Center parking area	20:23	0:10	3:47	183	Big brown, Eastern pipistrelle, Eastern red, Little brown
18-Aug-04	Linville River near Visitor Center	20:18	0:05	3:47	1318	Big brown, Eastern pipistrelle, Eastern red, Little brown
24-Aug-04	Yellowstone Creek	20:18	22:22	2:04	34	Eastern red

Table 6. Summary of transect sampling conducted along Blue Ridge Parkway using the Anabat bat detector system.

State	Date	Location started	Location stopped	Time started	Time ended	Distance (mi)	# of files	Bat species detected
NC	5/25/04	Headquarters	MP 400	21:00	23:30	35	188	Big brown, Eastern pipistrelle, Eastern red
NC	6/2/04	Craggy Gardens	Ridge Junction Overlook	20:46	22:18	11	67	Big brown, Eastern red, Hoary, Little brown
NC	6/10/04	Devils Courthouse	Mt. Pisgah	21:08	23:34	15	291	Big brown, Eastern red, Hoary, Little brown
VA	6/26/04	Otter Creek north	MP 55	20:56	0:11	29	102	Big brown, Eastern pipistrelle, Eastern red
VA	6/28/04	Peaks of Otter	HWY 43	21:07	23:24	33	89	Big brown, Eastern pipistrelle, Eastern red, Little brown
VA	7/8/04	Rocky Knob Campground	MP 147	20:58	1:02	38	207	Big brown, Eastern pipistrelle, Eastern red
VA	7/9/04	Rocky Knob CG	Rocky Knob Info Station	20:58	1:43	34	117	Big brown, Eastern pipistrelle, Eastern red, Little brown
NC	7/19/04	Junction with HWY 221	Julian Price	20:52	0:56	29	175	Big brown, Eastern pipistrelle, Eastern red, Little brown
NC	7/22/04	MP 297	MP 305	21:00	21:45	8	15	Big brown, Eastern red
NC	7/23/04	Linville Falls	Linville Falls VC	20:56	23:45	42	116	Big brown, Eastern pipistrelle, Eastern red, Little brown
NC	7/24/04	Bass Lake Parking area	Bass Lake Parking Area	20:59	21:26	1	31	Big brown, Eastern small-footed, Little brown
NC	7/25/04	MP 297	MP 295	21:06	0:00	42	152	Big brown, Eastern pipistrelle, Eastern red, Hoary, Little brown, Silver-haired

State	Date	Location started	Location stopped	Time started	Time ended	Distance (mi)	# of files	Bat species detected
NC	7/28/04	Devil's Courthouse	HWY 441	20:55	22:56	47	75	Eastern red, Hoary, Little brown
NC	7/29/04	MP 451	MP 444.6	20:57	23:12	63	151	Big brown, Eastern Pipistrelle, Eastern red, Little brown
NC	8/3/04	MP 249.3	Doughton Park CG	20:54	0:45	18	165	Big brown, Eastern pipistrelle, Eastern red, Little brown
NC	8/4/04	MP 249	Doughton Park CG	20:55	1:07	17	209	Big brown, Eastern pipistrelle, Eastern red, Little brown

Discussion

Mammals other than Bats

Most expected species were documented during this inventory. Additionally, a number of rare species were documented along the southern portion (MP 200 south) of the BLRI during the study. Occurrence of multiple rare species and the number of observations of more common species illustrates the importance of the southern section of BLRI for mammal conservation. While most expected species were detected during this survey, species like the eastern harvest mouse and least shrew were expected but were not captured despite sampling of apparently suitable habitat. More focused sampling should be conducted for the remaining undetected species to determine their presence or absence on BLRI.

Two factors made conducting the mammal inventory difficult. The first problem was associated with human disturbance. Presence of large numbers of visitors made it difficult to survey some areas because of concerns about disturbance and equipment security. Secondly, the linear aspect of BLRI made it difficult to document species presence on BLRI. Because there are large tracts of the Nantahala National Forest, Pisgah National Forest, and George Washington and Jefferson National Forests adjacent to BLRI, larger mammals may spend only small portions of their time on BLRI, thereby making it more difficult to document their presence on the BLRI. These 2 factors increased the difficulty in conducting this survey, particularly for the larger mammal species.

Habitats in which species were most commonly detected provide 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, talus/boulder slopes on the southern end of BLRI were extensively surveyed during this study to ensure documentation of rare species (e.g., long-tailed shrews and rock voles) expected to be present in these areas. For some species, rocky habitat was the habitat in which the species was most commonly detected simply because this habitat type was extensively surveyed. Additionally, some species were documented through visual observations, so habitat relationships (i.e. roadsides) may simply reflect the increased detectability in some habitats. As trapping was conducted in habitats throughout the BLRI, habitat associations for animals that were captured (especially in larger numbers) should reflect actual habitat associations. However, for species that were rarely captured or only documented through visual identification, habitat associations should be considered as a subset of all habitats used. Future sampling would help to further delineate the habitat associations of mammals on BLRI.

Relative abundance of species can be inferred from the number of observations of a species. However relative abundance of species should not be estimated for the BLRI as a whole, but simply on a habitat by habitat basis. For example, talus slopes were extensively surveyed so species in these habitats might be over represented in relative abundances. However within talus slopes/ boulder fields sampled, smoky shrews, masked shrews, and deer mice were much more abundant than the rock voles and long-tailed shrews. Habitats that were expected to house more common species were not sampled as extensively. Additionally, because of the difficulty in documenting larger

species on BLRI, efforts were focused on surveying smaller species. Thus species such as the red fox (*Vulpes vulpes*) probably occur more commonly than documented during this inventory.

Bats

Eight species of bats were documented in this inventory. Use of the Anabat system failed to document any species not documented in other ways, but did provide additional locations for some species. Despite the limited number of suitable netting sites along BLRI, most species expected to occur on the BLRI were documented. The relatively large number of little brown bats resulted from a single site near Price Lake. The dam on this lake appeared to house a maternity colony of little brown bats based on the timing of captures and the large numbers of bats seen swarming around the dam near sunset. Without this site, little brown bats would represent a much smaller percentage of the total number of bats captured. Additionally, due to a lack of caves and mines, few bats probably occur on BLRI during the hibernation period, however little sampling was conducted during this time due to the difficulty in accessing sections of BLRI during winter. For any caves or mines that exist on BLRI, a winter survey should be conducted to fill in this data gap.

Three species of bats were not documented in this study even though BLRI occurs within or near their ranges. The silver-haired bat is migratory and likely occurs on BLRI during spring and/or fall migratory periods. Eastern big-eared bats (*Corynorhinus rafinesquii*) are not likely to occur on BLRI. Although occasionally using buildings, eastern big-eared bats commonly roost in caves, mines, or rock shelters in the southern Appalachians. Lack of these habitats suggests that they may be a rare resident along the

BLRI. However, with the limited number of sites that can be mist-netted and the difficulty of detecting this species with bat detectors due to their low intensity echolocation calls, future survey work is needed to definitively document the absence of this species on BLRI. Indiana bats were also not documented in the project. BLRI lacks the winter sites suitable for hibernation of the species. Additionally, BLRI occurs on the eastern edge of the distribution of this species. With the improved ability of the Anabat system to document species presence (Murray et al. 1999), determination of absence of Indiana bats on BLRI has more support. Based on my experience with the roosting ecology of the Indiana bats throughout their range and the analysis of habitat during this project, BLRI lacks large tracts of suitable roosting and foraging habitat for this species. Thus, even though not every piece of BLRI was surveyed thoroughly, it is unlikely that Indiana bat maternity colonies occur on BLRI.

The federally endangered Virginia big-eared bat was observed in the Linn Cove Viaduct. While a nearby cave is known to contain this species, it was surprising to document a species that is sensitive to disturbance roosting at this site. The Viaduct is directly under the heavily-traveled BLRI and hiking trails come very close to it. Presence of this species as well as small-footed bats stresses the importance of this site as a roosting site for bats along BLRI (see management recommendations).

Management Recommendations

Mammals other than Bats

One of the most apparent features of the BLRI is the long expanse of roadway. Although the road is there to allow people to experience the entirety of the lands under

BLRI ownership and management, efforts should be undertaken to minimize its impacts on the mammals within the Parkway's boundary. Because easy access may increase potential disturbance to some habitats, strong efforts should be made to restrict human access by limiting trails through special habitats. Talus slopes house rare species such as rock voles and long-tailed shrews but these habitats may be impacted by human visitation causing loss of vegetation, presence of trash, and other activities that might affect the structure of the area. Additionally, the federally endangered northern flying squirrel (*Glaucomys sabrinus coloratus*) occurs in spruce-fir habitats that are rare along the BLRI, thereby making them susceptible to loss through inappropriate development of these habitats. The parkway itself also serves as a source of mortality for a lot of mammals within the BLRI. Records should be maintained on presence and location of road kills on the BLRI to determine specific problem areas. Along areas with high mortality rates, alternative passages should be constructed to reduce the impact of vehicles on wildlife.

BLRI contains a wide variety of habitats, including some that support rare species of mammals. Some habitats on the BLRI require little or no management to maintain under natural conditions (e. g., spruce-fir, mesic hardwoods), while others require continual management (e.g., grasslands). Conservation of habitat such as spruce-fir generally requires limiting degradation. In contrast, grassy areas near roads require continual management to be maintained. A mowing rotation to ensure that not all grassy areas are mowed at the same time would allow taller grasslands to serve as refugia for animals such as meadow jumping mice (*Zapus hudsonicus*) until mowed areas grow up sufficiently to support these species. Additionally, restoration of native grass in places

where fescue has taken over on the BLRI would likely improve the overall habitat for animals using these grassy openings.

Due to the location of the BLRI in the landscape, water sources are generally limited. Therefore, care should be taken to minimize impacts on the few 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 water shrew and star-nosed mole 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 the bank with smaller shrubs, but also the presence of larger trees along the stream. In addition to helping mammals, efforts to conserve water resources along the BLRI will help countless other species.

Bats

Bats roost in a variety of different sites including: trees, rock shelters, caves, and human structures. Dead trees provide suitable roosting conditions for a number of species. Indiana and northern long-eared bats roost under the exfoliating bark of dead trees (although Indiana bats were not found on BLRI during this inventory). Dead trees are generally deemed unsuitable from the aesthetic and safety viewpoints and are taken down along the BLRI. 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. Additionally, some bats such as small-footed bats roost in rock cliffs and have even been found roosting under rocks in talus slopes. The large amount of this habitat along BLRI

illustrates the potential importance of BLRI for this species. Hiking trails and climbing routes should be limited in these areas to minimize impact to these sites, and efforts should be made to discourage off-trail use. Reduction of human disturbance will ensure that bats continue to have access to these roost sites.

Various human structures housed bats in BLRI. Bats are utilizing these sites because they provide suitable roosting conditions. Therefore, management efforts should focus on conserving the suitability of these structures as bat roosts. One important factor that needs to be controlled is human disturbance. Some bats will not utilize roosts that have extensive human disturbance. Thus, efforts should be made to eliminate human access to important sites. This can be accomplished by providing bat-friendly gates at Linn Cove Viaduct, locking doors to barns with bat colonies, and limiting human access below bridges. Additionally, roost temperature profiles and accessibility need to be maintained. Maintaining body temperature is important to bats during summer, especially in the higher elevations along portions of the BLRI. 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 staying 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 other resource conflicts do not exist. 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.

The Linn Cove Viaduct deserves special discussion. Two rare species were found roosting in this structure in 2004 including a maternity colony of small-footed bats (at least one female with her young attached). Although male bats have roosting requirements that are much less restrictive than females, presence of male Virginia big-eared bats (Federally-listed as Endangered) and the close proximity of this site to a known hibernation site suggests that the Viaduct could be a maternity site if human disturbance was eliminated. Although there are doors on the entrances to the interior of the Viaduct, these have not effectively controlled access. Locks have been broken off the doors and access to the viaduct is now possible through both ends. To enhance protection of bats at this site, the lock should be vandal-proof. Additionally, bat friendly gates should be installed on both ends of this structure. A typical gate used at cave and mine entrances throughout the United States could be installed (Currie 2002). Due to the size and shape of the viaduct openings, the gates would be easy to design and build. Gates would allow bats to use the structure without disturbance, while not significantly altering airflow, temperature, or humidity within the viaduct. These modifications would increase the potential of this site for use by larger numbers of bats. On the adjacent privately-owned lands of Grandfather Mountain, a bat-friendly gate was installed several years ago over the entrance to a cave used by Virginia big-eared bats, with excellent results and significant increases in numbers of bats using the site for both hibernation and rearing of

young. Similarly positive results could be expected if the Park Service followed suit on Parkway property.

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