

Colonial Cavity Roosting Bats Guild

Big Brown Bat (*Eptesicus fuscus*)

Eastern Small-footed Myotis (*Myotis leibii*)

Little Brown Bat (*Myotis lucifugus*)

Northern Long-eared Bat (*Myotis septentrionalis*)

Rafinesque's Big-eared Bat (*Corynorhinus rafinesquii*)

Southeastern Bat (*Myotis austroriparius*)

Tri-colored Bat (formerly Eastern Pipistrelle) (*Perimyotis subflavus*)

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DESCRIPTION

Taxonomy and basic description

Colonial bats are those which gather in groups, forming maternity and/or hibernation colonies. The colony size can vary from 3-4 individuals to thousands. Cavity roosting bats use cavities or crevices for shelter. Most species of South Carolina bats are colonial cavity or crevice roosting. They include Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), Southeastern bat (*Myotis austroriparius*), big brown bat (*Eptesicus fuscus*), evening bat (*Nycticeius humeralis*), tri-colored bat (*Perimyotis subflavus*) formerly known as the Eastern pipistrelle, little brown bat (*Myotis lucifugus*), Northern long-eared bat (*Myotis septentrionalis*), Eastern small-footed myotis (*Myotis leibii*), and Brazilian free-tailed bat (*Tadarida brasiliensis*). Seven of these species are of conservation concern and are discussed in this CWC Plan; Rafinesque's big-eared bat, Southeastern myotis, little brown and Northern long-eared bats, small-footed myotis, big brown bat and Eastern pipistrelle. Rafinesque's big-eared bat was first described by Lesson in 1827, the Southeastern bat by Rhoads in 1897, and the Eastern small-footed myotis by Audubon and Bachman in 1842. The Northern long-eared myotis or Northern myotis (formerly Keen's myotis) was described by Trouessart in 1897. The Eastern pipistrelle was described by F. Cuvier in 1832 and renamed to their current Genus in 2006 by Hooper, Van Den Bussche and Horacek. The little brown bat was first described in 1831 by LeConte, and Palisot de Beauvois described the big brown bat in 1796.

All South Carolina bats are nocturnal, feed on insects, and navigate or locate prey by ultrasonic echolocation. Echolocation is the use of reflected sound waves to locate objects. Ultrasonic echolocation means the sound waves used are typically above the human hearing range. Fecundity in these species is low, with bats producing 1-2 young (pups) annually in the summer. The Rafinesque's big eared bat, small-footed myotis, little brown bat, and Northern long-eared bat produce only a single pup while the Southeastern myotis, big brown bat, and Eastern pipistrelle typically give birth to up to 2 young per year. All of our bats give birth once a year, at most.



Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) have enormous ears, 27-37 mm (1.06-1.5 in.) which they fold up (deflate) while resting or hibernating. These bats have hairy toes, relatively large feet (9-13 mm or 0.4-0.5 in.), and two distinct fleshy protuberances, on either side of the nose. They weigh 7-10 g (0.24-0.35 oz.). Fur color in adults is a dark brown on back with dark rooted whitish hairs on the underside of the animal. Juveniles appear dark gray. The first upper incisor tooth has two cusps or points. Photo of Rafinesque's big-eared bats (left) by Mary Bunch.

Previously accepted designations for this species were *Corynorhinus macrotis* and *Plecotus rafinesquii*. The current accepted scientific name, *Corynorhinus rafinesquii*, is based on chromosomal variation and morphometric measurements. Two subspecies of Rafinesque's big-eared bats are recognized within South Carolina. *Corynorhinus rafinesquii rafinesquii* is the subspecies found in the mountains of South Carolina and into North Carolina, Georgia and beyond along the Appalachian mountains. The disjunct Coastal Plain populations are recognized as *C. r. macrotis*.



The Eastern small-footed myotis (*Myotis leibii*) is a monotypic species and is South Carolina's smallest bat. Adults typically weigh only 3-6 g (0.1-0.2 oz.) and have a wingspan of 212-247 mm (8.3-9.7 in.). They have distinctively small feet only 6-8 mm (0.2-0.3 in.) long, a dark mask at the eyes, and black ears. Their fur is shiny brown on back and whitish or buff on the belly. Wing and tail membranes as well as the muzzle, are a dark chocolate color. Photo of Eastern small-footed bat (left) provided by BCI.

One subspecies of the Southeastern myotis occurs in South Carolina, *Myotis austroriparius austroriparius*. Southeastern bats have a pinkish face or muzzle. The fur of the Southeastern bat has a wooly texture and is generally a dull-grayish brown. Fur color may vary with season, with some individuals having a bright reddish-orange appearance in the summer. These bats weigh 5-12 g (0.17-0.42 oz.). The hindfoot is hairy and averages 10 mm (0.39 in.) long. Photo of red phase Southeastern myotis (right) by Merlin Tuttle, BCI.





The tri-colored bat, formerly known as the Eastern pipistrelle, is small, weighing an average of 6 g (0.2 oz.). For their size they have large feet, 7.3-9.9 mm (0.29-.39 in.). They are not as colorful as the term “tri-colored” implies. Tri-color refers to the banding on the hairs; from the base to tip each hair appears dark, light and dark. Most pipistrelles are buff-yellowish but can appear brown. The radius bone visible through the skin appears pink. The face and ears also have

a pinkish color. *Perimyotis subflavus* is a monotypic species.

Photo of tri-colored bat (above, left) by Mary Bunch.

Little brown bats can be difficult to tell from Northern long-eared bats. Both are small bats with brown fur. Little brown bats tend to have dark brown fur on the back that appears glossy. The tragus (a structure within the ear) is straight on both the little brown bat and the Northern long-eared bat, but it is more pointed in the Northern long-eared bat. The little brown bat typically weighs 7-14 g (0.24-0.49 oz.) and is 8-9.5 cm (3.1-3.7 in.) long. The hairs on the feet of the little brown bat extend beyond the nail, unlike those of the Northern long-eared bat. Northern long-eared bats are also 8-9.5 cm (3.1-3.7 in.) long and their average weight is 7.4 g (0.26 oz.). Their ears, if folded toward the nose, would extend slightly beyond the tip of the nose.



Photo of Northern long-eared bat (above, right) provided by NPS/Steven Thomas. Photo of little brown bat (left) provided by USFWS.

Big brown bats are large bats weighing, 13-18g (0.4-0.6 oz.) with a body length of 10.3-13.0 cm (4.05-5.11 in.). They have dark brown glossy fur and the muzzle is dark with an inflated appearance. Adults have a forearm measurement of 4 cm (1.57 in.) or more.

Photo of big brown bats (right) by Mary Bunch.



Status

In South Carolina, Rafinesque's big-eared bat is imperiled (S2?) and is listed as State Endangered. In North Carolina it is listed as State Threatened. Georgia and Kentucky rank these bats as Rare or Vulnerable, while Virginia and Florida rank them as Imperiled. West Virginia considers the species to be Critically Imperiled. They have a rounded global status of Rare or (G3/G4).

The Southeastern myotis is Critically Imperiled in South Carolina (S1) and is designated as "in need of management," or threatened. Kentucky, Virginia, and North Carolina rank the species as Imperiled, while it is considered Rare or Vulnerable in Georgia, Tennessee and Florida. The rounded global status is Rare or Vulnerable (G3/G4).

Eastern small-footed bats have a global rank of Rare (G3) and are on the IUCN Red List under the Lower Risk category. In South Carolina small-footed bats are Critically Imperiled (S1), and are designated as "in need of management" which equates to State Threatened. Virginia, West Virginia, and Alabama also rank Eastern small-footed bats as Critically Imperiled. The species is considered Imperiled in Georgia, Tennessee and Kentucky and is under review in North Carolina. In 2013, USFWS determined that the species did not warrant listing under the ESA.

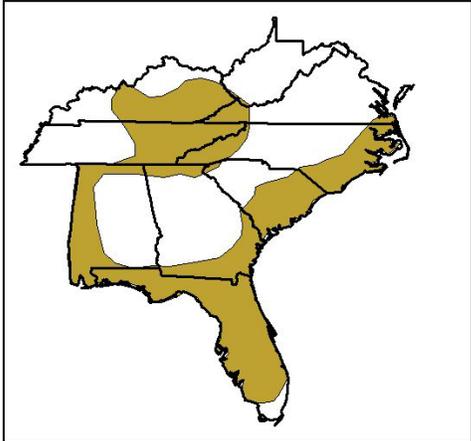
The tri-colored bat, big brown bat and little brown bat are all ranked as globally Secure (G5), and the big brown and tri-colored bat are not currently on the South Carolina list of Special Concern species (SNR). Little brown bats have a state rank of possibly Vulnerable (S3?). However, states in the Northeast have recently listed these species as species of concern. Vermont lists little browns as State Endangered. The US Fish and Wildlife Service conducted a status review of the Northern long-eared bat and is proposing a status of Endangered under the ESA due to threats from white-nose syndrome (WNS). South Carolina currently ranks Northern long-eared bats as Apparently Secure (S4); they are globally ranked Secure (G5).

WNS is a fungal disease of hibernating bats. The fungus, *Pseudogymnoascus destructans*, attacks the dermis of bats while their immune systems are not active during hibernation. The fungus prefers cool, humid conditions such as those bats seek for winter hibernation in caves and mines. The fungus is difficult to detect on bats during the warm summer months when their body temperature is high and their immune systems launch effective attacks on the fungus. However an individual's past affliction with WNS may manifest as damage to wing membranes post-hibernation. By fall much of the damage from the previous winter is not evident. Close to 7 million bats are estimated to have been killed by WNS in the Northeast since the discovery of WNS in 2006. The impact that WNS will have on bats in South Carolina is not known. All colonial bat species do not succumb equally; with greater survivorship in larger bodied bat species. Many of the mines and the handful of caves known in South Carolina do reach temperatures favorable to WNS. However, some have hypothesized that the warmer and shorter winters in the South will allow more bats to survive with WNS.

In February 2013, a tri-colored bat was found dead at Table Rock State Park. Testing by the Southeastern Cooperative Wildlife Disease Study in Athens, GA confirmed that the bat had WNS, the first case in SC. In April 2013, an Eastern small-footed myotis from a more southerly location in the same park was identified. As of March 2014, the farthest south the disease has reached is Polk County, Georgia.

POPULATION SIZE AND DISTRIBUTION

Rafinesque's big-eared bats (*C. r. macrotis*) range from North Carolina, southward along the entire coastal plain and into the Sandhills of South Carolina (Figure 1). They extend southward through Georgia and into Florida. The Piedmont of North and South Carolina and Georgia represents a gap in distribution. Rafinesque's big-eared bats (*C. r. rafinesquii*) are distributed within the Southern Appalachian Ecoregion from West Virginia southward into South Carolina and Georgia. They also reach into Alabama.

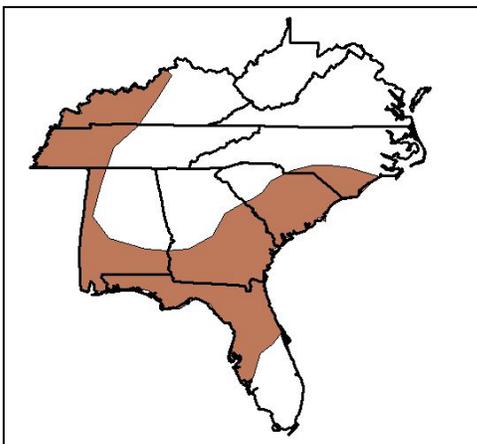


These bats have never been considered abundant. Colony sizes are larger in the northern end of their range where the species often inhabits caves and mines, but tend to be smaller in the southern portions of the range where caves and mines are less abundant.

Figure 1. Distribution of *Corynorhinus rafinesquii* in the Southeast.

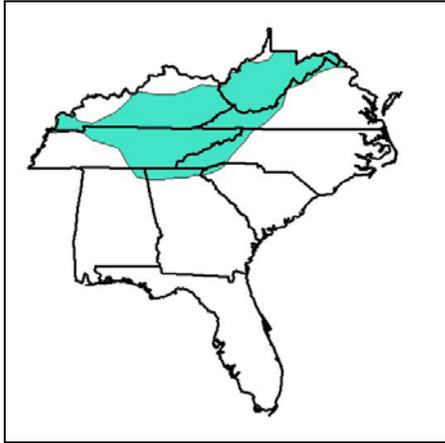
Southern roosts tend to be in tree cavities and man-made structures. Colony sizes are often less than 30 (usually 5-12) and seldom over 100.

Population trend information is sparse, but most states suspect declines. Size of home range varies, averaging 93.2 ha (230.3 acres) in the Inner Coastal Plain Ecoregion, and ranges from 64-89 ha (158-220 acres) in a forested old growth swamp on the Outer Coastal Plain.



The Southeastern myotis occurs from Florida northward mostly in the Coastal Plain through South Carolina, North Carolina and into the Southern Coastal Plain of Virginia (Figure 2). The distribution extends westward along the Coastal Plain of Georgia, Alabama, Louisiana, and Mississippi and northward along the Mississippi River into western Tennessee, Kentucky, and southern Illinois and Indiana. Population trends are not known in South Carolina, but Florida reports significant declines.

Figure 2. Distribution of *Myotis austroriparius* in the Southeast.



The range of the Eastern small-footed myotis extends from the mountains of South Carolina and Georgia, northward along the Appalachian Mountains into Virginia, West Virginia, Pennsylvania and southern New England and Canada. Populations extend westward into Kentucky, Tennessee, Alabama, and into Oklahoma. Population trends for this species are largely unknown. Declines have been reported from other states. The species has never been regarded as abundant anywhere.

Figure 3. Distribution of *Myotis leibii*.

Big brown bats and Eastern pipistrelles or tri-colored bats are statewide in distribution. They are considered common in South Carolina, but that may soon change with advancing WNS. These bats will use T-beam bridges, buildings, mines, tunnels, caves, and hollow trees for roosts. They are sometimes deemed a nuisance by homeowners.

Both little brown and Northern long-eared bats are found primarily in the mountains of South Carolina. There are some noteworthy patchily distributed records of the Northern long-eared bat in the Coastal Plain of North Carolina.

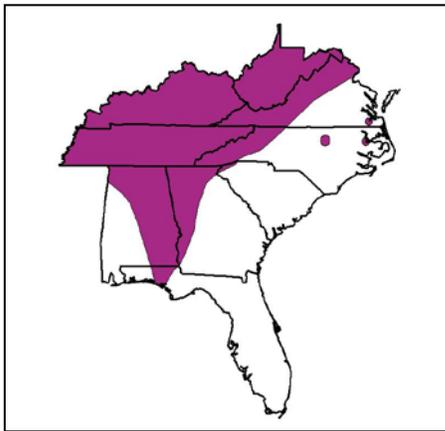


Figure 4. Distribution of *Myotis septentrionalis* in the Southeast.

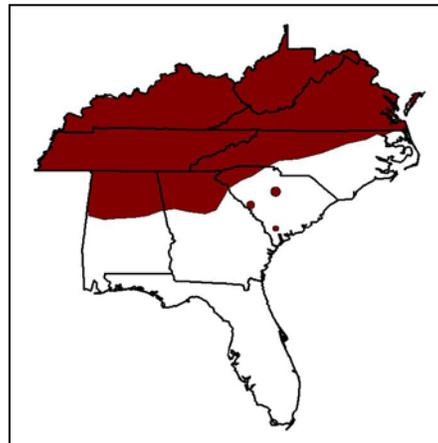


Figure 5. Distribution of *Myotis lucifugus* in the Southeast.

Tri-colored and big brown bats are found statewide as well as throughout the Southeast.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Rafinesque's big-eared bats:

In South Carolina, some Coastal Plains' and Sandhills' populations use T-beam and I-beam bridges, abandoned buildings, old bunkers and tunnels, and cavity trees. The mountain populations apparently do not use bridges for roosts but use cavity trees, typically large hollow tulip poplars (*Liriodendron tulipifera*), abandoned buildings, cave or cave-like structures called rock shelters, and abandoned mines. Rafinesque's big-eared bats are non-migratory. Movement is described as localized, not far-ranging from the roost; and distribution is patchy.

Habitat in the Blue Ridge Mountains for *C. r. rafinesquii* includes rock outcrops (for roosting), mesic and cove hardwood forests, forested bottomlands, bottomland agricultural fields, dry deciduous forest, pine woodlands, and forested riparian areas. Coastal Zone and Sandhills habitat of *C. r. macrotis* for roosting and foraging include black gum (*Nyssa sylvatica*) and water tupelo (*Nyssa aquatic*) stands, bald cypress (*Taxodium distichum*) swamp forests, maritime forests, and mature forested bottomlands (hardwood or mixed). They require very large tree cavities, frequently found in gum (*Nyssa sp.*) trees. Foraging was documented in a young pine plantation in a study with a small sample size. The best way to locate colonies is to examine cavities of large trees in appropriate areas.

Rafinesque's big-eared bats are reported to be moth specialists, although other insects are also consumed. Studies have shown that consumption of moths varied, with 48-100% of samples containing moths (Lepidoptera).

Southeastern myotis:

Caves (including limestone sinks), mines, abandoned buildings, and large hollow trees are used for roosting, maternity colonies and hibernation sites. In addition, they use forested bottomlands, forested swamps, Carolina bays, mesic deciduous and mixed forests. This bat forages and prefers to roost over or near water.

In Florida studies show that food habits vary with season. In summer Coleoptera and Lepidoptera were primary prey. Winter consumption included Coleoptera, Lipidoptera, Diptera, and especially Culicidae.

Eastern small-footed myotis:

These small bats are known to use caves, mines, abandoned buildings, rock crevices and shelters, and crevices within bridges in wooded areas of the Southern Appalachian Ecoregion. In South Carolina, only few small-footed bat roosts have been found. They included a crevice in a rock outcrop in mature hardwoods (also suitable for green salamanders, *Aneides aeneus*), loose tarpaper on an abandoned log cabin, a wood pile on a porch, a fish hatchery building, and a picnic shelter.

Hardwood and evergreen forests, mixed hardwood-conifer stands, bottomland, and floodplains are reported as important habitat for the Eastern small-footed myotis. They appear to prefer to forage over streams and ponds. For example, in South Carolina, they have been observed foraging over Reedy Cove Creek >100 m (328 ft.) downstream from the waterfalls. These bats are slow fliers with a fluttery flight pattern. It is likely they require forested corridors between roosts and foraging areas. The winter and summer roosting requirements and foraging habitats are poorly understood for this species.

Several species of colonial bats are sometimes nuisances or unwanted residents of homes, businesses, stadiums, and other man-made structures. Most often, nuisance colonies in South Carolina can be attributed to four species: big brown, free-tailed, evening bats, and tri-colored bats. While all three colonial species of conservation concern do sometimes use buildings, those buildings are usually unoccupied; it is very uncommon for them to use sites frequented by humans.

Little brown bats:

In South Carolina summer or maternity colonies are known from buildings and picnic shelters. They also are likely to use cavity trees. Only one hibernaculum is known from a single cave in Pickens County, South Carolina. It is unknown where most of South Carolina's summer little brown bats overwinter.

Northern long-eared myotis:

Little study of Northern long-eared bats has been done in South Carolina. A Northern long-eared bat was tracked to a dead pine; the bat was under loose bark on National Forest land near Oconee State Park. Studies of their roosting habits in North Carolina, Kentucky, Arkansas, and West Virginia show they use a variety of tree species. Oaks are primarily used in North Carolina, shortleaf pine (*Pinus echinata*) has been shown to be used in Arkansas and Kentucky, and in West Virginia black locust was used for roosting. Northern long-eared bats tend to prefer crevices and cavities in dead or live-damaged trees, but they sometimes roost between loose bark and the bole of dead trees. Females prefer larger diameter trees than those used by males.

Northern long-eared bats are considered to be clutter-adapted species; meaning that they often forage in densely forested areas. In South Carolina, they are most likely to forage in mature stands. Northern long-eared bats often glean their prey from the surface of vegetation although they also forage by aerial hawking.

Tri-colored bat (formerly Eastern pipistrelle):

The small-bodied tri-colored bat is often one of the first species to move into a mine or cave for hibernation and is often the last to leave in the spring. In winter these bats often use abandoned mines and caves, and they are abundant in the incomplete Blue Ridge Railroad tunnels. Although considered colonial bats, individuals are often not physically

clumped together. While hibernating, tricolored bats hang singly but can be near conspecifics. Frequently they are covered in condensation while hibernating.

During summer tri-colored bats can be found under certain bridges and in buildings in the summer. They are sometimes regarded as a nuisance by homeowners. In South Carolina and Indiana, females often form small maternity colonies (3-5 individuals) in clusters of live or dead leaves in trees. Male tri-colored bats in North Carolina use large diameter oaks and hickories for roosts. Tri-colored bats may switch roost sites in summer but their roosts are typically close together.

South Carolina data shows that tri-colored bat activity does not seem to be influenced by thinning forest stands or by conducting controlled burns. In Illinois the diet of tri-colored bats consisted mainly of Trichopterans (caddisflies) and also consist of Coleoptera and Hymenoptera.

Big brown bat:

Big brown bats are ubiquitous. They are frequently found in buildings, cavity trees, under bridges and in bat boxes. They are infrequently found in tunnels and caves. Typically, they do not move to underground structures until extremely cold temperatures arrive and they are often the first species to leave the hibernaculum. They are frequently excluded from homes by wildlife control operators.

Big brown bats usually forage in open areas such as fields and wildlife openings or large gaps within forests. In the eastern United States, their diet consists primarily of Coleoptera. Lepidoptera are also an important part of their diet in some areas.

CHALLENGES

Threats to these bat species are summarized as follows:

All colonial bats in South Carolina¹:

- White-nose syndrome threatens all of these species, although Rafinesque's big-eared bats have not suffered mortality due to WNS, to date. An Eastern small-footed myotis and a tri-colored bat were discovered at Table Rock in 2013 suffering from WNS. In 2014, SCWDS confirmed a tri-colored bat, collected by SCDNR, as positive for WNS via histopathology. The bat came from an abandoned railroad tunnel at Stumphouse Mountain Heritage Preserve in Oconee County, SC. In March 2014, Oconee and Pickens Counties were also added to the map of confirmed WNS cases in North America. Then in July 2014, SCWDS confirmed that another tri-colored bat—this time from Richland County—tested positive for WNS.
- Disturbance/destruction of natural roost structures (caves, rock shelters, trees).
- Global climate change may make southern hibernation sites unsuitable (too warm).
- Increased predation by natural predators due to habitat alterations that either make the bats more vulnerable to predation or increase the density of predators.

- Destruction and disturbance of artificial roost structures (girder type bridges, abandoned houses and barns, mines, and tunnels).

Rafinesque's big-eared bat and Southeastern myotis:

- Destruction of natural roosts, particularly large hollow trees in the Coastal Plain.
- Destruction and fragmentation of bottomland hardwood forests that are used for roosting and foraging.
- Pesticide and heavy metal contamination.
- Unnatural predation at roosts by feral cats.
- Alteration of natural flood regimes may affect the regeneration of important forest community types such as cypress-gum, thus preventing recruitment of future roost trees.
- Alteration of local hydrology can increase flooding of natural roosts.
- Genetic isolation of populations.
- Abundant invasive exotic vegetation, such as some privet species, may prevent regeneration of forest species and impair recruitment of suitable roost trees.

Rafinesque's big-eared bat:

- Destruction and fragmentation of mature forests in the mountains and Coastal Plain.
- Potentially, deforestation from gypsy moths (*Lymantria dispar*) and / or control measures for gypsy moths, such as broadcast usage of *Bacillus thuringiensis* var. *kurstaki* (Btk) may impact this bat species.

Southeastern myotis:

- Flooding / inundation of natural roost sites.

Other threats (not species-specific) on the horizon:

- Wind turbines erected near roosts, and colony sites, and along migratory routes kill bats. Significant mortality of tri-colored bats was noted at one wind power facility. No wind turbines have been placed in South Carolina to date, but Clemson University is constructing a test facility for turbines at the coast.
- Sudden Oak Death (SOD) caused by *Phytophthora ramorum* could lead to extensive deforestation of oak (*Quercus* spp.) forests. The disease was recently detected on nursery stock (though not found in natural settings to date).

CONSERVATION ACCOMPLISHMENTS

Currently over 65,963 ha (163,000 ac.) of mountain habitat in South Carolina is protected by state, federal, or nonprofit conservation organizations. Many of those tracts protect Rafinesque's big-eared bat and small-footed myotis roosts or foraging areas. Examples are Ashmore Heritage Preserve, the Greenville Water System's South Saluda watershed that is held in a conservation easement, and the Andrew Pickens District of the Sumter National Forest.

Several important roost and/or foraging sites in the Coastal Plain are in public ownership. An excellent example of old growth forest with Rafinesque's big-eared bats and Southeastern myotis is the Francis Beidler Swamp, also known as Four Holes Swamp, owned by the Audubon Society. In 2011 Congaree National Park added 1840 acres to the park. That park provides important roosting and foraging habitat for big-eared bats and the Southeastern myotis.

These activities have benefited bats:

- Surveys of mines, tunnels, bunkers and rock shelters/caves and trees along the Savannah River floodplain have located some colonies of Rafinesque's big-eared bats, Southeastern bats, tri-colored bats and occasional records of the other colonial species listed here.
- Contribution to poster, "Bats of the Eastern United States" used for educational outreach and provided free to the public.
- Completed a survey of Pest Control and Wildlife Control Operators in 1991 to evaluate the use of chemicals / pesticides vs. exclusion on nuisance bat colonies and reported findings at the South Carolina 33rd Annual Pest Control Operators School (38% had been using pesticides/chemicals on bats).
- Provided several training sessions on exclusion techniques and bat identification to Wildlife Control operators (WCOs) and Clemson University students.
- Posted WNS information and important links on the SCDNR website.
- Conducted numerous information and education programs on South Carolina's bats.
- Gated 10 tunnels to reduce human disturbance to Rafinesque's big-eared bat and tri-colored bat colonies, and modified 5 to improve air traps for Rafinesque's big-eared bats and big browns.
- Completed state-wide survey of bridges (2002-2003) to determine distribution of Rafinesque's big-eared bats; 52 bridges were used by Rafinesque's big-eared bats and of those 24 were used by maternity colonies. That work also located several big brown colonies and one tri-colored bat colony.
- Good baseline data on the use of natural roosts and foraging areas by Rafinesque's big eared bat and the Southeastern myotis are available for the Francis Beidler Forest in the Outer Coastal Plain, Congaree National Park in the Inner Coastal Plain, the Savannah River Site, Webb Wildlife Center and Groton Plantation.
- Various agencies and NGOs have erected artificial roost structures (concrete bat towers and/or wooden bat boxes) at Silver Bluff Audubon Sanctuary, Hamilton Ridge WMA, Oconee, Devils Fork, Kings Mountain, and Table Rock State Parks, Clemson Experimental Forest, Sumter National Forest, South Carolina National Guard McCrady Training Site, Jocassee Gorges and Ashmore Heritage Preserve.
- Cave closure signs were posted at Santee State Park with WNS information. WNS information was posted at the main Stumphouse Tunnel owned by Clemson University.
- Acoustic survey routes have started to provide baseline population and diversity information within the Andrew Pickens and Long Cane and Enoree Districts of the Sumter National Forest, the Savannah River Site, and Carolina Sandhills

National Wildlife Refuge. A new acoustic survey grant in the works will help cover the entire state using the newest national standards.

- An online form was developed for citizens to report colonies observed throughout the State of South Carolina. It can be found at SCDNR's website at the following link: <http://www.dnr.sc.gov/wildlife/bats/>.

CONSERVATION RECOMMENDATIONS

Habitat protection

- Efforts should be made to protect foraging areas and migration corridors in addition to protecting known roosts. Protections could vary including landowner incentive programs, conservation easements, lease agreements, or purchases.
- Some formal agreement, such as a Memorandum of Understanding, between SCDNR and SCDOT regarding adaptations to new, long bridges over water in the Sandhills and Inner and Outer Coastal Plain is desirable. Currently, some of this work is handled through discussions with environmental consultants working on bridge projects with wetlands impacts.
- Protection of mature bottomland hardwood forests and connecting corridors in the Inner and Outer Coastal Plain is important for *C. rafinesquii* and *M. austroriparius*. Recruitment of younger stages of high quality bottomland habitat for growth into future roost trees is needed.

Management

- Control human access to important mines, caves, and rock shelter formations by signage or other restrictions, and do not create trails or roads to these sites.
- Designate buffers (no-cut zones) around known roosts.
- Provide forested corridors between any harvested units and retain large snags.
- Retain and recruit cypress-gum swamp forests containing large cavity trees.
- Regarding roosts in buildings: Measures should be taken to provide alternate roost structures at each significant site, or repairs should be made to the structure to ensure roost longevity. Typical bat box structures will not suffice for species that prefer large open cavities (Rafinesque's big-eared bats), not crevices. Structures which mimic large hollow trees may be suitable alternative roosts (similar to artificial chimney structures now used for chimney swifts) for Rafinesque's big-eared bats and Southeastern bats. Multi-chamber nursery boxes should be erected for significant little brown bat, Northern long-eared, and small-footed bat colonies. Alternatively, large bat towers for Rafinesque's big-eared bats can be modified to accommodate these species.

Priority research and survey needs

These research and survey needs are not restricted to South Carolina and could involve partnerships with other states in the respective ecoregions.

All colonial bats:

- Because we are at the southern most range to find bats hibernating, evaluation of roost availability along with roost temperature and the availability of appropriate food (insects high in polyunsaturated fats) should be compared to winter survival.

Rafinesque's big-eared bat and Eastern small-footed myotis and Southeastern myotis:

- Determine if prescribed fire represents any threat, and also what the acceptable distance of fire, smoke and fire lines from roosts.

Eastern small-footed and Southeastern myotis:

- Determine summer and winter roost site requirements.

Rafinesque's big-eared bat and Southeastern myotis:

- Determine the genetic structure of selected colonies and test whether populations are experiencing adverse genetic consequences from isolation and fragmentation.
- Survey and map mines, tunnels, wells and cave-like structures not surveyed in previous efforts.
- Obtain long-term demographic data including reproductive success, sex ratios, survival, immigration and emigration facilitated by dispersal, and determine the effects of biotic and abiotic factors on these parameters.
- Determine if unnatural predation at roosts by feral cats is occurring. The study sites should include the Southeastern myotis roost at Orangeburg State Park.
- Develop suitable man-made roosts specific to these species.
- Use existing data on habitat preferences to identify the availability of natural roost habitat and to determine the amount of protected versus unprotected habitat.

Rafinesque's big-eared bat:

- Determine alternate roost sites for bridge roosting individuals.
- Locate and map roost trees by physical searches where possible.
- Determine foraging habitat requirements (habitat types, size, and distance from roosts).
- Determine the effects of habitat fragmentation and roads on foraging behavior of Rafinesque's big-eared bats.
- Study the feeding ecology requirements in the mountains and coastal plain.

Southeastern myotis:

- Determine roosting habitat requirements including landscape factors that influence roost habitat quality.
- Obtain basic information on colony size, composition, dynamics, and how these vary with roost site characteristics.
- Little brown, Northern long-eared myotis:
- Locate any hibernacula of South Carolina bats.
- Conduct demographic studies on little brown bats to measure the effects of WNS if it occurs.

Monitoring

- Continue long-term monitoring of bridges in the Coastal Plain for Rafinesque's big-eared bats.
- Continue long-term monitoring of Rafinesque's big-eared bat roosts in the mountains.
- Identify colonies of Eastern small-footed myotis and Southeastern myotis and begin long-term monitoring on colony size, persistence, and roost sites.
- Monitor any winter colonies of little brown bats, if found and continue monitoring of hibernacula of other species where access is permitted.
- Monitor the little brown bat maternity colony at the SCDNR Fish Hatchery in Oconee County.
- Develop a statewide distribution of acoustic survey routes that includes all regions.
- Swab bats captured in the spring or fall and submit the swabs to the Southeastern Cooperative Wildlife Disease Study (SCWDS) to test for *Geomyces destructans*.

Education, public outreach and cooperative efforts

- Currently, bats are gaining recognition and popularity largely due to efforts of conservation organizations such as Bat Conservation International. Development of brochures, interactive websites and study plans should benefit the public and the species.
- Incorporate bats, particularly those of conservation concern, into forest plans, and other land management plans.
- Require certification of WCOs that includes exclusion training, restrictions or recommendations on appropriate timing of exclusion, and mandatory notification of SCDNR if any of the bat species in this document are involved. Clemson University's Pesticide Regulation and Control, Clemson Extension, and SCDNR could partner in training and administering this program.
- If suitable designs for man-made alternate roosts prove effective, those plans should become mainstreamed by making the plans and placement guides available as a pdf document to be shared with organizations such as the South Carolina Wildlife Federation (SCWF).

MEASURES OF SUCCESS

Public education and outreach were deemed a high priority in public meetings regarding the 2005 version of the CWCP. All of the proposed education and outreach actions should satisfy that need, but the effectiveness of those efforts may be difficult to measure. Certainly any significant bat roost, that is protected or created from these actions, can be interpreted as success. Not all threats can be abated, though, such as flooding of natural roosts.

Surveys and density estimates in the southern region should provide some population estimations, which will be used to more accurately rank the species and prioritize future management needs. It is important to determine important roost site locations to provide long-term habitat for the species.

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¹ Threats to eastern small footed bats are not known in South Carolina. At best, they are poorly understood throughout their range.