# Chapter 4: Conservation Actions and Strategy

Typically, bat conservation and research has focused on easily surveyable populations of species that aggregate in large numbers, such as big brown bats and tricolored bats. However, very little is known about bat species that roost singly, which include all of the foliage roosting species in South Carolina, or species that tend to roost in small groups in difficult to survey areas, such as two of the highest priority species in the state: the threatened northern long-eared bat and the eastern small-footed bat. One of the largest requirements needed for the success of this conservation plan is complete and reliable information on abundance, distribution, demography, life history, and habitat needs for most of South Carolina's bat species. Without much of this basic ecological data, habitat protection plans and land management strategies cannot be fully informed, and can therefore only contribute limited benefits toward bat conservation. One of the most well known threats to bats over time has been the loss or degradation of important roosting and foraging habitat, so conservation efforts that seek to protect species habitat associations may be most successful. A current emerging threat to bats in the state is WNS, and a continued commitment to decontamination protocols as well as more research on how exposure to *P.d.* may affect certain species is needed. Other major threats that need to be addressed include human disturbance, environmental contaminants, wind energy development, unknown impacts of agriculture and forest management practices, and potential environmental changes associated with climate change. Lastly, partnerships and cooperation between government agencies, private landowners, non-governmental organizations, and the general public are essential if the state is to accomplish its bat conservation objectives.

This chapter addresses these concerns with both short and long-term goals, including specific tasks that seek to conserve populations of South Carolina's bat species. Much of the conservation actions combined and organized here come directly from the Colonial Cavity Roosting Bats Guild, Foliage Roosting Bats Guild, and Silver-haired Bat Supplemental Volumes in the South Carolina SWAP (SCDNR 2015*a*), as well as The Conservation Strategy for Rafinesque's Big-Eared Bat (*Corynorhinus rafinesquii*) and Southeastern Myotis (*Myotis austroriparius*) (BCI and SBDN 2013). These peer-reviewed recommendations include pertinent information for monitoring, education, public outreach, cooperative efforts, and priority research and survey needs that help guide specific conservation and management actions for South Carolina's bats.

CONSERVATION OBJECTIVES

1. Develop Specific Action Plans
2. Continue Baseline Population Inventory and Monitoring
3. Maintain and/or Contribute to a Bat Database
4. Protect and Provide Specific Roost Sites
5. Monitor and Mitigate Emerging Threats
6. Identify, Protect, and Enhance Bat Habitat and Drinking Resources
7. Conduct Necessary Research
8. Provide Education, Extension, and Outreach
9. Partner with Agencies, Landowners, and Other Groups
10. Integrate and Maintain the South Carolina Bat Conservation Plan

# Conservation Actions and Strategy

## 1. Develop Specific Action Plans

### 1.1. Identify Species and Habitats of High Priority

Twelve of the 14 bat species in South Carolina are "Species of Greatest Conservation Need" and "Highest Priority" in the SWAP (SCDNR 2015*a*), and include those listed as threatened or endangered either federally or at the state level (refer back to Table 2). These species are the federally threatened northern long-eared bat, the state endangered Rafinesque's big-eared bat, the state threatened eastern small-footed bat, and the big brown bat, hoary bat, little brown bat, northern yellow bat, eastern red bat, Seminole bat, silver-haired bat, southeastern bat, and tricolored bat. Only two of South Carolina's bat species are not considered priority, the Brazilian free-tailed bat and evening bat. Habitats of high priority have been delineated in the SWAP, and are defined as any habitat type optimally suited for one or more priority species. The habitat types utilized by the highest priority bat species are shown in Table 6. The greatest number of threatened and endangered species fall under four habitat types in the Blue Ridge ecoregion and are Appalachian oak forest, high elevation forest, low elevation acidic

Table 6: Terrestrial priority species and their ecosystems. Modified from Appendix 1-A in SWAP (SCDNR 2015*a*). Bat species highlighted in gray are endangered or threatened either federally or on the state level.

| | BLUE RIDGE ECOREGION | | | | | | | | | PIEDMONT ECOREGION | | | | | | | | SANDHILLS ECOREGION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Appalachian Oak Forest | High Elevation Forest | Low Elevation Basic Mesic Forest | Low Elevation Acidic Mesic Forest | Rock Outcrops | Bottomlands and Riparian Zones | Depressions | Wet/Moist Unique Landforms | Grasslands/Early-Successional | Upland Pine Forest | Mesic Forest | Rock Outcrops | River Bottoms | Piedmont Small Stream Forest | Cove Forest | Depressions | Grasslands/Early-Successional | Sandhills Pine Woodlands | Mesic Forest | Rock Outcrops | Blackwater Stream Systems | River Bottoms | Depressions | Seepage Slopes | Upland Mixed Forest | Grasslands/Early-Successional |
| **COMMON NAME** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Big Brown Bat** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Eastern Red Bat** | 1 | 1 | 1 | 1 | | 1 | 1 | | | 1 | 1 | | 1 | 1 | 1 | 1 | | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | |
| Eastern Small-footed Bat | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | |
| **Hoary Bat** | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | | 1 | 1 | 1 | 1 | | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | |
| **Little Brown Bat** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | |
| Northern Long-eared Bat | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | |
| **Northern Yellow Bat** | | | | | | | | | | | | | | | | | | | | | | 1 | | | | |
| Rafinesque's Big-eared Bat | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | 1 | 1 | 1 | 1 | | |
| **Seminole Bat** | | | | | | | | | | 1 | 1 | | | 1 | | 1 | | 1 | 1 | | 1 | 1 | 1 | | 1 | |
| **Silver-haired Bat** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | | 1 | 1 | | | | | | 1 | |
| **Southeastern Bat** | | | | | | | | | | | | | | | | | | | 1 | | 1 | 1 | 1 | | 1 | |
| **Tri-colored Bat** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | |
| ***Total Species*** | ***9*** | ***9*** | ***9*** | ***9*** | ***7*** | ***8*** | ***8*** | ***3*** | ***2*** | ***6*** | ***6*** | ***2*** | ***5*** | ***6*** | ***5*** | ***5*** | ***1*** | ***6*** | ***7*** | ***2*** | ***7*** | ***8*** | ***7*** | ***4*** | ***7*** | ***1*** |

Table 6 (cont): Terrestrial priority species and their ecosystems. Modified from Appendix 1-A in SWAP (SCDNR 2015*a*). Bat species highlighted in gray are endangered or threatened either federally or on the state level.

| | COASTAL PLAIN ECOREGION | | | | | | | | | | | COASTAL ZONE ECOREGION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pine Woodland | Sandhill Pine Woodland | Mesic Forest | Carolina Bays | Hardwood Slopes & Stream Bottoms | Blackwater Stream Systems | River Bottoms | Depressions | Upland Mixed Forest | Maritime Forest | Grasslands/Early-Successional | Pine Woodland | Mesic Forest | Hardwood Slopes & Stream Bottoms | Blackwater Stream Systems | River Bottoms | Depressions | Hammock Islands | Maritime Forest | Upland Mixed Forest | Marine | Man-Made Structures |
| **COMMON NAME** | | | | | | | | | | | | | | | | | | | | | | |
| **Big Brown Bat** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | | 1 |
| **Eastern Red Bat** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | | 1 | 1 | 1 | | | | | 1 | 1 | | |
| Eastern Small-footed Bat | | | | | | | | | | | | | | | | | | | | | | |
| **Hoary Bat** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| **Little Brown Bat** | | | | | | | | | | | | | | | | | | | | | | |
| Northern Long-eared Bat | | | | | | | | | | | | | | | | | | | | | | |
| **Northern Yellow Bat** | 1 | 1 | 1 | | 1 | | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | | 1 | 1 | | |
| Rafinesque's Big-eared Bat | 1 | | 1 | | 1 | 1 | 1 | 1 | 1 | | | | | | 1 | 1 | 1 | | | | | 1 |
| **Seminole Bat** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| **Silver-haired Bat** | 1 | 1 | 1 | | | | | | | 1 | | 1 | 1 | 1 | | | | | 1 | 1 | | |
| **Southeastern Bat** | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | | 1 |
| **Tri-colored Bat** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | |
| ***Total Species*** | ***8*** | ***7*** | ***9*** | ***6*** | ***8*** | ***7*** | ***8*** | ***7*** | ***8*** | ***7*** | ***1*** | ***7*** | ***8*** | ***8*** | ***6*** | ***6*** | ***6*** | ***3*** | ***8*** | ***8*** | ***1*** | ***3*** |

mesic forest, and low elevation basic mesic forest; and one habitat type in the Coastal Plain, mesic forest. These habitats are not only used by the largest number of bat species, but also by those that are threatened and endangered either federally or on the state level. Other habitats utilized by over half of the state's highest priority bat species include bottomlands and riparian zones, depressions, hardwood slopes and stream bottoms, maritime forest, pine woodland, river bottoms, upland mixed forest, blackwater stream systems, rock outcrops and sandhill pine woodland. Within these habitats are specific habitat requirements for high priority bat species used during various stages of their life cycle, and the SWAP also briefly outlines these more commonly used sites (Table 7).

Table 7: Specific habitat requirements for highest priority bat species. Modified from Appendix 1-A in SWAP (SCDNR 2015*a*). Bat species highlighted in gray are endangered or threatened either federally or on the state level.

| COMMON NAME | SPECIFIC HABITAT REQUIREMENTS |
|---|---|
| Big Brown Bat | Buildings, cavity trees, under bridges and in bat boxes; forage in open fields or forest gaps |
| Eastern Red Bat | Thinned stands; roost on smaller branches or twigs, often in the hardwood tree canopy; may roost in leaf litter |
| Eastern Small-footed Bat | Caves, mines, abandoned buildings, rock crevices and shelters, and crevices within bridges in wooded areas |
| Hoary Bat | Tree cavities, trunks, tree foliage, squirrel nests, and Spanish moss |
| Little Brown Bat | Buildings and picnic shelters, cavity trees, caves |
| Northern Long-eared Bat | Crevices and cavities in dead or live-damaged trees, but they sometimes roost between loose bark and the bole of dead trees; forage in mature stands |
| Northern Yellow Bat | Forage over open areas such as fields, pastures, golf courses, marshes, and along lake and forest edges; roost in clumps of Spanish moss or under old palm fronds |
| Rafinesque's Big-eared Bat | T-beam and I-beam bridges, abandoned buildings, old bunkers and tunnels, cavity trees, rock outcrops, mines, caves |
| Seminole Bat | Roost in large pines located near forested corridors; may roost in leaf litter |
| Silver-haired Bat | Roosts include tree cavities, under loose bark, rock crevices, under tree foliage, and occasionally in buildings, stacks of firewood, and bird boxes; forage over water |
| Southeastern Bat | Caves (including limestone sinks), mines, abandoned buildings, and large hollow trees; prefers to feed and roost over water |
| Tri-colored Bat | Abandoned mines and caves, bridges, buildings |

1.2. Determine Lead Agencies and Potential Funding Sources

1.2.1. Lead agencies could include:

- South Carolina Department of Natural Resources (SCDNR)
- South Carolina Department of Parks, Recreation, and Tourism (SCPRT)
- South Carolina Forestry Commission (SCFC)
- United States Forest Service (USFS)
- United States Fish and Wildlife Service (USFWS)
- National Wildlife Refuge System (NWRS)
- National Park Service (NPS)
- South Carolina Universities
  - Clemson University, Furman University, Lander University, South Carolina Upstate, Southern Wesleyan University, University of South Carolina, etc.

1.2.2. Potential funding sources could include:

- State Wildlife Grant Program - provides federal grant funds for developing and implementing programs that benefit wildlife and their habitats (including species not hunted or fished) with priority for projects benefitting species of greatest conservation need.
- Wildlife Restoration Program - provides grant funds to the states and insular areas fish and wildlife agencies for projects to restore, conserve, manage and enhance wild birds and mammals and their habitat.
- SC Forest Legacy Program - a habitat protection program that contributes funding for high conservation value land purchases.
- Farm Bill Programs - may contribute funding on cultivated and pasture land for conversion to native vegetation, which could benefit bats by providing higher quality foraging habitat.

1.2.3. Other potential funding could come from environmental organizations such as:

- South Carolina Wildlife Federation (SCWF)
- The Nature Conservancy (TNC)
- The Wildlife Society (TWS)
- National Fish and Wildlife Foundation (NFWF)
- National Wildlife Federation (NWF)
- Bat Conservation International (BCI)

## 2. Continue Baseline Population Inventory and Monitoring

In addition to other conservation actions outlined, it is important to continue to allocate effort and funds toward ongoing long-term inventory and monitoring projects.

2.1. Caves and Mines

- Continue full and follow-up counts at Stumphouse Tunnel hibernacula (SCDNR 2015*b*).
- Continue entrance or emergence counts at Santee State Park when partners are available (SCDNR 2015*b*).
- Continue monitoring of other hibernacula where access is permitted at sites without a vertical component on a rotation of three to five years or more (SCDNR 2015*a*).

2.2. Buildings and Bridges

- Continue monitoring, netting, and sampling of the little brown bat maternity colony at the SCDNR Walhalla Fish Hatchery in Oconee County (SCDNR 2015*a*).
- Continue long-term monitoring of bridges in the Coastal Plain for Rafinesque's big-eared bats (SCDNR 2015*a*).

2.3. Other Roosting Areas

- Continue and/or increase infrared (IR) video photography monitoring of some known roosts to detect dramatic declines in bat populations (SCDNR 2015*b*).

- Continue long-term monitoring of Rafinesque's big-eared and other known bat roosts in the Blueridge and Piedmont ecoregions (SCDNR 2015*a*).

2.4. Acoustic Surveys

- Continue survey routes in Carolina Sandhills National Wildlife Refuge and Francis Marion National Forest (SCDNR 2015*b*).
- Continue survey route at Long Cane Ranger District (SCDNR 2015*b*).
- Continue the 30 NABat acoustic driving routes established statewide to monitor bat occupancy rates on a seasonal and annual basis. The first year of sampling was completed in 2015, and will be conducted annually each summer.

## 3. Maintain and/or Contribute to a Bat Database

A main component of monitoring and research is maintaining capture and location information for all of South Carolina's bat species. This way data can be more readily analyzed and shared with cooperators.

3.1. Heritage Trust Database and the USGS Bat Population Database

- Continue maintaining and contributing to the Heritage Trust Database. The SCDNR Heritage Trust tracks high priority species, and researchers are requested to submit bat data and occurrence records to their database. The Heritage Trust periodically provides data to the USGS Bat Population Database (BPD), a multi-phase, comprehensive effort to compile existing population information for bats in the US and Territories at https://my.usgs.gov/bpd/.

## 4. Protect and Provide Specific Roost Sites

South Carolina's bat species utilize a wide variety of roosting locations for processes their populations depend on to survive, such as caves and mines for hibernation and hollow trees or human made structures for maternity colonies. To address protecting bats from disturbance at roost sites, SCDNR has partnered with several parks in the state. In general, implementation of signs, gates, and fences help to protect existing roost sites.

4.1. Protect Existing Roost Sites

4.1.1. Caves and Mines

- Construct a fence around the southeastern bat colony at Orangeburg State Park and find a way to maintain it.
- Control human access to important mines, caves, and rock shelter formations by signage or other restrictions such as road closures, and do not create trails or roads to these sites (BCI and SBDN 2013, SCDNR 2015*a*).
- Do not seal off, alter, or destroy cave, karst, and other subterranean roosts (BCI and SBDN 2013).
- Close subterranean hibernacula to recreational activities to avoid waking hibernating bats or disturbing maternity colonies (BCI and SBDN 2013).

- Gate and construct fences around underground entrances to enhance human safety and reduce landowner liability (BCI and SBDN 2013).
  - Install bat friendly and custom fit cave and mine gates on site with horizontal steel bars that allow bat access yet control human access through locked entrances, whenever financially feasible. To allow bats in and out of the cave, spacing between bars should be 5 3⁄4 inch (14.6 cm). For larger bat colonies that may be restricted by standard gate rails, consider gate designs that incorporate windows, chutes, and flyover options (Kennedy 2006, Powers 2004). Avoid fences at distances within 16 feet (5 m) of an entrance. Sufficient distances are generally over 50 feet (15 m). The most effective fences for deterring trespassers are those over 10 feet (3 m) high made of no-climb chain link or other small-mesh, and include a smooth top wire angled away from the entrance (Ludlow and Gore 2000). Smooth wire instead of barbed wire prevents bats from becoming entangled closer to the entrance, though barbed wire will help deter trespassers if the fence is far from the entrance (BCI and SBDN 2013).
- Designate a habitat buffer zone of at least ¼ mile (400 m) around priority cave and mine roosts (BCI and SBDN 2013). Larger buffer zones may be needed for species such as Rafinesque's big-eared bats and southeastern bats, but more research is needed to evaluate this (Clark 1990, Hurst and Lacki 1999).

4.1.2. Snags and Trees

- Collect GPS coordinates and mark maternal roost trees for re-identification to assist in land management so that tree roosts that are buffered from disturbances such as the removal of neighboring trees, creation of roads and trails at or near the roost site, and other changes in the surrounding habitat. Doing so will help to avoid changes in roost microclimate or alter roosting conditions that may change tree suitability for bats (BCI and SBDN 2013).
- Designate buffers (no-cut zones) around known roosts to avoid altering microclimate roosting conditions and the suitability of trees for bats (BCI and SBDN 2013, SCDNR 2015*a*).
- In timber harvest projects, retain a snag density of >21 snags/hectare for silver-haired bats, as well as for northern long-eared bats and evening bats (SCDNR 2015*a*).
- Retain Spanish moss and old palm fronds on public lands to benefit northern yellow bats (SCDNR 2015*a*).
- Encourage retention of Spanish moss and old palm fronds on private lands to benefit northern yellow bats (SCDNR 2015*a*).
- Provide, protect, and maintain large diameter roost trees, large snags, decadent trees, hollow trees, and roost structures, especially near water or riparian areas (BCI and SBDN 2013, SCDNR 2015*a*).

- Provide suitable roost sites for northern long-eared bats, which include live trees and/or snags greater than 3 inches dbh with exfoliating bark, cracks, crevices, and/or cavities (USFWS 2015*c*).
- Use active management at selected sites to inhibit understory or mid-story development to provide access for bats to roost trees (BCI and SBDN 2013).
- Species of trees that produce basal cavities such as bald cypress, sycamore, sweet gum, water tupelo, tulip poplar, and black gum where bats use these tree hollows as roosts should be encouraged in forest management. This can be done by allowing younger, developing trees of these species to mature and promote recruitment of future roost trees (BCI and SBDN 2013).

4.1.3. Buildings and Bridges

- Repair structures to protect bat roosts and ensure longevity. If this is not possible, measures should be taken to provide alternate roost structures at each significant site before the structure is taken down or altered in a way that renders it no longer beneficial to bats (see section 4.2 for species-specific roost structures) (SCDNR 2015*a*).
- Collaborate with the South Carolina Department of Transportation (SCDOT) to protect bat roosts and habitats during and after road construction, bridge replacement, and bridge maintenance (BCI and SBDN 2013, SCDNR 2015*a*). Specific guidelines exist for bridge design and maintenance for sites with bat roosts, and planning should begin at least a full year prior to replacement (BCI and SBDN 2013).

  Currently, the SCDOT receives a copy of the SCDNR's Heritage Trust Threatened and Endangered Species database on an annual basis for use in planning purposes. They are also encouraged to report bat colonies on bridges so that mitigation efforts can be made if the bridge needs to be modified or replaced. For example, at the Stevens Creek bridge by the SCDNR Heritage Preserve, a replacement will be constructed that will be I-beam or T-beam instead of slab to benefit bats. Some of this work is handled though discussions with environmental consultants working on bridge projects with wetlands impacts. However, SCDNR needs to create a Memorandum of Understanding (MOU) with SCDOT that covers voluntary guidelines for assessing bat use, conservation actions, and bridge replacement strategies (BCI and SBDN 2013, SCDNR 2015*a*). For example, it's been suggested that alternate roosts become a standard part of bridge replacement requests from the SCDNR (SCDNR 2015*a*). Other suggestions might include:

  - Create adaptations to new, long bridges over water in the Sandhills and Inner and Outer Coastal Plain (SCDNR 2015*a*).
  - If a structure similar enough in design to allow continued roosting by bats cannot be constructed in a bridge replacement, consider alternate roosts specific to the species in question (BCI and SBDN 2013).
  - Don't schedule maintenance on the underside of bridges housing summer

bat colonies when and flightless young and pregnant or lactating females are present. To avoid the maternity period in South Carolina, bats should not be evicted from May through July.

- Exercise caution when conducting maintenance under bridges housing winter bat colonies, as some species such as Rafinesque's big-eared bats, southeastern bats, and eastern small-footed bats are known to use bridges during winter (BCI and SBDN 2013).
- If bats must be excluded from bridges, follow proper exclusion methods and exclusion timing (BCI and SBDN 2013).
- Avoid the creation of bat roosts above exposed metal components as droppings may cause oxidation of unprotected metal bridge parts (BCI and SBDN 2013).
- Discourage maintenance workers from handling bats. When dust from bat droppings cannot be avoided, provide workers with respirators capable of filtering 2 to 3 micron-sized particles (a protection factor of at least 10) (BCI and SBDN 2013).

4.1.4. Talus, cliff faces and other rock formations

- Avoid disturbance of talus and cliff roosting species (where known) from road construction, mining, or reservoir flooding.

4.2. Provide Specific Roost Sites

- Construct suitable artificial roosts specific to each bat species, especially in areas of depleted roosting resources. These structures should provide similar microclimate conditions to natural or anthropogenic roosts used by bats (BCI and SBDN 2013). Typical bat box structures will not suffice for species that prefer large open cavities. Structures that mimic large hollow trees, similar to artificial chimney structures now used for chimney swifts, may be suitable alternative roosts 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, and large bat towers for Rafinesque's big-eared bats can also be modified to accommodate these species (SCDNR 2015*a*).

5. Monitor and Mitigate Emerging Threats

White-nose Syndrome is currently the most devastating threat facing bats in North American bat populations, and the South Carolina White-nose Response Plan was updated in February of 2015 (SCDNR 2015*b*) to address WNS concerns in the state. Wind energy development, pesticides and environmental contaminants, controlled burning, towers, global climate change, and feral hogs all also pose a threat to South Carolina's bat species.

5.1. WNS

- Coordinate with cooperators and partners of the conservation community in adhering to state and federal WNS Response Plan guidelines and the South Carolina WNS Response Plan.

- Annually contact the Southeastern Cooperative Wildlife Disease Study (SCWDS) to determine if submission of swabs from certain bat species captured in the spring or fall to test for *Pseudogymnoascus destructans (P.d.)* are being accepted (SCDNR 2015*a*).
- Collect more temperature data for suitability to *P.d.* in the two best known caves by SCDNR on SCPRT land (SCDNR 2015*b*).
- Minimize nonessential research or educational programs without research value that involves handling or disturbance of bats, but continue acoustic surveys of same route(s) for rough population trends (SCDNR 2015*b*).
- Monitor cave/mine roosts to evaluate survivorship, using methods that minimize stress on roosting bats (SCDNR 2015*b*).
- Continue to take WNS disinfection precautions (SCDNR 2015*b*).

5.2. Wind Energy Development

- Work with wind energy development companies to mitigate impacts of wind turbines by making recommendations such as increasing the cut-in speed of turbines (between 1.5 and 3.0 m/s, for example) or turning off selected turbines during peak migration to help reduce mortalities (Arnett et al. 2013, SCDNR 2015*a*).

5.3. Pesticide Poisoning and Environmental Contaminants

- Minimize large-scale pesticide use whenever possible.
- Protect habitat above or around maternity roosts and known foraging areas from pesticides.

5.4. Controlled Burning

- Advise forestry professionals to conduct controlled burns when minimum night temperatures are > 39°F (4°C), temperatures at the time of ignition are > 50°F (10°C) in order to minimize negative impacts to tree bats (Perry and McDaniel 2015, SCDNR 2015*a*). Additionally, smoke propelled by increased wind speeds may increase awareness and more quickly wake bats in leaf litter from torpor (Layne 2009).

5.5. Towers

- Only use flashing lights on towers, rather than lights that are constantly on; this is now regarded as acceptable by the FAA and can reduce bat mortality (SCDNR 2015*a*).

5.6. Global Climate Change

- Employ correlative models using historical and current distributions to evaluate habitat change based on various climate change scenarios, particularly distributions of important roost tree species (BCI and SBDN 2013).

5.7. Feral Hogs

- Control feral hogs through increased hunting and trapping on public land, and encourage the same on private land. Currently, there is no closed hunting season for wild hogs on private lands with a valid hunting license, and it is possible to hunt hogs at night with artificial lights and nightvision devices using any legal firearm, bow, or crossbow if SCDNR is given 48 hours notice. See SCDNR Rules and Regulations at http://www.dnr.sc.gov/regs/pdf/hog.pdf for more information.

## 6. Identify, Protect, and Enhance Bat Habitat and Drinking Resources

One of the largest and most well known threats to bats is the loss or degradation of important habitat that provides roosting, foraging, and drinking resources to many species in the state. Therefore, efforts that seek to protect and manage these habitats for bats should be a primary concern.

6.1. Identify Occupied Roosting and Foraging Habitat

- Identify known high priority roosting and foraging bat habitats.
- Encourage landowners and land managers to determine the presence or absence of bats, maternity roosts and hibernacula by searching previously unsurveyed public and private lands (BCI and SBDN 2013).

6.2. Protect Roosting and Foraging Habitat and Drinking Resources

- Protect mature bottomland hardwood forests and connecting corridors in the Inner and Outer Coastal Plain, especially for the Rafinesque's big-eared bat. Recruitment of younger stages of high quality bottomland habitat for growth into future roost trees is needed (SCDNR 2015*a*).
- Retain upland forest corridors to prevent isolation of Seminole bats (SCDNR 2015*a*).
- Enforce existing legislation such as the Cave Protection Act of 1988 and the Clean Water Act, Section 404 that protect sites surrounding caves and along riparian corridors in locations near or adjacent to bat roosts, when applicable (BCI and SBDN 2013).
- Manage stream-side management zones (SMZs) to encourage retention of roost-tree species on lands actively managed for timber production (BCI and SBDN 2013, Wigley et al. 2007).

6.3. Manage and Enhance Roosting and Foraging Habitat and Drinking Resources

- Provide forested corridors between harvested units (SCDNR 2015*a*).
- Retain and recruit cypress-gum swamp forests containing large cavity trees (SCDNR 2015*a*).
- Encourage timber management at selected sites in the Piedmont region that creates uncluttered forest such as pine thinning or controlled burns (SCDNR 2015*a*).
- Advocate for management that creates or maintains patches of structurally diverse forest with high densities of large-diameter cavity trees in order to provide a wide variety of suitable roosting and maternity sites (BCI and SBDN 2013).

- Encourage and adhere to forest management actions that retain late succession forests with a relatively open understory, and high structural complexity and species diversity at selected sites for Rafinesque's big-eared bat and the southeastern bat (BCI and SBDN 2013).
- Encourage landowners managing forests that support bat populations to implement Best Management Practices (BMPs; Stringer and Perkins 2001) and create wider SMZ buffers (BCI and SBDN 2013). The functional width of riparian buffer zones near small streams, according to a study by O'Keefe et al. (2013), is greater than or equal to 32 feet (10 m) (though research on larger buffer sizes needs to be conducted).
- Encourage silvicultural prescriptions that produce more open woodland habitat such as partial harvests, mid-story removal, and controlled burning in upland forest habitats. Caution should be used before applying these recommendations to cavity-roosting bats in bottomland hardwood forests, since these prescriptions were studied on mostly upland forest bat species (BCI and SBDN 2013).
- Maintain or increase woody plant diversity. This will provide a diverse and abundant selection of moth prey for species such as Rafinesque's big-eared bat (BCI and SBDN 2013).
- Spatially and temporally provide sufficient older-aged trees in habitat prescriptions accompanying timber harvests (BCI and SBDN 2013).
- Preserve and/or manage for waterways and wetlands that connect lands of different ownership (BCI and SBDN 2013).

## 7. Conduct Necessary Research

In order for this conservation plan to be successful, complete and reliable information on abundance, distribution, demography, life history, and habitat needs for many of South Carolina's bat species is needed. Habitat protection plans and land management strategies cannot be fully informed without this essential ecological data.

7.1. For Current Status Assessments

7.1.1. Short-term surveys

- Survey and map mines, tunnels, wells and cave-like structures not surveyed in previous efforts in order to locate hibernacula (SCDNR 2015*a*).
- Determine alternate roost sites for bridge roosting Rafinesque's big-eared bats (SCDNR 2015*a*).
- Locate and map roost trees by physical searches where possible for Rafinesque's big-eared bats (SCDNR 2015*a*).
- Obtain basic information on colony size, composition, dynamics, and determine how these vary with roost site characteristics, especially for the southeastern bat (SCDNR 2015*a*).
- Identify colonies of eastern small-footed bats, little brown bats, northern long-eared bats, southeastern bats, and tricolored bats (SCDNR 2015*a*).

- Identify priority areas for field surveys for northern yellow bats (SCDNR 2015*a*).
- Determine northern yellow bat distribution in the Carolinas through surveys (SCDNR 2015*a*).
- Locate significant northern yellow bat roost sites through survey efforts (SCDNR 2015*a*).
- Establish dependable estimates of range-wide population sizes, especially for Rafinesque's big-eared bat (BCI and SBDN 2013).

7.2. For Life History and Habitat Needs

7.2.1. Short-term research projects

*Roosting Habitat*

- Evaluate roost availability along with roost temperature and the availability of appropriate food (insects high in polyunsaturated fats) compared to winter survival (SCDNR 2015*a*).
- Determine summer and winter roost site requirements, including temperature and humidity measurements, for eastern small-footed bat, Rafinesque's big-eared bat, southeastern bat, silver-haired bat, and all lasiurine bat species (BCI and SBDN 2013, SCDNR 2015*a*).
- Use existing data on habitat preferences to identify the availability of natural roost habitat and to determine the amount of protected versus unprotected habitat, especially for Rafinesque's big-eared bat and southeastern bat (SCDNR 2015*a*).
- Using landscape factors that influence roost habitat quality, determine roosting habitat requirements for southeastern bats (SCDNR 2015*a*).
- Establish methods that promote roost switching of southeastern bats to alternate sites when exclusion from a structure cannot be avoided (BCI and SBDN 2013).
- Determine preferred roosting microclimates inside artificial structures for southeastern bats (BCI and SBDN 2013).
- Assess placement, habitat conditions, and structural configuration for artificial structures used by Rafinesque's big-eared bats and southeastern bats (BCI and SBDN 2013).
- Determine buffer sizes required to protect roosts of South Carolina's highest priority bat species.
- Determine the efficacy of roost buffers by assessing how roost tree longevity, use, and internal microclimate are affected by the configuration and extent of surrounding habitat influences, especially for Rafinesque's big-eared bat and the southeastern bat (BCI and SBDN 2013).

- Obtain spatial and temporal data on roost tree densities in South Carolina, especially for Rafinesque's big-eared bats and southeastern bats (BCI and SBDN 2013).
- Establish the minimum number of roost trees required to support Rafinesque's big-eared bat and southeastern bat populations in bottomland hardwood forests, as well as the other highest priority bat species in South Carolina (BCI and SBDN 2013).
- Calculate the approximate annual survival of hollow tree roosts in bottomland hardwood forests (BCI and SBDN 2013).

*Foraging Habitat*

- Determine foraging habitat requirements such as habitat types, size, and distance from roosts for highest priority bat species, especially northern long-eared bats and Rafinesque's big-eared bats (SCDNR 2015*a*).
- Determine connections between forest structure and foraging success, especially for Rafinesque's big-eared bats (BCI and SBDN 2013).
- Calculate approximate home range sizes and geographical use of available foraging habitats, especially for southeastern bats (BCI and SBDN 2013).

*Diet*

- Study the feeding ecology requirements for all South Carolina bats, especially for southeastern bats and Rafinesque's big-eared bats in the mountains and Coastal Plain (BCI and SBDN 2013, SCDNR 2015*a*).

*Migration Patterns*

- Research migration routes, timing, patterns and seasonal movements of the hoary bat, red bat, silver-haired bat, southeastern bat, and tricolored bat (BCI and SBDN 2013, SCDNR 2015*a*) .
- Determine where South Carolina's over-wintering silver-haired bat population migrates over summer, potentially through stable isotope research from hair or nail samples (SCDNR 2015*a*).

*Social Organization and Behavior*

- Ascertain more detailed information on colony patterns of social organization and behavior, especially for Rafinesque's big-eared bats (BCI and SBDN 2013).
- Examine the maternity colony roosting behavior of southeastern bats (BCI and SBDN 2013).

*Longevity and Survival*

- Calculate the estimated longevity and age-related survival for Rafinesque's big-eared bats and southeastern bats (BCI and SBDN 2013).

*Land Management*

- Determine the effects of habitat fragmentation and roads on foraging behavior of Rafinesque's big-eared bats, southeastern bats, and northern long-eared bats (BCI and SBDN 2013, SCDNR 2015*a*).
- Determine how roost selection and foraging behavior are affected by forest management, especially in bottomland hardwood forests on Rafinesque's big-eared bats and southeastern bats (BCI and SBDN 2013), but also for northern long-eared bats.
- Examine the effects of selective thinning, cutting, and extended rotation lengths, especially in bottomland hardwood forests on Rafinesque's big-eared bats and southeastern bats (BCI and SBDN 2013) but also for northern long-eared bats.
- Examine the effect of SMZ width and extent of corridor fragmentation allowable in upland forests (BCI and SBDN 2013).
- Compare foraging and roosting habitat use with stream buffer dimensions (BCI and SBDN 2013).

*WNS*

- Determine how exposure to the *P.d.* fungus affects Rafinesque's big-eared bats and southeastern bats (BCI and SBDN 2013).

*Wind Energy*

- Identify the best placement of wind turbines, as well as other strategies that would minimize wind energy impacts to South Carolina's bats.
- Determine the extent of coastal and off-shore foraging and commuting and its seasonality to assess vulnerability of lasiurine bats to off-shore and coastal wind energy development, particularly during fall migration (SCDNR 2015*a*).
- Study potential impacts from wind farms and develop strategies to reduce silver-haired bat mortality (SCDNR 2015*a*).
- Calculate estimated mortality rates at wind turbines located near roosting sites of Rafinesque's big-eared bats and southeastern bats (BCI and SBDN 2013).

*Fire*

- Determine if prescribed fire presents any threats to Rafinesque's big-eared bats, eastern small-footed bats, southeastern bats, or silver-haired bats (SCDNR 2015*a*).
- Determine acceptable distance of fire, smoke and fire lines from roosts (SCDNR 2015*a*), especially for northern long-eared bats.
- Examine the impacts of winter burns during cold weather on silver-haired bats (particularly on south-facing burn units) (SCDNR 2015*a*).
- Evaluate prescribed fire for enhancement of bat habitat (BCI and SBDN 2013).

*Pesticides and Heavy Metals*

- Determine if northern yellow bats, silver-haired bats, and southeastern bats are threatened by pesticide and/or heavy metal contamination (SCDNR 2015*a*).

*Introduced Predators*

- Determine if unnatural predation at roosts by feral cats is occurring. Study sites should include the southeastern bat roost at Orangeburg State Park (SCDNR 2015*a*).

*Climate Change*

- Collect reliable information on how bats respond to potentially higher temperatures and an increased need for water (BCI and SBDN 2013).
- Create correlative models using historical and current distributions to evaluate habitat change based on various climate change scenarios in the state, particularly distributions of important roost tree species in South Carolina (BCI and SBDN 2013).

*Acoustic Monitoring*

- Continue to improve acoustic monitoring, such as increasing call identification accuracy for all of South Carolina's bat species, particularly those with similar calls from sympatric *Myotis* species (BCI and SBDN 2013).

7.3. For Demography, Distribution and Abundance

7.3.1. Long-term monitoring

- Follow protocols outlined in the 2015 Plan for the North American Bat Monitoring Program (NABat) (http://www.srs.fs.usda.gov/pubs/gtr/gtr_srs208.pdf). This is a continental program to monitor and track bat populations at local and rangewide scales in order to provide reliable data for conservation decision making and long-term bat population viability. Data is collected using winter hibernacula counts, maternity colony counts, mobile acoustic surveys along road transects, and stationary acoustic surveys. For acoustic surveys in South Carolina, a grid of 30 surveyable cells 10 km by 10 km in size was developed by USGS and implementation has been initiated by Ben Neece (http://myweb.clemson.edu/~bneece/about.php).
- Monitor any winter colonies of South Carolina's bats, especially little brown bats (SCDNR 2015*a*).
- Conduct demographic studies on little brown bats to measure the effects of WNS if it occurs (SCDNR 2015*a*).
- 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 for Rafinesque's big-eared bats and southeastern bats (SCDNR 2015*a*).
- Begin long-term monitoring on colony size, persistence, and roost sites for eastern small-footed bats (once colonies are found) and southeastern bats

(SCDNR 2015*a*).

- Monitor significant northern yellow bat roost sites for continued usage (SCDNR 2015*a*).
- Conduct annual maternity season surveys for Rafinesque's big-eared bat and the southeastern bat at cave or mine entrances using IR camera when young are flightless, and again soon after volancy begins, to assess colony size changes and determine reproductive success of the maternity colony. When both surveys can't be completed during the same season due to time and resource constraints, complete only the post-volancy survey (BCI and SBDN 2013).
- Conduct distribution and abundance surveys on southeastern bats in order to compile more complete data (BCI and SBDN 2013).
- Survey all historically occupied roosts, especially for southeastern bats (BCI and SBDN 2013).
- Conduct building and bridges surveys, especially for significant bat hibernacula and maternity colonies in South Carolina.

7.4. For Metapopulation Studies and Population Connectivity

7.4.1. Long-term research studies

- Create a statistically-robust sampling strategy to estimate range-wide population sizes of bats using counts during hibernation and maternity periods (BCI and SBDN 2013).
- Develop inventory and monitoring approaches that can detect biologically meaningful changes in bat population size (BCI and SBDN 2013).
- Determine how habitat connectivity and patch size affect movements, colony size, frequency of dispersal, and gene flow, especially for Rafinesque's big-eared bats and southeastern bats (BCI and SBDN 2013).
- Establish research and survey protocols that allow for comparisons across bat habitat and bat populations (BCI and SBDN 2013).
- Determine the minimum habitat patch size requirement to support specific bat colonies of over time, especially for Rafinesque's big-eared bats and southeastern bats (BCI and SBDN 2013).

7.5. For Genetic Diversity and Effective Population Size

7.5.1. Genetics-based research studies

- Determine the genetic structure of selected colonies of Rafinesque's big-eared bats and southeastern bats, and test whether populations are experiencing adverse genetic consequences from isolation and fragmentation (SCDNR 2015*a*).
- Conduct molecular research to determine the validity of the northern yellow bat subspecies designation and the variation within the species across its known distribution (SCDNR 2015*a*).

## 8. Provide Education, Extension, and Outreach

A large piece of any effective conservation strategy involves working to create comprehensive public and environmental education programs and increase the visibility of species being threatened. Educational programs should focus on why the existence of South Carolina's bat species across the landscape is essential, and provide details on how to help prevent population declines. Additionally, as suggested by Bat Conservation International and the Southeastern Bat Diversity Network (BCI and SBDN 2013), *"clearly written guidelines for land management need to be developed and distributed to lawmakers, decision makers, enforcement officials, landowners, and the general public to foster pro-active habitat management. These guidelines should include strategies for recruiting roost tree species, options for sustainable timber management practices, information about laws and legal issues affecting bats, and tools for protecting bat roosts from disturbance and alteration, while reducing landowner liability."*

8.1. General Public

8.1.1. Conduct outreach for prevention of WNS

- SCDNR staff and SCDNR spokesperson will continue to coordinate press releases with the USFWS WNS information/outreach specialist to educate the public and update elected officials (SCDNR 2015*b*).
- Inform the public to report unusual die-offs to their regional wildlife biologists for submission for testing (SCDNR 2015*b*).
- Work with caving clubs such as the South Carolina Interstate Grotto to assist with WNS education and outreach (SCDNR 2015*b*).

8.1.2. Educate home owners, landowners and land managers

- Inform landowners and land managers about the importance of bats on their land, along with the current conservation status of each of South Carolina's bats (BCI and SBDN 2013).
- Encourage landowners and land managers to search previously un-surveyed public and private lands by providing effective survey methodologies that will help determine presence or absence of bats and assist in locating potential maternity roosts and hibernacula (BCI and SBDN 2013).
- Discourage the practice of removing roosting habitat such as old palm fronds and large amounts of Spanish moss from trees (SCDNR 2015*a*).
- Create demonstration areas on publicly owned site(s), leaving old fronds uncut on palms in a highly visible area with prominent signage explaining that old fronds provide important roosting habitat for northern yellow bats (SCDNR 2015*a*).
- Emphasize conservation of Rafinesque's big-eared bat throughout its entire range (BCI and SBDN 2013).
- Develop clearly written guidelines to help promote pro-active bat habitat management (BCI and SBDN 2013).

8.1.3. Develop and distribute informational materials

- Develop and distribute brochures and study plans.
- Develop more interactive websites. For example, a successful occupied bat box can now be reported online at http://www.dnr.sc.gov/wildlife/bats/batbox.html.
- Make human-made alternate roost design plans and placement guides for bat houses, as well as clearly written guidelines for bat habitat management, available as pdf documents to be shared with both the public and organizations such as the South Carolina Wildlife Federation (SCWF) (BCI and SBDN 2013, SCDNR 2015*a*).

8.1.4. Increase the visibility of bats

- Provide bat species information for, and generate interest through, social media.
- Create a bat watch program where the public counts bats exiting known roosts to measure population declines, similar to the program in Pennsylvania. This would require a set up of a data file and an online reporting page for the public (SCDNR 2015*b*).

8.2. Specialized Audiences

8.2.1. Private Landowner Caves

- Conduct outreach to prevent disturbance to bat colonies in private caves.

8.2.2. Federal Highway Administration and SCDOT

- Develop a strategy for outreach and education in order to protect bat roosts and habitats during and after road construction, bridge replacement, and bridge maintenance (BCI and SBDN 2013, SCDNR 2015*a*).

8.2.3. Wildlife Control Operators (WCOs)

- Require certification of WCOs that includes exclusion training, restrictions or recommendations on appropriate timing of exclusion, and mandatory notification of SCDNR if any colonial roosting bat species (big brown bat, eastern small-footed bat, little brown bat, northern long-eared bat, Rafinesque's big-eared bat, southeastern bat, or tricolored bat) are involved. Clemson University's Pesticide Regulation and Control, Clemson Extension, and SCDNR could partner in training and administering this program (SCDNR 2015*a*).

## 9. Partner with Agencies, Landowners, and Other Groups

Partnerships and cooperation between government agencies, private landowners, non-governmental organizations, and the general public are essential if South Carolina is to accomplish the conservation objectives set out in this plan.

9.1. Develop State and Federal Agency Partnerships with Land Owners

- Utilize the Cooperative Extension Programs at land grant universities (BCI and SBDN 2013).

9.2. Provide Conservation Incentives

- Bat habitat protections may be accomplished through landowner incentive programs, conservation easements, lease agreements, purchases, stewardship and management agreements, and means of financial assistance (BCI and SBDN 2013, SCDNR 2015*a*).
- Encourage conservation-friendly tax structures that reward habitat protection, water conservation, and sustainable forestry practices, (BCI and SBDN 2013).
- Promote already existing state and federal programs that manage forests, wetlands, and roosting resources of bats (BCI and SBDN 2013).

9.3. Reconvene a Mammal Taxa Team to Evaluate State Rankings

- Invite bat experts from all sources, including state, federal, universities, and nonprofit organizations to re-evaluate current state rankings and recommend new rankings if necessary. SCDNR Chief of Wildlife Statewide Projects, Derrell Shipes, has initiated the review of all species' rankings, but no preliminary lists or rankings are available at this time.

## 10. Integrate and Maintain the South Carolina Bat Conservation Plan

In order to ensure conservation strategies are applied on the landscape, including them in other management plans is necessary. Also, conservation priorities and strategies are dynamic, so updates that reflect recent changes and include new scientific information are vital to an accurate and relevant bat conservation strategy.

10.1. Integrate bat conservation into other management plans

- Incorporate bats, particularly those of conservation concern, into forest and other land management plans (SCDNR 2015*a*). For example:
  - Maintain large, cavity-producing trees and provide future roost trees in forest management planning on federal and private lands (BCI and SBDN 2013).

10.2. Keep the South Carolina Bat Conservation Plan Up to Date

- Update and revise this conservation plan every 2-5 years with current scientific information and additional land management strategies.
- Reevaluate species designations if new evidence suggests the status of bat species should be changed at the state level.