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Strategic Environmental Research and Development Program

Species Profile: Southeastern Myotis (*Myotis austroriparius*) on Military Installations in the Southeastern United States

by Larry A. Reynolds, Wilma A. Mitchell

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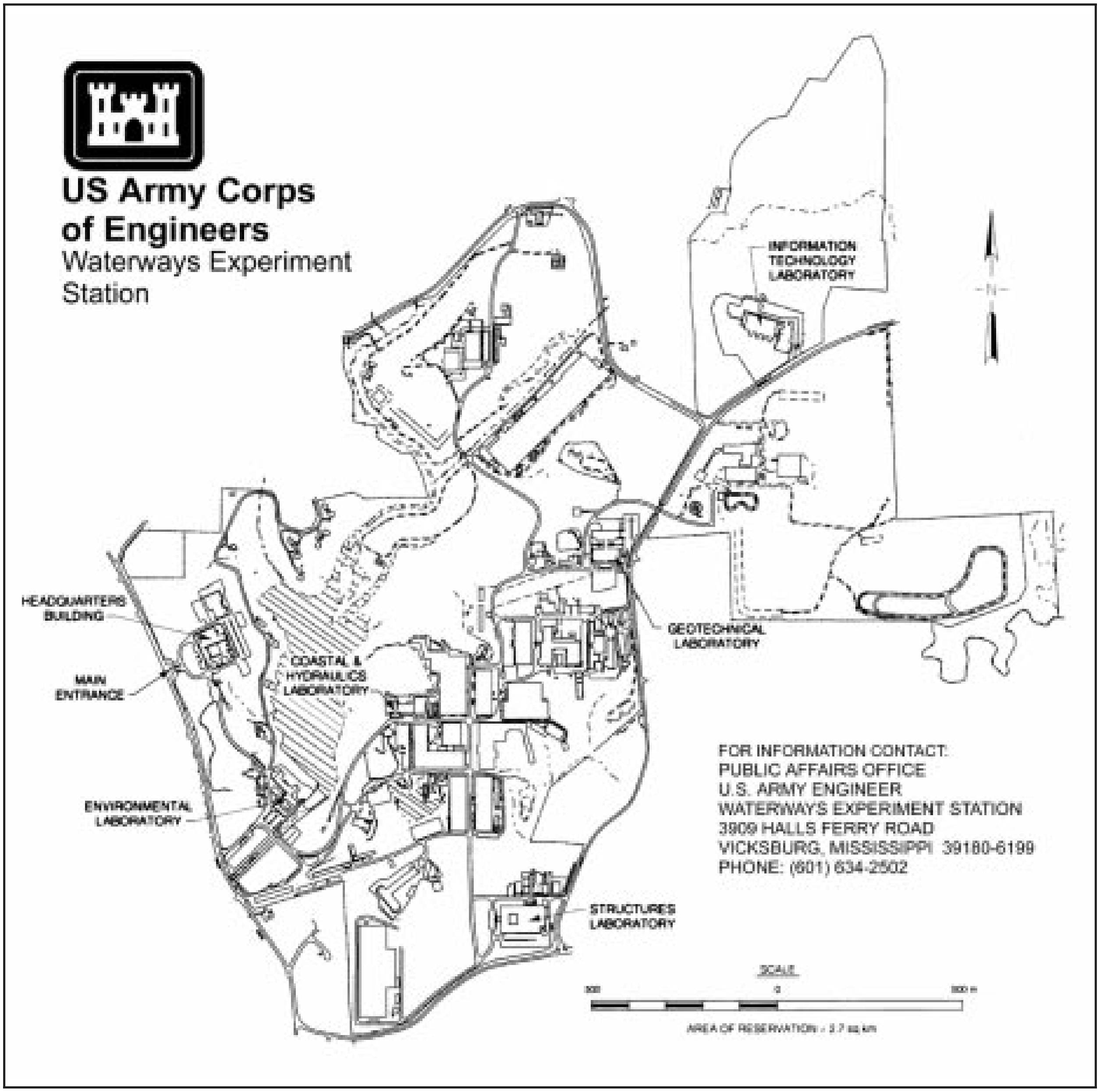

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Preface

The work described in this report was authorized by the Strategic Environmental Research and Development Program (SERDP), Washington, DC. The work was performed under the SERDP study entitled "Regional Guidelines for Managing Threatened and Endangered Species Habitats." Mr. Brad Smith was Executive Director, SERDP.

This report was prepared by Mr. Larry A. Reynolds and Dr. Wilma A. Mitchell, Stewardship Branch (SB), Natural Resources Division (NRD), Environmental Laboratory (EL), U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS. Mr. Reynolds is currently a doctoral student at Louisiana State University, Baton Rouge. Mr. Chester O. Martin, EL, WES, and Ms. Ann-Marie Trame, Land Management Laboratory, U.S. Army Construction Engineering Research Laboratories, were Principal Investigators for the regional guidelines work unit. Dr. Richard A. Fischer, EL, managed and coordinated preparation of species profiles for this study. Report review was provided by Dr. Jeffery A. Gore, Florida Game and Fresh Water Fish Commission, Panama City; and Ms. Peggy Horner, Texas Parks and Wildlife Department, Austin. WES technical review was provided by Mr. Martin and Dr. Fischer. Ms. Tiffany Cook, EL, provided assistance in assembling species information.

This report was prepared under the general supervision of Dr. Michael F. Passmore, Chief, SB; Dr. David Tazik, Chief, NRD; and Dr. John Harrison, Director, EL. At the time of publication of this report, Dr. Robert W. Whalin was Director of WES. COL Robin R. Cababa, EN, was Commander.

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Species Profile: Southeastern Myotis
(Myotis austroriparius)

Photo by Merlin Tuttle, Bat Conservation International

Taxonomy

Class	Mammalia
Order	Chiroptera
Family	Vespertilionidae
Genus/species	*Myotis austroriparius*
Other Common Names	Southeastern bat, Mississippi myotis

Description

The southeastern myotis is a medium-sized bat first described by Miller and Allen (1928). The species was originally thought to consist of three subspecies distinguished primarily by pelage color (Lowery 1943, Rice 1957). However, color variations of the pelage lack a uniform geographic or temporal distribution, and mensural characters are not statistically different across the geographical range of the southeastern myotis (LaVal 1970). Consequently, the species is now considered to be monotypic.

The pelage of the southeastern myotis appears dull and woolly; newly molted specimens share the same grayish brown color with little contrast between the base and tip of each hair (Miller and Allen 1928, Barbour and Davis 1969, LaVal 1970). The dorsal pelage varies from gray to bright orange-brown, and the ventral pelage varies from tan to white (LaVal 1970, Gardner et al. 1992, Humphrey and Gore 1992). LaVal (1970) collected more individuals with grayish pelage in fall and winter but captured more specimens with orange-brown pelage in spring and summer; this was especially true of females.

The southeastern myotis weighs from 4 to 9 g (0.14 to 0.32 oz) (Choate et al. 1994). Adult females are generally larger than adult males, and weights vary according to geographical location. The average weight of males in Louisiana is 5.9 g (0.21 oz), whereas the average weight of females is 6.9 g (0.24 oz) (Lowery 1974). In Texas, the average weight of males is 6.45 g (0.23 oz), and the average weight of females is 7.24 g (0.26 oz) (Mirowsky and Horner 1997).

Adult forearm length ranges from 31 to 41 mm (1.2 to 1.6 in.) (Barbour and Davis 1969, Mirowsky and Horner 1997), and wingspread ranges from 238 to 270 mm (9.4 to 10.6 in.) (Barbour and Davis 1969). The foot measures 10 mm (0.4 in.) in length; the wing membrane attaches at the base of the toe; no keel is present on the calcar (cartilaginous support for free edge of the membrane connecting the legs); and the hairs between the toes extend to or beyond the claw tip (Barbour and Davis 1969, Humphrey and Gore 1992). The skull has a globose braincase and usually a sagittal crest; the crest was once considered a diagnostic character, but further examination has revealed considerable variation in this feature (LaVal 1970).

Similar Species

The southeastern myotis is most similar to the Indiana bat (*Myotis sodalis*) and little brown bat (*M. lucifugus*) (Barbour and Davis 1969, Burt and Grossenheider 1976). However, the Indiana bat lacks long hairs on the toes and has a slight keel on the calcar, and the little brown bat has smooth, glossy fur (Barbour and Davis 1969). The gray myotis (*M. grisescens*) is larger than the southeastern myotis, and the wing membrane attaches at the ankle rather than the base of the toe. Another similar species, Keen's myotis (*M. keeni*), has long ears, 17 to 19 mm (0.70 to 0.75 in.) compared with 15 mm (0.60 in.) of the southeastern myotis. Distinguishing among similar species of *Myotis* is very difficult; therefore, an experienced bat biologist should conduct or assist with procedures that require species identification.

Status

Legal designation

Federal. The southeastern myotis was a candidate species (C2) for listing as either threatened or endangered by the U.S. Fish and Wildlife Service (USFWS) (USFWS 1989, Wood 1992). However, the USFWS discontinued the designation of C2 species as candidates for listing (50 CFR 17), published 28 February 1996. The southeastern myotis is now considered to be a species of concern, but more biological research and field studies are needed to resolve its conservation status.

State. The southeastern myotis has no legal status in most southern States. However, it is listed as endangered in Illinois and Kentucky and is given protection as a species of special concern in Alabama, South Carolina, and Texas. In Texas, the southeastern myotis is designated as S3 (20-100 occurrences) and in South Carolina as S2 (possibly imperiled statewide) and S3 (rare). Its designation in Mississippi is S1 (5 or fewer population occurrences) during the breeding season and S2 (from 6 to 20 occurrences) during the nonbreeding season.

Military installations

Table 1 represents the known status of southeastern myotis on military installations in the southeastern United States.

Table 1
Known Status of Southeastern Myotis on Military Installations in the Southeastern United States

State	Installation	Status on Installation
AL	Anniston Army Depot	Potential.
FL	Tyndall Air Force Base	Documented onsite (Stephen Shea, Personal Communication, 1996).
	Camp Blanding	Potential.
GA	Fort Stewart	Potential.
	Fort Benning	Potential.
	Fort Gordon	Documented (Kenneth Boyd, Personal Communication, 1997).
LA	Fort Polk	Potential; individuals have been documented in parishes surrounding installation (Kenneth Moore, Personal Communication, 1997).
SC	Fort Jackson	Documented.

Distribution and numbers

The southeastern myotis primarily inhabits the southeastern United States. Its range extends from southeastern North Carolina to peninsular Florida, across the southern

States to eastern Texas and Oklahoma, and northward in the Mississippi River Valley to western Kentucky, southern Illinois, and southern Indiana (Barbour and Davis 1969, Jones and Manning 1989, Humphrey and Gore 1992) (Figure 1). Until the 1990s, the western limit of the species range appeared to be extreme east Texas, as only a few specimens were known from counties along the eastern boundary (Packard 1966, LaVal 1970, Michael et al. 1970, Schmidly et al. 1977). However, more recent surveys indicate that the range extends throughout east Texas (Schmidly 1991, Horner 1995, Walker et al. 1996, Mirowsky and Horner 1997). Summer and winter ranges may be the same, as both lactating females and wintering colonies have been found in Alabama (Best et al. 1992), western Tennessee (Graves and Harvey 1974), Illinois (Gardner et al. 1992), and Florida (Rice 1955).

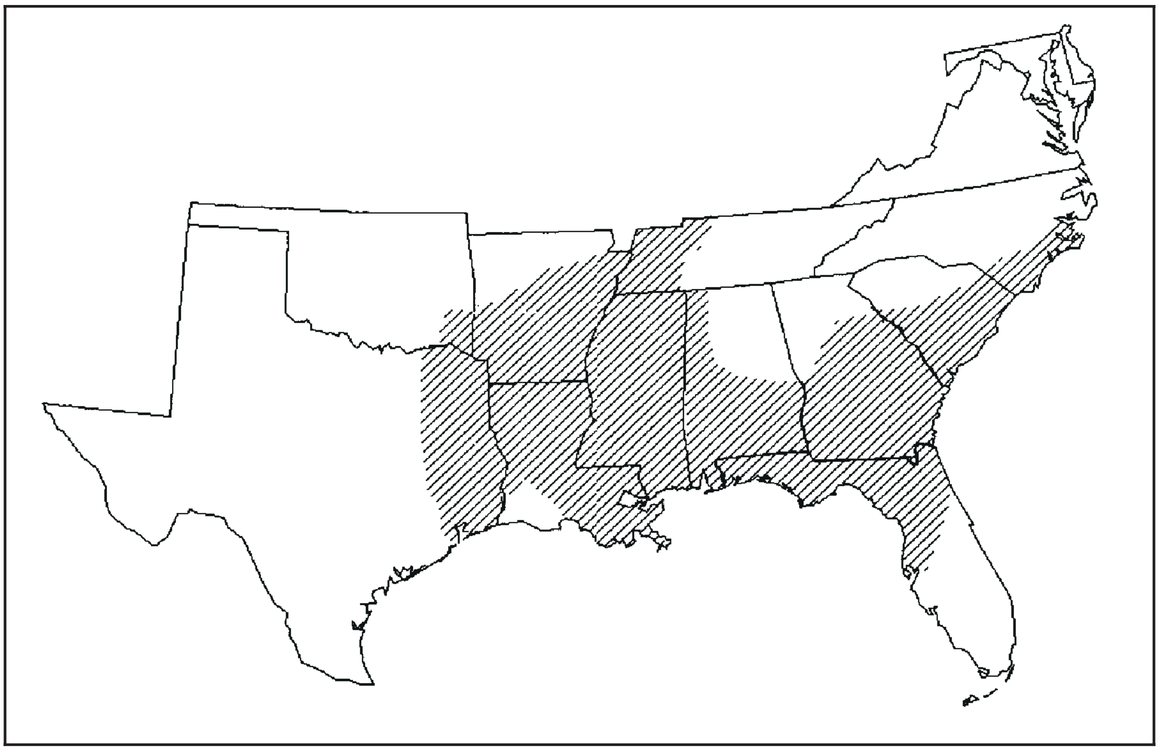

Figure 1. Approximate distribution of the southeastern myotis in the southeastern United States (composite map based on information from Barbour and Davis 1969, LaVal 1970, Graves and Harvey 1974, Jordan 1986, Schmidly 1991, Saugey et al. 1993, Walker et al. 1996, and Mirowsky and Horner 1997)

Surveys have not been conducted to estimate the total population of the southeastern myotis. Most population surveys have been restricted to Florida (Rice 1955, Gore and Hovis 1994) with estimates based on data collected from maternity caves where females gather in large numbers to bear and rear young. In the 1950s, Rice (1957) estimated 334,000 southeastern myotis in peninsular Florida in July after young were reared. More recently, Gore and Hovis (1994) included the panhandle of Florida in their estimate of 650,000 bats in winter and provided a discussion of problems inherent in making this estimate.

Gore and Hovis (1994) also summarized and compared historical counts from maternity caves in Florida with the counts made in 1991 and 1992. No southeastern myotis were found in nine caves that had a combined historical maximum use by more than 140,000 bats, but four caves that had not been previously reported were used by approximately 85,000 individuals. Gore and Hovis (1994) estimated a minimum decrease of 16 percent in the number of adults using maternity caves in Florida but strongly advised that these data be viewed with caution because of the lack of knowledge about sex ratios, movements from breeding to wintering habitats, extent of reproduction from noncave habitats, and recruitment from other parts of the range. These data are necessary to extrapolate from maternity cave counts to total population estimates. However, counts of the southeastern myotis from maternity caves provide minimum population estimates for some portions of the range and are the best available data for assessing population trends.

It is difficult to estimate populations of the southeastern myotis in portions of the range devoid of caves. Mist net surveys have been conducted in areas with potential roost trees, such as old growth forests of South Carolina (Clark 1994) and east Texas (Horner 1995, Horner and Mirowsky 1996, Mirowsky and Horner 1997). However, the primary objective of these surveys was to document presence and distribution of the species rather than to estimate population size. Southeastern myotis have been counted at roosts in man-made structures (Lowery 1974, Zinn 1977, Foster et al. 1978, Bain 1981), but launching a survey of structural roosts would probably not be feasible since the majority of the population roosts in caves.

Population levels in high-quality habitat within interior portions of southeastern myotis range may change less than those at the edge of the range during periods of population growth or decline; therefore, marginal populations may be the more sensitive indicators of population trends. Gardner et al. (1992) found southeastern bats in only one of nine previously reported winter roosts in Illinois. Barbour and Davis (1969) provided early evidence of declining numbers in Illinois, Indiana, and Kentucky and concluded that the species was nearing extinction in the Ohio River Valley. The largest summer colony in Alabama was extirpated by vandals and careless cave explorers (Jordan 1986), and the only known summer colony showed evidence of excessive human disturbance (Best et al. 1992). The consensus of more than 40 authorities from States within the range of the southeastern myotis is that the population is declining and the species deserves at least a Federally threatened status (Gardner et al. 1992).

Species Occurring with the Southeastern Myotis

The southeastern myotis has been found in maternity colonies in Florida with the gray bat (Wenner 1984) and free-tailed bat (*Tadarida brasiliensis*) (Sherman 1937, Hermanson and Wilkins 1986). It has been captured from summer caves in Illinois with the gray bat, little brown bat, Keen’s myotis, eastern pipistrelle (*Pipistrellus subflavus*), and big brown bat (*Eptesicus fuscus*) (Whitaker and Winter 1977). Bachelor (nonbreeding male) roosts and winter roosts in Florida are also shared with other species, including the free-tailed bat, eastern pipistrelle, big brown bat, and evening bat (*Nycticeius humeralis*) (Rice 1957, Bain 1981, Gore and Hovis 1994). The southeastern myotis hibernates with eastern pipistrelles and big brown bats in Arkansas (Saugey et al. 1989), Illinois (Gardner et al. 1992), and Texas (Walker et al. 1996). It shares roosts with eastern big-eared bats (*Corynorhinus rafinesquii*) in Texas (Mirowsky and Horner 1997) and with eastern big-eared bats and eastern pipistrelles in Louisiana (Jones and Suttkus 1975). The southeastern myotis associates with eastern pipistrelles during both breeding and wintering seasons in Alabama (Best et al. 1992).

Significance of the Species

Bats are major insect predators, consuming approximately one-third their body weights in insects per night (Anthony and Kunz 1977). Many prey species consumed by bats are considered pests, such as alfalfa weevils (*Hypera postica*) eaten by big brown bats (Belwood 1979) and mosquitoes by little brown bats (Anthony and Kunz 1977) and the southeastern myotis (Zinn 1977, Zinn and Humphrey 1981). Although the quantity of insects consumed by the southeastern myotis has not been determined, this bat is an important biotic control agent in areas where it is common. The economic cost of losing the insect control provided by southeastern bats has not been estimated.

In addition to natural insect control, guano from cave-dwelling bats directly or indirectly provides a food source for many species of rare cave-dwelling animals. Cave faunas associated with guano deposits have disappeared in areas where landowners have sealed off caves from bat use (Lee and Tuttle 1970).

Life History and Ecology

The southeastern myotis is most common in Florida, a State where the genus *Myotis* is not well represented. The endangered gray bat occurs there only in small numbers, but the southeastern bat has flourished because of behavioral adaptations that allow it to succeed in Florida's warm climate. In Texas, where habitat is suitable, the southeastern myotis is the most common bat captured (Horner and Mirowsky 1996).

Hibernation

Males and females roost together in winter and use a wider variety of noncave roost sites than in summer, but the bulk of the population remains concentrated in caves (Humphrey and Gore 1992). Unlike many other species, the southeastern myotis has a flexible hibernation strategy. In the northern portion of its range where temperatures are much lower, this species is known to hibernate up to 7 months of the year, from September through March (Barbour and Davis 1969, Gardner et al. 1992). However, it may remain active for much of the winter in the lower coastal plain. In Louisiana, southeastern myotis found in a semitorpid state at temperatures below 4.4 °C (40 °F) resumed nightly foraging during periods of warmer temperatures (Lowery 1974). Humphrey and Gore (1992) reported the evening emergence of thousands of bats at two maternity caves from December through March as evidence that bats are active all winter in Florida. By being active during winter, the southeastern myotis can take advantage of food resources still available in a region where winter cave temperatures are generally too warm for a myotis-sized bat to hibernate (McNab 1974). However, the bats experience abbreviated periods of hibernation, or at least torpor, during colder than average temperatures (Humphrey and Gore 1992). Bats then cluster closer together at roosts (Bain 1981) and hibernate for short periods of time, usually from mid-February to mid-March (Humphrey and Gore 1992).

Migration

Little is known about movements of the southeastern myotis between breeding and wintering areas. Although this species uses different winter and summer roost sites, and possibly different foraging areas, it tends to stay in the same region. Rice (1957) presented band-recovery data for southeastern bats banded in June and recovered during November or January, showing that movements ranged from only 7 to 24 km (4 to 15 miles). Evidence from other published studies also suggests that summer and winter ranges are probably the same. Both lactating females and wintering groups have been found in Florida (Rice 1957), Louisiana (Lowery 1974), Tennessee (Graves and Harvey 1974, Harvey et al. 1991), Kentucky (Harvey et al. 1991), Illinois (Gardner et al. 1992), Alabama (Best et al. 1992), and Texas (Walker et al. 1996). Mumford and Whitaker (1975) suggested that recapture of several bats banded the previous year in the same cave may indicate roost-site fidelity from year to year.

In central Florida, arrival of southeastern myotis at maternity caves begins in early March and reaches a peak by mid-April (Rice 1957). Pregnant females and some males gather in maternity colonies, but most males and nonbreeding females form separate colonies in other caves or in roosts outside of caves. Unless disturbed, the maternity colony typically roosts in the same cave until the young are volant or the population disperses to wintering areas (Kunz 1982). In Florida, Rice (1957) found a marked decrease in the number of bats in maternity colonies by late October, which corresponded to the arrival of the first wintering bats at a pole-barn roost studied by Bain (1981). In east Texas, maternity colonies disperse once pups are volant and weaned, but it is unknown where colony members go in autumn (Mirowsky and Horner 1997). The ambient temperature seldom drops low enough to warrant hibernation, but a shift in prey base or a change in water levels may contribute to the dispersal phenomenon (Kunz 1982, Mirowsky and Horner 1997).

Reproduction and development

A characteristic feature of reproduction in many northern cave-dwelling bats is delayed fertilization, a phenomenon in which copulation occurs in autumn, sperm is stored by the female during winter, and ovulation occurs upon emergence from hibernation (Guthrie 1933, Humphrey 1982). Delayed fertilization is thought to be an adaptation of hibernating bats for minimizing energetically expensive mating activities immediately after hibernation. Most copulation in bats presumably occurs when the majority of males have enlarged testes (Mumford 1958). In Illinois and Indiana, southeastern myotis were found to have enlarged testes during late November and early December (Rice 1957). Although the majority of males in west Florida populations also had enlarged testes during the fall and early winter, almost all males examined in peninsular Florida had enlarged testes from mid-February to mid-April. Therefore, mating of southeastern myotis apparently occurs during the spring in peninsular Florida.

By mid-March, pregnant females begin to congregate in maternity caves, and the young are born in mid-May (Rice 1957). The southeastern myotis is unique in the genus *Myotis* in that females usually give birth to twins. Young southeastern myotis are more altricial than the young of other cave bats (Sherman 1930) and experience higher mortality than other species in the first few weeks of life (Foster et al. 1978, Hermanson and Wilkins 1986). The young remain in the maternity cave while females forage during the evenings, and the older young form clusters while the females are away (Rice 1957). The young become capable of flight at 5 to 6 weeks of age, usually between early June and early July. In areas without caves, maternity colonies are typically located in large hollow trees or man-made structures, but members exhibit behavior characteristic of those roosting in caves (Mirowsky and Horner 1997). In Texas, Horner and Mirowsky (1996) found that parturition occurs from the end of April to early May and the young become volant by the end of May, a few weeks earlier than in Florida.

Estimation of recruitment at the population level has not yet been possible for the southeastern myotis. Foster et al. (1978) found that 11.8 percent of young die between birth and weaning, but this study was done on a maternity colony that roosted in the chimney of an old residence rather than a cave, where the vast majority of southeastern myotis are born. Furthermore, estimates of survival are lacking for either adults or young from weaning until dispersal to wintering areas.

Food habits and foraging

Southeastern myotis appear to prefer foraging over water and utilize a wide variety of foraging sites. Schmidly et al. (1977) reported them feeding over narrow, slow-moving creeks adjacent to large upland areas of loblolly (*Pinus taeda*) and shortleaf (*P. echinata*) pine, stands of hardwoods, and narrow beech-magnolia (*Fagus-Magnolia* spp.) bottoms. Other reported foraging sites include mature, high-quality, forested wetlands in Illinois (Gardner et al. 1992) and Texas (Horner 1995), watercourses in forests of Tennessee (Graves and Harvey 1974), and livestock ponds in Florida (Bain 1981). In dry areas of Florida, southeastern myotis feed around live oaks (*Quercus virginiana*) (Humphrey and Gore 1992) and over upland vegetation such as small woodlots and shrubby oldfields (Zinn and Humphrey 1981).

Most studies have provided a broad description of foraging behavior of the southeastern myotis, but few have addressed specific food items selected by this species. Zinn and Humphrey (1981) studied prey selection by southeastern myotis on three nights in Florida. They suggested that this species is a generalist with regard to food habits because they are active throughout winter when prey availability is strongly influenced by temperature. On the colder, spring nights, only Dipteran species were active, and bats selected mosquitoes and crane flies. Feeding took place only during the first 3 hr after dark, when prey activity was greatest. A wider variety of prey items were available on the warmer spring and summer nights, and bats selectively consumed mostly mosquitoes, beetles (Coleoptera), and moths (Lepidoptera) in that order of preference. Two peaks of foraging activity were seen on warmer nights, one at dusk when the insect community was diverse and another between 0100 and 0300 hr when only Dipterans were available. Prey selection may be quite different in other parts of the range where availability differs.

Mortality

Predation is the most important mortality factor among populations of the southeastern myotis in Florida (Rice 1957). Rat snakes (*Elaphe obsoleta*) are major predators, and the yellow rat snake (*E. o. quadrivittata*) is known to consume adults, as well as young bats (Foster et al. 1978). The cockroach (Hemiptera) is probably the second most important predator, especially for young that have fallen from the roost, but beetle larvae also kill fallen young (Hermanson and Wilkins 1986). Other predators include owls and opossums (*Didelphis virginianus*) (Rice 1957).

Habitat Requirements

Associations of the southeastern myotis with specific plant communities have not been firmly established. In cavernous regions of the Southeast, especially in Florida, the presence of appropriate caves appears to be the essential criterion for roost-site selection (Gore and Hovis 1994). In east Texas, Schmidly et al. (1977) found southeastern myotis in the oak-pine and longleaf pine (*P. palustris*) vegetation zones, and Horner and Mirowsky (1996) monitored maternity colonies in hollow trees of bottomland hardwood forests. Southeastern myotis have been captured in mature bald cypress (*Taxodium distichum*) - tupelo gum (*Nyssa aquatica*) swamps in South Carolina (Clark 1994) and Illinois (Gardner et al. 1992). Most southeastern myotis studied in Tennessee (Graves and Harvey 1974) and Kentucky (Gardner et al. 1992) were captured in mature floodplain forests.

Little is known about habitat requirements of the southeastern myotis beyond the roost. Because summer and winter ranges are probably the same, the foraging habitat information was discussed previously in the Food habits and foraging section. Consequently, this section will focus on roosting habitat.

Summer habitat

Maternity caves are probably the most important habitat component for the southeastern myotis, as the vast majority of young are born and reared in cave habitats (Humphrey and Gore 1992). Rice (1957) believed that maternity caves must have permanent bodies of water and a large area of horizontal ceiling at least 1.8 m (6 ft) above the water. These characteristics would help maintain high humidity and stable temperatures at the roost, deter predators, and provide lactating females with a convenient water supply (Rice 1957, Tuttle 1975, Zinn 1977). However, a survey of maternity caves in Florida found that only two of eight caves had water under the colony and four caves were completely dry (Gore and Hovis 1994). Comparisons of productivity in caves with and without water are needed to determine if standing water is beneficial to maternity colonies.

The physical features that make a cave suitable as a maternity roost are not well understood. Gore and Hovis (1994) found that five of eight maternity caves had domed ceilings ranging in height from 2.0 to 6.0 m (6.6 to 19.7 ft); in the three caves without domed ceilings, ceiling heights ranged from only 1.4 to 2.4 m (4.6 to 7.9 ft). Zinn (1977) reported that metabolic heat from roosting bats kept the roost at 28 °C (82 °F) when outside temperatures fluctuated from 19 to 30 °C (66 to 86 °F) and suggested that domed ceilings may trap metabolic heat and stabilize environmental conditions during the nursery period. Recent studies have suggested that human disturbance rather than cave structure may be the major factor determining maternity cave use (Mount 1986, Gore and Hovis 1994).

The characteristics of noncave habitats are not well known although maternity colonies of the southeastern myotis have been reported in chimneys (Foster et al. 1978), concrete culverts (Bain 1981), buildings (Kern et al. 1996), and hollow trees (Horner and Mirowsky 1996, Mirowsky and Horner 1997). Foster et al. (1978) studied a maternity roost in a house chimney in Alachua County, Florida. The chimney was narrow, 12.8 m (42 ft) tall, and contained more than 200 individuals. Horner and Mirowsky (1996) described roost trees in bottomland hardwood forests of east Texas. Typical roosts were located in the hollow cavities of live tupelo gum (*Nyssa* spp.) trees with triangular-shaped entrances at the bases. The cavities extended from 3 to 8 m (10 to 26 ft) up into the trees with no other exits, and the bats were typically located at or near the top of the cavities. Most roosts were associated with standing water from 4 to 30.5 cm (1.6 to 12 in.) deep. Structural roosts found in abandoned buildings were in densely wooded areas within 1 km (0.6 mile) of a river.

Bachelor roosts, composed of adult males and nonbreeding juveniles, support fewer bats than maternity roosts (Gore and Hovis 1994). These roosts are located in caves and other structures such as hollow trees, storm culverts, and buildings.

Winter habitat

In cavernous regions, most southeastern myotis spend the winter in roost caves. Temperatures in the caves and mines used by hibernating bats in Illinois, Indiana, and Arkansas range from 4.4 to 10 °C (40 to 50 °F) when outside temperatures are often below freezing (Rice 1957). Caves in peninsular Florida have temperatures of 20.5 to 22.8 °C (69 to 73 °F), which make them too warm for hibernation (Rice 1957). Therefore, southeastern myotis remain active throughout most of the winter and require habitat for hibernation only during brief periods of colder than average temperatures.

There is a paucity of published information on the physical features that comprise suitable winter roosting habitat for the southeastern myotis. A maternity colony of bats was found in an Alabama cave that was not subsequently used as a hibernaculum, and winter populations were found in four caves that bats did not use in summer (Best et al. 1992). Rice (1957) reported a marked decrease in the number of bats using maternity colonies in Florida by late October, which coincided with the arrival of a large group of southeastern myotis at a pole barn winter area (Bain 1981). These findings probably indicate differences in the roost sites selected by bats in winter and summer. Although bats apparently seek colder caves for winter roosts, other winter roost criteria are not well understood.

The southeastern myotis also uses a variety of noncave habitats for winter roosts. At least 200 bats roosted in crevices of a pole barn in Florida (Bain 1981). Saugey et al. (1993) found southeastern myotis in Arkansas hibernating in hand-dug water wells of the early 1900s. These wells were about 1 m (3 ft) in diameter, 15 m (50 ft) deep, and lined with tile or brick. Other potential winter roost sites include culverts (Zinn 1977, Walker et al. 1996), hollow trees (Fargo 1929, Gardner et al. 1992, Mirowsky and Horner 1997), and abandoned mines (Heath et al. 1986, Saugey et al. 1993).

Habitat Assessment Techniques

Little information on habitat assessment has been reported for the southeastern myotis. The research on maternity caves reported by Rice (1957) and Gore and Hovis (1994) forms the bulk of information on cave habitats. Foraging habitat has been generally identified and described by Gardner et al. (1992), who used radiotelemetry to determine habitat use by southeastern bats. Mirowsky and Horner (1997) established circular plots around roost trees to characterize the vegetation within 500 m^2 of each tree. However, uniform methods of habitat assessment have not been developed for the southeastern myotis, and habitat requirements of the species are still not well defined. Little is known about foraging habitat preferences beyond the apparent selection of overwater habitats. A radiotelemetry approach such as that used by Gardner et al. (1992) or sytematic netting in different, seemingly suitable foraging areas may provide insight into favored foraging habitats.

Inventory and Monitoring

Although Gore and Hovis (1994) have updated the status of maternity caves in Florida after nearly 40 years, much of southeastern myotis ecology is still unknown. The current focus should be on the determination of habitat requirements and assessment of population trends (Best et al. 1992, Gore and Hovis 1994). On military installations within the species' range, natural resources personnel should consider inventorying existing caves and other potential habitats to determine the status of the southeastern myotis on their installations. Programs can then be initiated to periodically monitor the population and provide protection on installations hosting southeastern myotis (and other species of bat).

Personnel assisting in census and monitoring should be aware of the potential for disturbing roosting bats. Studying bats at their roosts can be very disruptive and even lead to roost abandonment or population declines. Therefore, military installations should be extremely conservative in allowing activities by anyone, including biologists, that would disturb roosting bats (Jeffery A. Gore, Personal Communication, 1997). Obtaining the advice and assistance of an experienced bat biologist is strongly recommended before undertaking the survey of any bat population on an installation.

Census methods

Because bats are volant, nocturnal, and accoustically oriented, they are often difficult to observe, and therefore survey, in their natural habitats (Barclay and Bell 1988). Roost surveys and visual emergence counts have been frequently used for population studies at cave habitats. Technological advances in the past two decades have resulted in the development of methods, such as infrared imagery and night vision devices, that can be used to more effectively detect and census bats in the dark. Few surveys have been specifically designed for the southeastern myotis, but the methods described below have been or can be used to estimate population sizes of this species.

Cave surveys. Gore and Hovis (1994) surveyed maternity caves in Florida between late March and early May; this was the period after colony formation but prior to birth of the young. The numbers of adult bats were estimated while they roosted in the caves. To minimize disturbance, each cave was entered quietly once during daylight hours, red lights were used, and sound was minimized. Less than 30 min were spent inside each cave, and the survey was ended if the bats appeared irritated or started to fly.

Estimates of adult southeastern myotis have been made by measuring the surface area of cave ceiling covered by roosting bats and multiplying that figure by 2,000 bats/m^2 (Gore and Hovis 1994). This cluster density was derived from sample counts made at several occupied maternity caves previously visited. The overall condition of each cave was evaluated, and any evidence of natural or human disturbance was recorded. Other physical measurements were taken, such as air and cave wall temperatures, evidence of flooding, and presence of water.

Occupied southeastern bat caves were revisited between late June and mid-July to determine if young were produced (Gore and Hovis 1994). Bats were captured outside the cave in a harp trap or hand-held net (Kunz and Kurta 1988) as they emerged at dusk and were released after determination of sex and age. Maternity colonies containing volant young were considered reproductively successful, but efforts were not made to estimate the number of young produced by each colony.

Gore and Hovis (1994) surveyed unoccupied caves for evidence of previous bat habitation, utilizing signs similar to those described by Tuttle (1979) for gray bats. Evaluation criteria were based on several aspects of cave-bat interactions and included the following: (a) the area of stained cave ceiling, (b) the floor area covered by old versus new guano deposits, and (c) the presence of bat carcasses. The area of ceiling stains and guano deposits provided a relative estimate of the size of a former colony, based on mean density of roosting bats as measured at a few colonies. The color and texture of stains and deposits indicated whether a cave had been recently used.

Bat guano may harbor the fungus *Histoplasma capsulatum*, which can cause serious lung disease when inhaled by humans (Kern et al. 1996). However, the brief encounters experienced during cave surveys should pose no threat to researchers unless guano is actually disturbed. In that situation, protective clothing and a cartridge respirator should be worn to avoid respiratory contact with the fungal spores.

Visual emergence counts. The size of a bat population can be estimated by visually counting the numbers of bats emerging from summer roosts. At roosts housing only one species, counting individuals is not difficult, and relatively large numbers of bats can be accurately enumerated (Thomas and LaVal 1988). One or more observers are located in positions outside the roost where they can backlight flying bats against the sky and tally individuals exiting and entering the roost. At the beginning of emergence, many bats leave and return to the roost; therefore, those reentering must be counted and subtracted from the total number emerging. Hand counters may be used to tally the number of emerging bats.

Counts are usually conducted for given intervals of time and then extrapolated to the entire colony population. For example, the observer may count emerging bats for 5 min, estimate the length of time that bats emerge at that density, and calculate the number of bats that emerged during the estimated time period (Peggy Horner, Personal Communication, 1997). Time-interval counts are repeated as density of emerging bats changes.

Visual emergence counts were used to estimate large populations of gray bats at two caves in Alabama (Sabol and Hudson 1995). During evening emergence, a skilled observer counted bats seen crossing his field of view. He counted for intervals of 1 min followed by 1-min rest and recording periods. Since only one-half the bats occupying a cave were counted, a total emergence estimate was obtained by doubling the number counted. When emergence rates were rapid, estimates were made by counting by 10s, 20s, or 100s.

An advantage of using this technique is that minimal equipment is needed. However, observers must be experienced in observation and enumeration of bats on the wing, especially large numbers emerging together from a cave. A major disadvantage is that visual emergence counts are labor intensive (Thomas and LaVal 1988). Some roosts have several exit routes and require more than one observer, since each observer is limited to watching only one exit route per night. This limits the number of roosts that be can be adequately studied in a given period of time. Observers should also be aware that counts may be biased by factors that affect emergence behavior, such as inclement weather, presence of nursing young, or fall breeding activities.

Infrared-imaging. A census technique developed by Sabol and Hudson (1995) uses thermal infrared-imaging and digital picture processing to estimate cave-dwelling bat populations. Infrared-imaging systems, which take heat pictures, allow the detection of bats against a cooler background with or without the presence of visible light. This technique was used to estimate numbers of gray bats during nocturnal emergence at two Alabama caves. A thermal infrared scanning radiometer with a 20-deg horizontal and 20-deg vertical field-of-view lens was used in the tests, and imagery was continuously recorded on video tapes, beginning before the first signs of emergence and continuing until the end of emergence, which was about 1 hr.

Several options are available for counting bats with this technique (Sabol and Hudson 1995). An observer may view the video and make a visual count. Automated options include estimation based on sampling frames or on frame-by-frame tracking and counting. The most critical aspect of this technique is setting up the camera to achieve the proper viewing geometry and to view a background that is stationary and thermally bland; a stationary background is an absolute requirement. Prior knowledge of the cave and flight path taken by the bats is helpful. Sabol and Hudson (1995) found close numerical agreement between visual estimation and infrared-imaging. This technique should be more consistent than visual estimation and thus enable collection of better trend data. Its most appropriate use would be in estimating large populations for which accurate visual estimation would be difficult. Calculations for estimating total bat populations with infrared-imaging techniques are given in Sabol and Hudson (1995).

Mist net surveys. Mist netting can be effectively used to obtain baseline data for southeastern myotis populations in noncave regions of the Southeast. Horner and Mirowsky (1996) conducted mist net surveys in bottomland hardwood forests of east Texas, and Clark (1994) conducted a similar survey in North Carolina. Surveys should be conducted between May and September. Mist nets should be located in potential habitat, primarily old growth or bottomland hardwood forests, or at sites with previous records of occurrence. Nets are usually placed in openings or forest corridors, opened at dusk, and closed between 1200 and 1330 hr (Horner 1995). Nets should be monitored at 30-min intervals (or shorter intervals, depending upon the abundance of bats), and physical data should be collected on each captured bat (Horner and Mirowsky 1996). This survey method revealed an expansion of the range of the southeastern bat in Texas (Mirowsky and Horner 1997).

Personnel conducting mist net surveys must hold a permit from the State in which a survey is conducted. All persons handling bats should have a preexposure vaccination for rabies and receive training in the handling of bats prior to surveys.

Noncave roost surveys. In areas devoid of caves, roost sites in trees or man-made structures have been surveyed to obtain population data for the southeastern myotis (Horner and Mirowsky 1996, Mirowsky and Horner 1997). Roosts may be located from bats radiomarked in mist net surveys or by visual searches for sites characteristic of southeastern myotis roosts. Potential sites are areas of known roosts, bottomland hardwood forests with trees that have large basal hollows, and man-made structures such as bridges, culverts, storm drainage sewers, and abandoned buildings. Flashlights protected with a red filter should be used to inspect the insides of trees and structures for the presence of bats or bat sign, such as guano, stains, or insect parts. Although bats can be counted in the roosts, Horner (Personal Communication, 1997) suggested using a night vision device to count them during emergence. The observer should sit 10 to 30 m (11 to 33 yd) from the roost tree so that the entrance will not be obstructed but will still be clearly visible. Using the night vision device, the observer should then count emerging bats for given time intervals and extrapolate the data to the population as described above.

Night vision devices. Night vision devices are image intensifiers that electronically intensify ambient light to produce an image on a phosphor screen (Slusher 1978) and have been highly effective for making behavioral observations of nocturnal animals (Southern et al. 1946). These devices can be especially useful in emergence flight counts for bats or in studying bat behavior. Several types and models of night vision devices are available; many are extremely light-weight, give high resolution, and are battery operated (Barclay and Bell 1988). For stationary situations, night vision scopes permit detailed observations without undue disturbance and can be fitted with standard camera lenses to allow zoom or telephoto viewing. Bi-ocular viewers, which reduce eye fatigue, are available for night viewing scopes used in long-term observations. To provide higher resolution images, an infrared radiation source can be used, such as infrared camera filters (Slusher 1978).

Monitoring

After an initial estimate has been made, a southeastern myotis population should be monitored periodically, probably at 1-to 2-year intervals. Tuttle (1979) suggested that gray bat summer colonies be monitored annually, and the USFWS Recovery Plan for the gray bat recommended that hibernacula be censused every 2 years (Brady et al. 1982). Gray bats and southeastern bats are frequently found in the same caves, and all bats are censused during a survey. Therefore, these monitoring periods should be appropriate for the southeastern myotis. Some experience is necessary to distinguish species as they roost without disturbing them.

Monitoring existing caves used by southeastern bats and expanding the database by systematic searches for other maternity colonies in cave and noncave habitats would yield important information on population trends and recruitment from noncave habitats. However, caution must be used in extrapolating to estimates of trends in population size, as numbers of roosting bats can vary widely, especially those determined by emergence flights (Jeffery Gore, Personal Communication, 1997). Quantitative data on reproductive success from existing maternity colonies and characteristics of used versus nonused caves and structural sites are needed to determine the roost and habitat features most important for recruitment.

Impacts and Causes of Decline

Although the southeastern myotis is thought to be declining, there is little confirmatory evidence because few surveys have been done since the late 1950s (Gore and Hovis 1994). The work of Gore and Hovis (1994) was designed to obtain the status and current locations of maternity caves, information vital to the design of surveys that will produce a reasonable estimate of total population size. However, much more information is needed on the contribution of populations in noncave regions to the total population of the southeastern myotis.

The most important impact on the southeastern myotis is human disturbance of cave habitats. In Alabama, the largest summer colony was reportedly extirpated by vandals and careless cave explorers (Mount 1986), and the colony found by Best et al. (1992) is at high risk from human traffic. Rice (1955) reported 11,000 southeastern bats in Mud Cave, Florida, but the site became a dump and was filled with trash (Humphrey and Gore 1992). Gore and Hovis (1994) found two additional caves in Florida that had the entrances blocked, one by wire mesh installed by the landowner who was tired of tresspassers and the other by rocks deposited when nearby land was converted to agriculture. Bats left a maternity cave in Florida between April and May when someone apparently set fire to the guano deposits (Gore and Hovis 1994). Reduced production probably results when a colony is forced from a selected habitat; nearby habitats are likely not as suitable as the evacuated site.

Irresponsible acts occur, such as the killing of thousands of gray and southeastern bats with stones and clubs in Old Indian Cave near Marianna, FL (Lee and Tuttle 1970). People who do not want bats in their environment may refuse to cooperate with efforts to protect colonies and actually destroy the bats. Hermanson and Wilkins (1986) located three maternity colonies of free-tailed bats between 1976 and 1983, and all were exterminated or scheduled for extermination by the property owner.

Human disturbance also involves indirect habitat alteration. Noise and lights of cave explorers may awaken and disturb hibernating bats of all species; this is energetically costly and will reduce winter survival if repeated many times. Similar disturbances may occur at summer sites. A startled colony may take off hurriedly when disturbed, knocking many young from the roost and causing mortality (Foster et al. 1978, Hermanson and Wilkins 1986).

Natural environmental phenomena may cause serious impacts to southeastern myotis populations. Most caves in Florida are near streams or at groundwater level and thus susceptible to flooding. About 57,000 bats were killed when the Apalachicola River flooded Snead’s cave in February 1990; a cave flooded after a heavy summer rainstorm in 1989 and killed at least 6,500 bats (Gore and Hovis 1994). An impoundment or channelization that increases flooding in areas used by bats can, therefore, be detrimental to their populations. A disturbance that alters the airflow through a bat cave may change environmental conditions and render the cave unsuitable for hibernating or maternity colonies (Tuttle

1981). Collapse of cave ceilings or rockfalls can trap bats or close a roosting site to future use (Gore and Hovis 1994). Collapse and destruction of artificial roosting sites such as mines, bridges, and buildings may also impact southeastern myotis populations, but the effect on the entire population is presumed to be minimal.

Clark (1985) reviewed studies related to the harmful effects of pesticides on bat populations. One study evaluated the effect of heavy metal pollution on major colonies, including southeastern bats, in Jackson County, Florida (Clark et al. 1986). However, neither pesticides nor heavy metal pollution posed as serious a threat to bat populations as did the impacts of human disturbance, vandalism, and habitat destruction.

Harvesting of bottomland hardwoods and mature forests may impact the southeastern myotis in noncave regions, where the species utilizes hollow trees for roosts. Reservoir construction and diversion of floodwaters may also destroy suitable habitat, since most roosts are located in mature bottomland forests that become submerged and no longer capable of providing roost trees. It is likely that these alterations also result in impacts to foraging habitat of the southeastern myotis in cave regions of the eastern United States. Many southeastern myotis have been captured over slow-moving watercourses in mature forests, which suggests that these forests are preferred foraging habtitats. Gardner et al. (1992) found that bats foraged in mature high-quality forested wetland habitat, much of which had been cleared and drained in Illinois. Few studies have been directed toward the impacts of specific habitat alterations on southeastern myotis populations; the effects of wetland and bottomland forest alterations need further investigation.

Management and Protection

There is no recovery plan to provide guidance for the protection and management of the southeastern myotis, because it has not been officially designated as a Federally endangered or threatened species. A few States have given it limited protection by listing it as a State threatened, endangered, or special concern species. In some parts of its range, an indirect measure of protection has been afforded the southeastern myotis because of its association with the gray bat, a Federally endangered species (Wenner 1984).

The protection of cave habitats, especially maternity caves, is the best current management practice. Because so many species of cave fauna are endangered, the concept of protecting cave habitats is well accepted. However, complete protection of caves from human disturbance is difficult. Posted signs prohibiting cave entrance often bring the presence of the cave to the attention of vandals that might not otherwise notice the cave (Lee and Tuttle 1970). Cave entrances can be fenced or gated to exclude entry if human disturbance is excessive and signs are not effective. Although fences are less effective than gates for the exclusion of people, gates sometimes prevent bats from using a cave (Tuttle 1981). Spelunking (caving) is a source of disturbance, but experienced, informed cavers usually avoid caves with roosting bats (Gore and Hovis 1994). A wider educational effort can help reduce unwitting cave disturbance and intolerance of bats inhabiting artificial structures, such as buildings (Hermanson and Wilkins 1986).

Known and potential roost trees should be protected from harvest or other man-made disturbances. The area around the roost entrance should be kept clear to permit unobstructed passage for bats. Buffer zones should probably be developed and maintained around roost trees, but studies have not defined appropriate zone sizes or even provided evidence for need. One tree roost in east Texas is currently being monitored where the surrounding area has been clearcut; however, the population may be occupying the roost because it is the last suitable tree in a very large area (Peggy Horner, Personal Communication, 1997).

Gore and Hovis (1994) recommended a unified cave management plan for southeastern myotis maternity caves in Florida. The plan would identify the status and problems at each cave and recommend immediate and long-term goals for maintaining or restoring individual caves as maternity roosts. The plan should include the resources and cooperation of State and Federal natural resource agencies, landowners, private conservation groups, and spelunkers.

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13. ABSTRACT *(Maximum 200 words)*

The southeastern myotis (*Myotis austroriparius*) is a medium-sized bat with grayish-brown, woolly fur. This species primarily is found in the southeastern United States. Its range extends from southeastern North Carolina south to peninsular Florida, west to eastern Texas and Oklahoma, and north to western Kentucky, southern Illinois, and southern Indiana. The southeastern myotis is considered a species of special concern because of significant population declines. It migrates between cooler winter caves used as hibernacula and warmer summer caves used for rearing young. In noncave regions, the southeastern myotis roosts in large hollow trees or man-made structures. The southeastern myotis has been documented on at least two military installations in the southeastern United States. This report is one of a series of Species Profiles being developed for threatened, endangered, and sensitive species inhabiting southeastern United States plant communities found on military installations. The work is being conducted as part of the Department of Defense (DoD) Strategic Environmental Research and Development Program (SERDP). Information provided on the southeastern myotis includes status, life history and ecology, habitat requirements, impacts and causes of decline, habitat assessment techniques, inventory and monitoring, and management and protection.

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UNCLASSIFIED	UNCLASSIFIED		