Forest Management and Bats

Merlin Tuttle

Bat Basics

More than 1,400 species of bats account for almost a quarter of all mammal species worldwide.

Bats are exceptionally vulnerable to population losses, in part because they are one of the slowest-reproducing mammals on Earth for their size, with most producing only one young each year.

For their size, bats are among the world's longest-lived mammals. The little brown bat can live up to 34 years in the wild.

Contrary to popular misconceptions, bats are not blind and do not become entangled in human hair.

Bats are the only mammals capable of true flight.

Most bat species use an extremely sophisticated biological sonar, called echolocation, to navigate and hunt for food. Some bats can detect an object as fine as a human hair in total darkness.

Worldwide, bats are a primary predator of night-flying insects. A single little brown bat, a resident of North American forests, can consume 1,000 mosquito-sized insects in just one hour.

All but three of the 47 species of bats found in the United States and Canada feed solely on insects, including many destructive agricultural pests. The remaining bat species feed on nectar, pollen, and the fruit of cacti and agaves and play an important role in pollination and seed dispersal in southwestern deserts.

The 15 million Mexican free-tailed bats at Bracken Cave, Texas, consume approximately 200 tons of insects nightly.

A colony of 150 big brown bats (a species that often roost in tree cavities) can eat enough cucumber beetles each summer to eliminate up to 33 million of their rootworm larvae, a major agricultural pest.

Bat droppings in caves support whole ecosystems of unique organisms, including bacteria useful in detoxifying wastes, improving detergents, and producing antibiotics.

More than half of bat species in the United States are suspected to be in decline and several are considered endangered. Losses are occurring at alarming rates worldwide.

During cold weather, many bat species hibernate in caves, mines, or other sites that provide stable, cool temperatures. Others species migrate to warmer climates, sometimes traveling more than a thousand miles.

Forest Management and Bats

Because more than half of the forest land in the United States is privately owned, forest landowners play an important role in the stewardship of our wildlife resources. This publication will introduce you to a group of wildlife that is particularly important to forest ecosystems, but also one of the most misunderstood: bats. We will demonstrate how active forest management can improve forest health and productivity while maintaining and enhancing habitat for these fascinating and beneficial mammals.

As primary predators of night-flying insects, bats are essential for maintaining forest health. Many bats can eat nearly their own body weight in moths, beetles, and other destructive insect pests every night. Helping bats is a wise investment in our forests.

Bats are currently facing unprecedented population declines in the United States and Canada due to an introduced fungus that causes the disease white-nose syndrome (WNS). Millions of bats have died since this fungus first appeared in the northeastern United States in 2006, and this fungus has since spread throughout a large portion of North America. Some species, such as the northern long-eared bat, have largely disappeared across vast areas of the eastern United States. Efforts to combat this disease have so far been unsuccessful. Thus, managing forests to provide resources for bats is important to help these declining populations.

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WHITE-NOSE SYNDROME
RESPONSE TEAM

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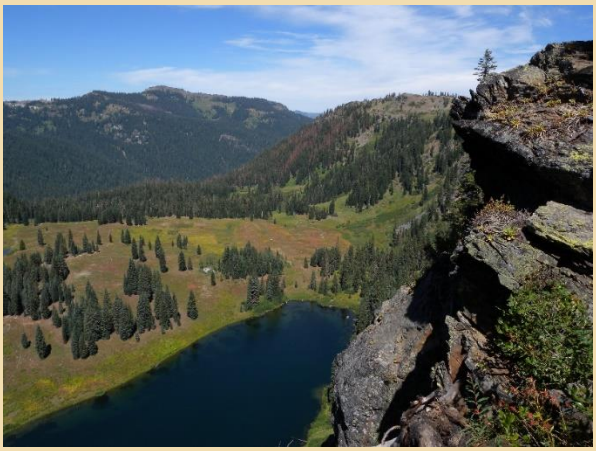
HABITAT NEEDS OF BATS

Bats have three basic habitat needs: resources for roosting, foraging, and drinking. Almost all North American bats rely on forests for survival. More than half of bat species roost in dead and dying trees (snags), especially beneath loose bark, in tree cavities, or in tree crevices left by lightning strikes or other damage. In the western United States (U.S.), the long-eared myotis is known to roost under exfoliating bark on stumps and downed logs. Other bat species roost exclusively in the foliage of living trees. Forest roosts are required by bats for rearing young (maternity roosts), as migratory stopover sites, and sometimes for hibernation, depending on the bat species and location. Other bat species roost in sites located in forests, including caves, mines, cliff faces, rock piles, and human-made structures such as old buildings, bridges, culverts, and cisterns. These bat species also use forests for foraging and as movement corridors. Bats also use many of these features as night roosts where they can rest and digest their food between nightly foraging bouts.

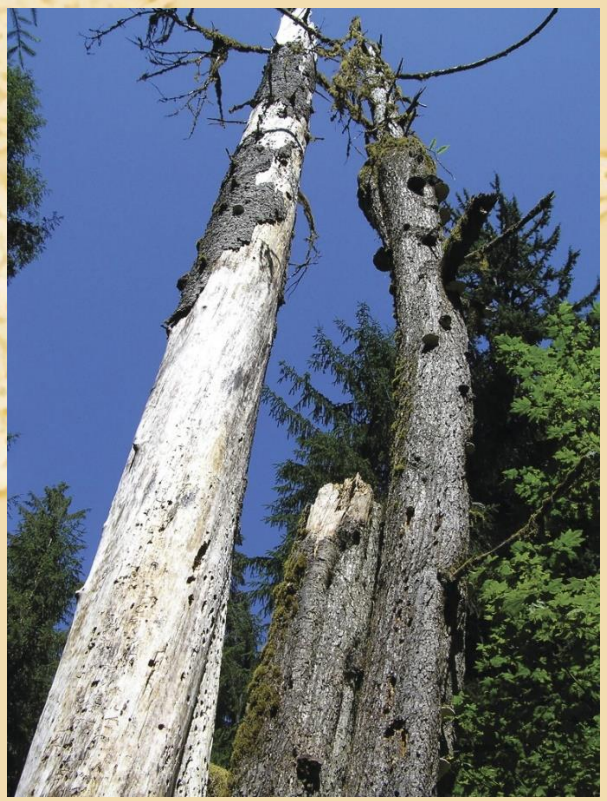
Bats forage in forests, along forest edges, over riparian areas (areas associated with water, such as ponds, swamps, and streams), along forest roads and trails, in forest gaps, and in harvest-created forest openings. Feeding strategies vary greatly among forest-dwelling species. Some forage around ground-level shrubs, whereas others prefer to forage below the tree canopy, in the canopy, or above it. Bats need clean, pooled, open bodies of fresh water that are large enough to enable them to scoop water into their mouths while in flight, and the usefulness of these pools can be reduced by obstructing vegetation, fencing, or other objects.

Roosting Requirements

Some species of forest bats roost exclusively in the foliage of living trees, while other species roost under loose, peeling bark or crevices of dead trees. Others will also use cavities in healthy trees or trees that are damaged or dying. Some bats, such as the big brown bat and silver-haired bat, frequently roost in cavities of either living or dead trees.



Forests can be managed for both wood products and bat habitat if adequate roosts, foraging areas, and water sources are maintained across the landscape. Photo: Virginia McDaniel.



Snags are important roosting sites for many species of bats and retaining snags in clusters increases use by bats. Photo: Darren A. Miller.

Most bat species that roost in living or dead trees move frequently between roost trees over successive days. Colonies of females and solitary males or bachelor (all-male) colonies exhibit this

behavior. This roost switching may be an effort to avoid predators, reduce parasites, or to seek warmer or cooler roosts based on weather conditions. For snag-roosting bats, switching is also likely tied to the temporary nature of dead and dying trees: if a roost tree falls or the bark falls off, the bats can move to an alternative roost. However, these bats often return to the same roost tree or group of trees over successive years when possible.

For some species, roost trees are often located along the edges of forests or in open forest stands, where they generally receive greater solar heating and have a less-obstructed flight approach. In landscapes with steeper topography, some evidence suggests that upland and ridge-top trees may be used as roosts more frequently than valleys and canyon bottoms where cold air accumulates.

Snags with cracks or split tops that are caused by ice-storms or wind damage, provide long-lasting roosting sites for forest bats. Photo: U.S. Forest Service

Dead Trees

The characteristics of a dead tree (height, diameter, level of decay) and its position in the forest stand and on the larger landscape appear to be the most important factors in determining its suitability as a roost site. These factors affect the roost's temperature, an important component in roost selection. The species of tree is important only as it relates to these structural attributes. Tree species with softer wood and those that are more susceptible to fungal infestations attract cavity excavators such as woodpeckers. Tree species such as black locust can provide snags that last for longer periods than other species. Often, insects or disease outbreaks may cause abundant snags of a particular tree species, resulting in bats using that tree species more often than other tree species in the area. Also, snags that retain bark for longer periods are more likely to provide appropriate roosting spaces.

Snags located in small openings are especially important for female bats rearing pups in summer. Photo: Roger W. Perry

Although the particular habitat needs of forest bats vary by bat species, geographic area, and climate, bats that roost under bark or in crevices and cavities of dead trees frequently select larger snags, which often extend above the forest canopy. This is especially true for roosts of maternity colonies because larger snags better retain the sun's warmth, which may benefit the pups by speeding their growth during cooler parts of late spring and early summer. Males often roost alone or in bachelor colonies and appear to use a wider range of snag sizes. Maternity colonies of more than 500 bats have been recorded emerging from cavities or under the exfoliating bark of snags in both eastern and western forests of the U.S., demonstrating the importance of a single dead or dying tree for bats. Most snag-roosting bats prefer trees in the earlier stages of decay with an ample amount of loose, peeling bark.

The Seminole bat (a foliage-roost species) is indistinguishable from pine cones when roosting in the foliage. Photo: S. Andrew Carter.

Living Trees

Some forest bats that roost under bark, in cavities, or in crevices of dead trees also use these same features in healthy living trees or trees that are damaged or dying. For example, the evening bat, which occurs in the southeastern U.S., may roost in cavities of living fork-topped pine trees. In bottomland hardwood forests of the southeastern U.S., the Rafinesque's big-eared bat and southeastern myotis form colonies in the hollow trunks of large, living gum, beech, and bald cypress trees with basal openings. In parts of their range, these bats will also roost under bridges and in old buildings and cisterns.

Eastern red bat with pups roosting in the foliage of a tree. Photo: Leslie Elmore.

Foliage-roosting bats typically roost in the foliage of a wide variety of living trees, both evergreen and deciduous. Tree bats often choose overstory trees with large crowns and roost in locations that offer suitable temperatures, humidity, and protection from adverse weather and predators. These species often have two to four pups and roost alone or in small groups. Tree bats, such as eastern red bats migrate south from northern parts of their range in fall, where they often roost beneath leaf litter on the forest floor during the coldest parts of winter. Some tree bats, such as the Seminole bat, roost mostly in the foliage of living pine trees, whereas the eastern red bat roosts mostly in deciduous trees. Northern yellow bats often roost in clumps of Spanish moss, and northern and southern yellow bats will roost beneath the dead, hanging fronds of palmettos.

Foraging Requirements

Bats feed on a variety of night-flying insects, catching them in the air or picking them off vegetation. Many bat species prefer to hunt in small- to medium-sized forest openings or gaps such as those created by timber harvests, tree death, or tree-fall. Bats also forage along roads and water courses, or over lakes and ponds. Bats often forage along edges where different-aged forest stands meet and along forest corridors and buffer strips. Smaller, more maneuverable bats, such as the northern long-eared bat and small-footed bat in the

Small forest roads are often used by bats as travel corridors and for foraging. Photo Roger W. Perry.

eastern U.S. and the long-eared myotis in the western U.S., can forage in cluttered vegetation in the forest midstory and in very small forest gaps. Larger, faster-flying and less maneuverable bats, such as the hoary bat, may forage above the forest canopy, in larger forest openings, along forest edges, or over clearings, fields, wetlands, and rivers.

Bat-foraging activity is often concentrated in riparian areas and in gaps in older, more diverse forest stands. Riparian areas are especially important because they provide drinking water, high-quality foraging habitat, and high-quality roosting habitat. Beaver ponds provide high-quality bat habitat that combines drinking, foraging and roosting resources. Bats often follow forested corridors when traveling from roosts to feeding and drinking areas.

FOREST MANAGEMENT AND BATS

Forest management practices such as tree harvest (thinning, selective cuts, or clearcuts), prescribed burning, site preparation, and other activities can have positive or negative effects on bats. These activities alter the structure of forests, affect the distribution and abundance of living and dead trees used for roosting, and influence the number of forest openings and edges used for foraging. For example, some forest management practices may negatively affect roosting habitat while improving foraging habitat.

Sustainable forest practices not only support a vibrant market for forest products and motivate landowners to maintain forests on their lands, but can also ensure habitat components for bats are provided across forested areas over time. Non-timber values can be conserved, and bat-roosting habitat, foraging habitat, and drinking resources can be maintained or enhanced, greatly benefiting bat populations.

Male big brown bat roosting alone under the loose bark of a pine snag. Photo: S. Andrew Carter.

Forest Management and Roosting Trees

Roosts are often considered the most important habitat component for bats, and roost switching during summer appears to be essential for most species. Forest landowners can maintain bat populations by providing a continuous supply of potential roost trees. These include snags in various stages of deterioration (especially those in early stages of decay), hollow trees, live trees and trees with peeling bark, and living trees that may become snags for roosting as the forest ages or is subjected to disturbances. Dozens of other wildlife species

that depend on dead and dying trees will also benefit.

Most state forestry agencies, state and local extension offices, and state or federal wildlife management agencies can provide guidelines and recommend practices for maintaining snags, live trees, and other forest structures that are tailored to local conditions. It is important to note that the U.S. Occupational Safety and Health Administration (OSHA) has strict guidelines regarding where snags may be retained on private, working forests due to the inherent danger of operating machinery around dead trees. These guidelines must be incorporated into any snag maintenance and protection program.

Multiple snags clustered in open areas provide alternative sites for bat colonies that move among different roosts throughout summer. Photo: Jane Rodrigue U.S. Forest Service.

How Many? The minimum number of roost trees needed to maintain bat populations is unclear, but likely varies by forest type, region, and bat species. Foliage-roosting bats that use live trees can find roosts in most forests, but it is important to ensure that enough dead and dying trees are left for the species that depend on cavities or shedding bark. Bats need multiple roosts over the course of a summer and from year to year. Because snags are a short-lived resource (especially in the eastern U.S.), the availability of suitable roost trees for snag-roosting bats fluctuates over time. Federally managed forests and some state forestry regulations for private owners may specify a minimum number of trees to leave for wildlife, but forest owners can strive to leave as many dead, damaged, dying and cull (defective) live trees as possible as safety and silvicultural objectives permit.

Mature forest stands produce more and larger snags, so well-distributed, variably sized patches of mature and older forest can be maintained where possible. Also, some stands can be managed through extended harvest rotations if these actions are compatible with landowner objectives.

Although developed for the Pacific Northwest, the DecAID Decayed Wood Advisor (see Sources of Assistance) is one of the most thorough resources available for snag and wildlife leave-tree planning in managed forests and can be adapted to other regions. Because our knowledge of how many roost trees are needed is limited for many species and regions, these recommendations should be taken as suggestions rather than strict guidelines.

Which Ones? The structure of a snag is often more important than its species, although some tree species make better snags than others because of the quality of the roosts they provide or because they may stay standing longer. Emphasize larger diameter snags because they generally remain standing and retain bark longer and support a greater variety of bats and other wildlife than smaller snags. In general, retain snags in the early stages of decay rather than more-decayed snags, tall and large-diameter snags rather than smaller snags, and snags with more bark cover than those with little bark. In conifer-dominated and mixed-conifer stands, leave as many hardwoods as possible that have natural or woodpecker-excavated cavities. The value of recently harvested stands for a variety of wildlife species, including bats, is greatly enhanced by leaving snags and future snags within a harvested area.

Where? Snags should be well-distributed across an area, including along drainage bottoms, upland slopes, and ridge tops. Maintaining snags along forest-stand edges and other open areas where they receive more sunlight is preferable. When

practicing even-aged management and where silvicultural and logging safety objectives are not compromised, consider leaving snags either evenly distributed across harvest units or in patches. Leaving snags in patches interspersed with live trees helps keep them from being blown over by high winds, as will leaving them in locations with protection from prevailing winds. This also makes it easier to conduct management operations. In landscapes where timber production is the primary objective, snags can be maintained primarily in streamside management zones, forested corridors, and other less-intensively managed stands. In coniferous forests, roosts of foliage-roosting bats that prefer broadleaf deciduous trees are often concentrated within riparian zones because they usually contain more broadleaf vegetation than the surrounding conifer stands.

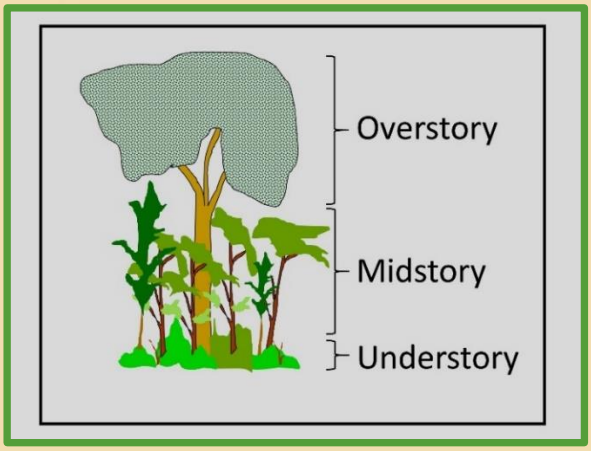
Timber-harvesting machinery, such as this feller-buncher, can be used to create snags by topping live trees. Photo: Ed Arnett.

Green-tree retention: Natural fall rates will eventually reduce snag numbers unless new snags develop naturally or are created. Leave as many large live or cull trees as "leave trees" as feasible to become future snags. Cull trees include those with broken tops, forked tops, wounds, cavities, evidence of fungal heart rot, or other defects that reduce their commercial value. Tree species with little commercial value can be left for future snag development if those species do not adversely affect forest-management goals.

Snag creation: In stands where snags are limited or absent, one option is to alter or kill living trees to create snags. This allows the number of snags created and their locations to be chosen by a forest manager. Methods for snag creation include girdling, topping with chain saws, injecting with herbicides, and using mechanical harvesting equipment (fellers). Creating snags can provide additional snags, but retaining existing structures is the most cost-effective and ecologically sound method.

Forest Management and Foraging

Forest-management practices that create small forest openings (less than 5 acres or 2 hectares) may provide foraging areas and may even enhance roosts located along forest gaps and edges. As noted above, bats often forage along edges between forests and cut areas. Smaller harvest areas have greater edge per unit area and promote plant and insect diversity that is beneficial to bats and other wildlife. However, some bat species will not forage in the middle of large (greater than 120 acres or 49 hectares), newly regenerating stands.



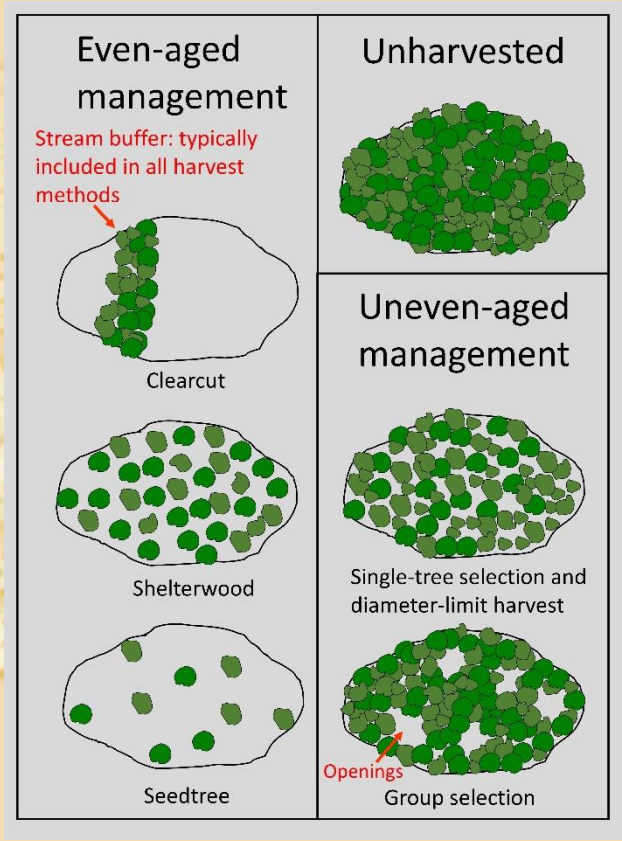
The three structural layers of a mature forest are the overstory, midstory, and understory.

When creating openings for bat foraging, care should be taken to reduce the loss of potential roost trees. It is also important to recognize that bats will travel daily between roosting and foraging sites. Understanding how foraging and roosting areas are distributed across an area may be beneficial when planning forest management activities.

Prescribed burns are used to fulfill many objectives, including reducing hazardous fuels, encourage regeneration, improving wildlife habitat, and encouraging understory growth of non-woody plants. Photo: U.S. Forest Service.

Open forests with reduced midstory subjected to periodic prescribed fire provide foraging areas for many bat species. Photo: U.S. Forest Service.

Many bat species benefit from midstory reduction or removal. This can be achieved through mechanical methods, herbicide treatments, and/or prescribed fire. Reducing the midstory reduces clutter below the forest canopy and provides unobstructed areas for bats to forage. If this midstory reduction is coupled with an open overstory that allows sunlight to reach the ground, a diverse herbaceous plant community can develop, which provides a diversity of insect prey for bats. Reducing midstories may also improve roosting habitat by increasing light penetration to the boles of snags and by providing uncluttered areas around roosts for less maneuverable juvenile bats to practice flying.



Timber harvest methods under both even-aged and uneven-aged silviculture systems.

Forest Management Practices

The following tables list some commonly used forest management practices and their potential benefits to bats.

TIMBER HARVEST		
Management	**Treatment**	**Implications**
Even-aged management: Begins with the complete, or nearly complete, removal of existing trees to create a new stand with young trees of approximately the same age. Stands of different age classes can form a diversity of forest conditions across an area.	**Clearcut:** Harvest of essentially all trees in a stand.	Creates edges and open areas for foraging. Smaller, irregular-shaped units are better for bats than larger blocks. The flush of herbaceous growth following timber removal can provide rich food sources for insects that are eaten by bats. Snags and green or cull reserve trees left standing add value as potential roosts and for other wildlife.
	Shelterwood and seedtree cut: Removes most trees in a stand, leaving only those needed to produce seed and/or provide shade for regenerating a new stand. Overstory trees are sometimes removed after regeneration is established. More trees are left with shelterwood harvests than with seedtree cuts.	Similar to recent clearcuts, these create edges, foraging space, and a food source for insects. Trees left on-site provide some mature forest structure until they are harvested. Value to bats and other wildlife can be greatly increased if adequate snags and green trees are left and if overstory trees are retained through the next harvest.
Uneven-aged management: Individual and small groups of mature trees are harvested, leaving a variety of tree sizes and ages. Uneven-aged management creates small canopy gaps similar to those formed by small-scale natural forest disturbances.	**Group selection:** Small groups of trees removed for regeneration of new age classes; width of cut rarely exceeds twice the height of mature trees. Shade-intolerant tree species can benefit when larger openings are created.	Promotes diverse forest structure, characterized by a patchwork of mature forest for roosting and small- to medium-sized gaps for foraging. Increases in herbaceous vegetation in openings may promote insect prey for bats.
	Single-tree selection: Individual trees of all size classes removed more or less uniformly throughout the stand to increase growth of remaining trees and provide space for regeneration.	Maintains diverse forest structure and roost trees, while creating small gaps and increasing edge for foraging. Promotes some increases in herbaceous vegetation, which can be favorable to production of insect prey for bats.
	Diameter-limit harvesting: Similar to single-tree selection, but only trees above or within a certain diameter class are cut.	Creates small gaps throughout the forest for foraging. Promotes understory vegetation and insect production. Retaining some larger overstory trees will help provide roosting sites.

SITE PREPARATION	
Treatment	**Implications**
Prescribed fire: Prescribed burning for site preparation after harvest is conducted to eliminate undesirable vegetation and increase availability of soil nutrients for tree seedlings.	Increases growth of herbaceous plants that can increase abundance and diversity of insect prey. Care must be taken to prevent losing snags and green-reserve (wildlife) trees left for bat roosting.
Herbicides: Selective herbicides are used to temporarily suppress competing vegetation. Plant response varies depending on the herbicide, time of application, site productivity rate, and forest conditions. Also used to reduce or eliminate invasive plant species.	Herbicides can be useful, often when combined with prescribed fire, for restoring early-succession plant communities and controlling undesirable vegetation. In the southeastern U.S., they have been used to promote the development of herbaceous vegetation, which can increase the abundance of insect prey and open up foraging space for bats in stand interiors by temporarily controlling woody stems.
Mechanical treatments: Shearing, raking, windrowing, ripping, mulching, and bedding are all mechanical methods used to clear debris and prepare soil seedbeds for tree planting.	Increases herbaceous plant growth that can increase the abundance and diversity of insect prey.

TIMBER AND WILDLIFE STAND IMPROVEMENTS	
Treatment	**Implications**
Thinning: Thinning reduces tree density and can remove weak or suppressed trees to open growing space for the remaining trees. Thinning can be used to remove trees from the lower or upper crown level or to increase spacing and growth in forest stands. Can be conducted multiple times and at different intensities depending on the silvicultural system and objectives. Can also be used to reduce risk of wildfire, especially in the Western U.S.	Thinning benefits bats by increasing flight space in a forest stand and increasing sunlight to the forest floor, which increases herbaceous growth for bats' insect prey. In southeastern pine and some other forest types, heavier thinning (e.g., 70 ft^2 per acre of basal area retained [16 m^2 per hectare]) is preferred for wildlife habitat improvement.
Midstory removal/reduction: In mature stands, decreases smaller trees within a stand that are not part of the overstory. Trees less than 6 inches (15 cm) in diameter are typically felled. Ladder fuels are removed, which reduces chances of crown fire. Often used in conjunction with controlled burning as part of wildlife stand improvements.	Provides bats with unobstructed areas below the canopy for foraging. Allows sunlight to reach the forest floor, which promotes herbaceous understory vegetation and insect production. Allows sunlight to reach tree boles that can increase the temperature of roosts under bark or in bole cavities, which benefits juvenile bats during cooler, early spring weather. Reduces clutter around the boles of overstory trees, which may help bats entering and exiting roosts that are under bark or in cavities.
Prescribed fire: Used to reduce forest fuels, reduce competition, decrease the risk of wildfire, and for ecological restoration. Prescribed fire can cause changes in plant community composition, tree densities, stand structure, and soil and hydrological conditions. Most prescribed burns are carried out under moister conditions to reduce the chance of wildfire. In many parts of the U.S., prescribed fire is used to maintain historic or desired forest conditions and improve forest conditions for multiple wildlife species.	Bats may benefit from fire by the creation of new roost trees, which result from direct or indirect tree mortality (via disease, insect or fungal attack). Fire can also decrease forest tree density, reduce midstory clutter, and increase openings, thereby improving foraging space and travel corridors and allowing more light to reach and warm roost trees. Increases insect prey diversity and abundance by increasing herbaceous and shrub growth. Prescribed burning can have short-term negative effects on bats by eliminating some snags and stumps used for roosting. Raked firebreaks can be created around important snags, or the bases sprayed with retardant, to protect them. Prescribed burns and fires occurring when bats are rearing young (May-July) or in deep hibernation (mid-winter) could have negative effects on local populations. In the southeastern U.S., red bats and Seminole bats sometimes hibernate for short periods within the leaf litter and some may be unable to escape burns conducted on very cold days. However, prescribed fire can be planned to avoid times when bats are mostly likely to be roosting in leaf litter.
Forest corridors, leave strips, buffer strips: Includes strips of unmanaged forest between managed stands, windbreaks, shelterbelts and other plantings.	In addition to providing edges for foraging, forest corridors and buffer strips are often used as travel corridors and may provide roost trees.

WATER RESOURCES

When active, all but the most desert-adapted bat species must have daily access to clean water for drinking, especially during lactation and periods of increased activity. Several species will also arouse from hibernation to drink during winter. Some bat species usually roost near or forage over water. Gray bats, little brown bats, Yuma bats, southeastern myotis, and tricolored bats prefer to forage over lakes, rivers, and ponds. Eastern red bats, hoary bats, Indiana bats, and big brown bats are known to use waterways for travel and foraging.

RIPARIAN MANAGEMENT	
Treatment	**Implications**
Riparian management: Maintaining the integrity of riparian zones in managed forests is a critical aspect of good forest stewardship. Forestry Best Management Practices (BMPs) are widely implemented and designed to protect water quality during forest management activities. Vegetation and landscapes associated with water are important for most bat species. Although these features can represent a relatively small proportion of the landscape, they often provide more concentrated sources of shelter, food, and water than drier, upland forests. In coniferous forests, broadleaf deciduous trees are often concentrated in riparian zones, providing roosts for the foliage-roosting bats that prefer them. Riparian areas also provide abundant insect prey for bats.	Riparian areas are one of the highest quality foraging areas available to bats. If compatible with other riparian management objectives, selective harvest that minimizes disturbance can enhance foraging habitat. The width of riparian management zones (retained for water quality) affects understory development within these zones. Narrow zones will allow sunlight penetration and subsequent development of a dense midstory layer that may be unfavorable to bats and other wildlife species. All state forestry agencies have BMPs or standards and guidelines that address local riparian buffer area/stream zone management. However, these guidelines are designed to protect water quality and may recommend narrower streamside zones than would be most beneficial to some wildlife.

Ponds, stream pools, seasonal pools and wetlands, and meadows with pooled water offer important drinking and foraging resources for forest bats. Along with riparian zones, beaver ponds are a valuable aquatic resource, as they provide drinking, roosting, and foraging habitat in close proximity. In forests of the eastern U.S., even temporary water-holding features such as road ruts are often used by bats. Troughs, tanks, and other livestock-watering facilities are often critical watering sites for bats in some forests of the western U.S. and may be an overlooked resource for eastern forest bats. Because bats drink while flying, standing water that contains obstructing vegetation, such as emergent saplings or cattails can prevent bats from drinking; so unobstructed pools are preferable.

Forest-management practices that eliminate or limit access to water or degrade water quality through siltation can negatively affect bats. Forest buffers and adherence to state Best Management Practices (BMPs; careful placement of skid roads, for example) are very effective at protecting water quality at forest ponds, seasonal pools, wet meadows, and bogs. Note, however, that BMPs are designed for water-quality protection, not for creating wildlife habitat per se, so forest landowners may want wider buffers than recommended if the goal is to provide more diverse riparian forests and to mimic mature forest conditions. Landowners can obtain copies of BMPs through their state forestry offices, county cooperative extension offices, and other landowner assistance programs.

Water sources such as stream pools are important sites for bat foraging and drinking. Photo: Phillip N. Jordan

Small woodland ponds can often be created using earthen catchments in locations that capture natural surface runoff, piping water from natural springs, or by excavating small ponds or pot holes. This type of pond can provide high-quality foraging and drinking areas for bats and many other wildlife species when located in a small forest opening. An excellent resource for creating small ponds is listed in the “Sources of

Assistance" section, along with information on obtaining copies of BMPs.

Wildlife ponds, sloughs, wetlands, and vernal pools can be maintained across the landscape for bats and other wildlife.

OTHER RESOURCE NEEDS

Geologic Resources

Several species of bats that roost in trees in spring through autumn spend their winters in caves, mines, and other geologic features, such as cliff-face crevices, rock outcrops, rock shelters, and boulder fields. Some species also use geologic features as roosts during summer. These geologic features are often found within forests.

Dense aggregations of bats, sometimes numbering in the hundreds of thousands or even millions, hibernate, rear young, or night-roost in the small percentage of caves or abandoned mines that provide suitable temperatures. In eastern North America, only a few caves, mines, and cliff crevices are warm enough or able to trap enough bat body heat to be used as summer maternity roosts. Those sites that do can be extremely important to species such as the Virginia big-eared bat and Ozark big-eared bat. Sites used for hibernation in winter must provide cool, stable temperatures while protecting bats from freezing. Because these sites are uncommon, bats may travel hundreds of miles to reach a suitable hibernation site. Sites that do not meet these criteria may still be used by solitary males, colonies of bachelor males, and non-reproductive females as breeding sites, night roosts, or for stopovers during migration.

Bat roosts in caves and mines are easily disturbed or destroyed by human disturbance from commercial and recreational activities or vandalism. All bats naturally arouse periodically during hibernation, but forced arousals due to disturbance can cause them to use their fat reserves that are needed to sustain them throughout winter.

Caves provide critical sites where many bats species hibernate during winter. Some bat species roost year-round in caves and mines. Important bat caves are often gated to prevent disturbance to bats. Photo: Ann Froschauer, U.S. Fish and Wildlife Service

Some bat species roost among the crevices of boulder fields. Photo Virginia McDaniel.

Caves, mines, cliff faces, rock shelters, and talus slopes often provide essential roosts that should be identified and protected. Forests surrounding important caves and mines, which may include an entire watershed, can be carefully managed to avoid negative impacts.

In western areas, many bats roost in talus slopes, rocky areas, or in the crevices of cliffs. Photo Virginia McDaniel.

Timber harvests near caves and mines can be conducted carefully to avoid direct disturbance of roosting bats, causing collapse, or impacting roost environments by changing airflow patterns, sun exposure, humidity, groundwater flow, or by increasing public access.

With properly designed buffers, forest-management activities can be implemented while maintaining the integrity of geologic features. Forest landowners and managers can consult state agencies responsible for managing wildlife and cave resources to determine appropriate mitigation measures. Public education, interpretive signs, closing access roads and trails, fencing, and gating can help reduce roost disturbances. Properly constructed, bat-friendly gates placed across important cave and mine entrances can prevent human entry while allowing most species of bats to enter and exit. However, inappropriate gates may exclude bats, increase predation, or negatively affect airflow and temperature. An excellent resource for planning and constructing bat gates is available on Bat Conservation International's (BCI) website at **www.batcon.org.**

White-nose Syndrome

Although disturbances can be harmful to bats in underground sites, the greatest threat to bats hibernating underground is the disease white-nose syndrome (WNS). This disease is caused by a non-native fungus and has caused the recent death of millions of bats. In 2006, WNS was first detected in a cave in New York State, and it is believed that the fungus was transferred there by human visitors to a cave. These visitors had likely been in caves in Europe or Asia previously, where the fungus is abundant. Since then, WNS has spread across the eastern and central United States and Canada and has been detected at several sites across western regions of North America.

Cisterns, bunkers, old wells, and other man-made structures underground are often used as roost sites by forest bats. Photo: W. Mark Ford.

The fungus that causes WNS grows on bats during winter in their underground hibernation sites and only affects those bats that hibernate in caves, mines, tunnels, or similar structures. Not all species that hibernate in caves and mines are

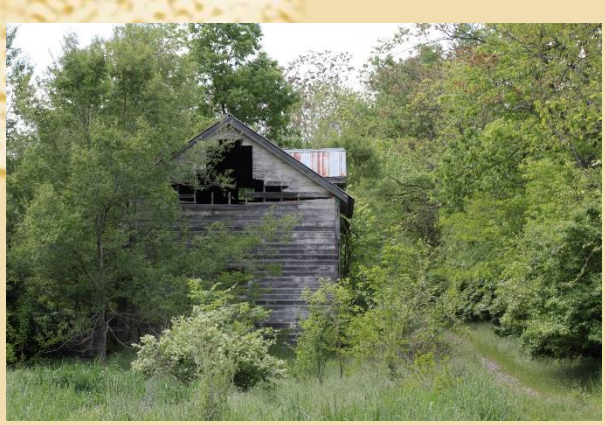
affected equally by WNS, but some species such as northern long-eared bats, little brown bats, and tricolored bats have declined significantly due to WNS. Other bats, such as eastern red bats and hoary bats that do not hibernate in caves or mines are not affected by WNS. In coastal plain areas of the southern U.S., some species such as northern long-eared bats, may not hibernate underground, and these populations may be less at risk. Fungal spores can be spread from one cave or mine to another by people if their equipment and clothing is not decontaminated between sites. For more information on WNS and decontamination of equipment used in caves or mines, visit **whitenosesyndrome.org.**

An Indiana bat suffering from white-nose syndrome while hibernating in a cave. Photo: Phillip N. Jordan.

Artificial Roosts and Other Human Structures

Human-made structures, such as buildings, bridges, culverts, dams, abandoned railroad and highway tunnels, abandoned military bunkers, and old cisterns have become important roost sites for many bat species. These sites may be especially important where natural roosts have been eliminated or where they are naturally in short supply. Because roost availability is a major factor influencing bat survival and population size, artificial roosts and human structures can be important conservation tools, especially where natural roosts are lacking. Artificial roosts are not a substitute for sound habitat management of natural roosts, but they can provide crucial alternatives where natural roosts are scarce.

Expansion joints in bridges and concrete box culverts provide summer roosts for many bats. In southern areas, these sites are also used for hibernation. Photo: National Park Service.



Abandoned buildings in forested areas often provide roost sites for multiple species of bats.

Concrete bridges can provide ideal roosts and sometimes accommodate very large, regionally important bat colonies. Concrete bridges and road culverts in forested environments are often important roosting sites and may attract several species of bats, including big brown bats, tri-colored bats, and Rafinesque big-eared bats. The

best roosts are in concrete bridges with expansion joints that are 10 feet (3 meters) or more above ground and heated by the sun. Concrete box culverts are also important hibernation sites for many species of bats in warmer areas. Bridges and culverts can be retrofitted with simple and inexpensive modifications to create excellent roosting sites for large numbers of bats. These modifications can be incorporated during original construction at little or no additional cost.

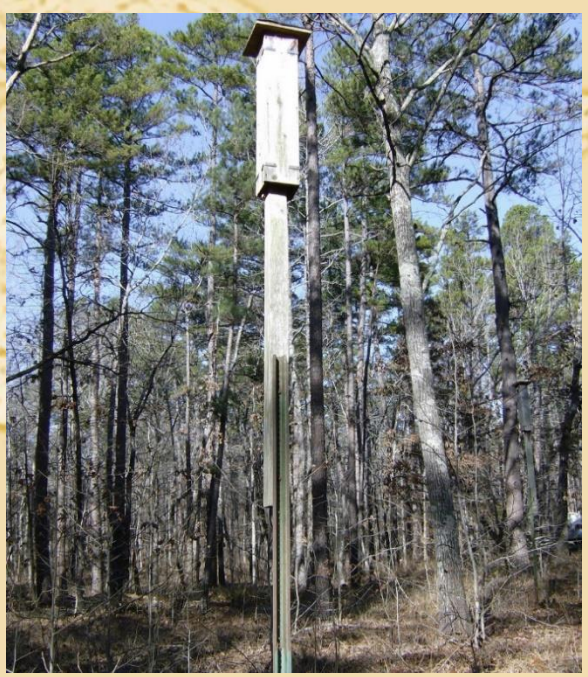
Buildings have become primary roosts for many bats, with at least 20 species known to use them. Big brown bats, Mexican free-tailed bats, and little brown bats have adapted exceptionally well and now appear to rely primarily on human-made structures in some areas. Older and abandoned houses, sheds, barns and other human structures found on forest landscapes often house important bat colonies, including rare and sensitive species. In parts of the southeastern and Pacific northwestern U.S., many of the largest known maternity colonies of big-eared bats have been found roosting in old buildings in forested landscapes. Old buildings that harbor bat colonies can be shored up and stabilized, and bats have on several occasions moved into replacement structures built nearby.

At least a dozen bat species have been reported to use bat houses and other artificial roosts. Use of these roosts by bats continue to increase as designs are tested and improved. The best-occupied bat houses are multi-chambered units at least 24 inches (61 centimeters) tall and with crevices 3⁄4 to 1 inch (19 to 25 millimeters) wide with roughened landing and roosting surfaces. They are painted black in the coolest climates and lighter colors in warmer areas to support appropriate solar heating. Rocket box bat houses are also used extensively by bats.

Bat houses should be mounted at least 12 feet (3.6 meters) off the ground. Bat houses can be placed on the sides of wood or concrete buildings or on poles (not on trees), whereas rocket box houses are slipped over non-treated wood or metal poles. The best locations for bat houses include small openings or edges near streams, rivers, or lakes.

In the southeastern U.S., cinder-block artificial roosts that are 12 feet (3.6 meters) high and 4 feet (1.2 meters) across with openings on the sides and at the base have been built in forested areas to mimic the trunks of the large, hollow gum trees that are characteristic of older bottomland hardwood forests. These roosts have been colonized by both Rafinesque's big-eared bats and southeastern myotis, two species of concern in southeastern forests.

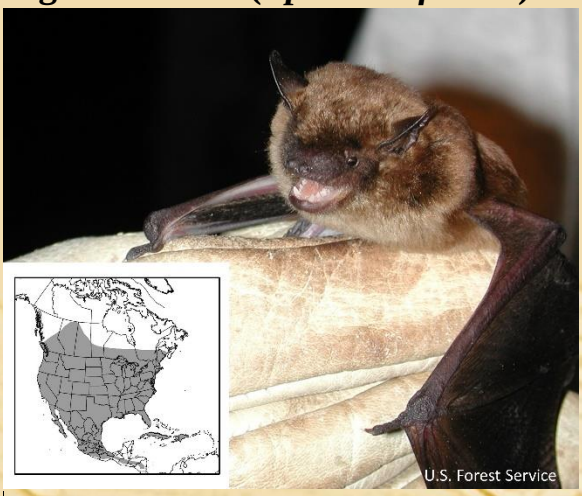
Long-lasting and realistic looking polyresin artificial bark has been successfully used as a substitute for natural, peeling tree bark in many areas. Multiple bat species bat have been reported using these roosts, including endangered Indiana bats. Detailed information on construction and placement of bat houses is available on BCI's website at **www.batcon.org.**



A rocket box-style bat house placed in a forest opening where natural roosts may be limited in supply. In areas subjected to periodic burning, bat houses can be placed on steel posts or metal poles to prevent damage from fires. Photo: Roger W. Perry.

INTRODUCTION TO SOME FOREST BATS

Big Brown Bat (*Eptesicus fuscus*)



The big brown bat is the largest bat in North America that roosts in tree cavities. They weigh from 0.46 to 1.16 ounces (13 to 33 grams). They are copper to chocolate brown in color with a broad, sparsely furred nose. They have a distinct lump on each side of their snout. Found in every U.S. state and most Canadian provinces, it is one of our most commonly encountered bats.

Although still found roosting in trees during the summer, many summer roosts are now in attics, barns, and other human-made structures, including bat houses. Big brown bats hibernate in caves, mines, rock crevices, snags, and buildings. They can survive periods of subfreezing body temperatures, enabling them to occupy a wide variety of winter roosts.

Big brown bats roost and forage in a variety of places, but are most abundant in deciduous forests, often in areas mixed with agriculture. Their diet is heavily dominated by beetles, but they also consume stinkbugs, moths, leafhoppers, flying ants, caddisflies, crickets and katydids. They are an important consumer of agricultural and forest pests. Individuals have been recorded living up to 20 years.

Little Brown Bat (*Myotis lucifugus*)

Little brown bats are relatively small bats and weigh from 0.18 to 0.35 ounces (5 to 10 grams). They vary from pale to chocolate brown.

Summer colonies are found in tree cavities, bat houses, and buildings and can consist of hundreds of individuals, which makes them particularly vulnerable to human-wildlife conflicts. They hibernate in caves and old mines, sometimes migrating hundreds of miles to reach a suitable site. Hibernating populations of 300,000 to 500,000 individuals have been documented in the past, and some abandoned mines held a million or more. Historically, they were one the most abundant species in forested areas of the northeastern U.S., but WNS has caused substantial declines in their numbers across this region.

Mothers give birth to one young (referred to as a pup) each summer. Pups are capable of flight 20 to 27 days after birth. Although most nursery colonies feed over water, non-reproductive little brown bats forage in a variety of places, including stream and forest borders, trails, cliff faces, meadows, farm land, and in nearly every kind of forest. Favored prey include many aquatic insects, such as midges, mayflies, mosquitoes and caddisflies. One little brown bat can capture hundreds of mosquito-sized insects in a single hour. They can live over 34 years in the wild.

Northern Long-Eared Bat (*Myotis septentrionalis*)

About the same size as the little brown bat, the northern long-eared bat can be distinguished by its long, narrow ears, which measure 0.5 to 0.7 inches (14 to 19 mm).

Northern long-eared bats have been affected by WNS more than most other species. Dramatic declines have occurred across most of their range and in many areas where they were once abundant they can no longer be found. Because of WNS, this species was recently listed as federally threatened under the U.S. Endangered Species Act.

In the fall, the northern long-eared bat is commonly encountered at cave and mine entrances, where some hibernate. However, large numbers have been reported entering caves in March, leading to the suspicion that some may hibernate outside, perhaps in rock crevices and road cuts. Their habit of squeezing into small crevices in caves and mines makes them difficult to observe and document. In the Coastal Plain of the Southeastern U.S., some northern long-eared bats overwinter in trees and snags in bottomland hardwood and upland pine forests, and they have also been found in road culverts. In summer, females congregate in groups of 3 to 60 individuals at maternity roosts in cavities and under bark of live trees and snags, from less than 5 inches diameter (12 cm) to the largest trees in the forest. Nursery colonies have occasionally been found in attics, behind wooden window shutters, beneath wooden shingles and in bat houses.

Northern long-eared bats are relatively slow flyers that are adapted to hunting in cluttered environments, where they often pick insects directly off foliage. These bats seem to prefer feeding beneath the canopy level, often 3 to 10 feet (1 to 3 meters) above ground along forested hillsides, ridges, and especially over small pools beneath the forest canopy. They consume beetles, flies, midges, mosquitoes, caddisflies, moths, leafhoppers, and spiders.

Evening Bat (*Nycticeius humeralis*)

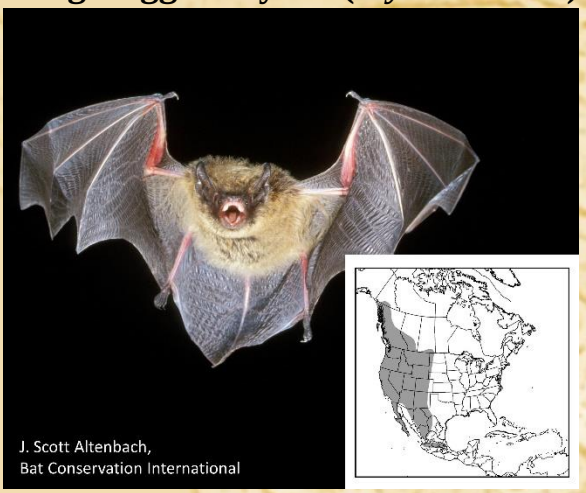
The evening bat is dark brown with black wings and ears. A medium-sized bat, it resembles a smaller version of the big brown bat and weighs 0.28 to 0.56 ounces (8 to 16 grams). Evening bats are found from the east coast of the U.S. to eastern Nebraska and south through eastern Texas to northern Mexico. Evening bats in the northern part of their range are believed to migrate southward in the fall where they remain active through winter, roosting in cavities and under bark of live trees and snags.

Females give birth to two or sometimes three pups, which are capable of flight within 20 days of birth. In addition to roosts in tree crevices and under loose bark, evening bats roost in cavities created where the tops of live pine trees fork, in buildings, and in bat houses. They are often abundant in urban areas where they roost in attics and old buildings. A maternity colony of over 400

individuals was recorded under the bark of one dead pine tree.

Evening bats prefer to forage along edges of mature forests, in clearings and over waterways. A colony of 300 evening bats consumes an estimated 6.3 million insects per summer, typically feeding heavily on spotted cucumber beetles, a costly crop pest to vine plants and corn crops. The evening bat appears to have a relatively short life span, perhaps only a few years.

Long-Legged Myotis (*Myotis volans*)



Long-legged myotis are dark brown with relatively short ears. They are similar in size to little brown bats, weighing 0.18 to 0.35 ounces (5 to 10 grams). Their fur is long and dense, extending along the underside of the wing from the body to a line joining the elbow and the knees. Its range stretches across western North America from southeastern Alaska, British Columbia and Alberta in Canada to Baja California and central Mexico and eastward through the Great Plains and Texas. It lives primarily in coniferous forests, but also occurs seasonally in riparian areas and deserts.

The long-legged myotis primarily roosts under loose tree bark and in tree cavities, but has also been found in abandoned buildings, cracks in the ground, and cliff crevices. It will sometimes hibernate in caves and old mines. It is a rapid, direct flyer and often travels considerable distances while foraging. It feeds in and around the forest canopy, primarily on moths and other soft-bodied insects. Life spans of more than 21 years have been reported.

Silver-Haired Bat (*Lasionycteris noctivagans*)

The silver-haired bat has black or dark brown fur with silver tips. Unlike the red or hoary bat, it has no contrasting markings on the wrists and shoulders. They are medium-sized, weighing from 0.25 to 0.60 ounces (7 to 17 grams). Silver-haired bats are one the most abundant forest bats in northern parts of North America.

Most of these bats overwinter in the southern third of the United States and return north in the spring. They may remain year-round in areas of relatively mild coastal climate, such as coastal British Columbia, Alaska, and the coastal mid-Atlantic. Winter roosting sites include small tree hollows, loose tree bark, woodpiles, cliff-face crevices, holes in the ground, cave entrances, and occasionally buildings.

Silver-haired bats are slow, highly maneuverable flyers that typically feed in areas sheltered by vegetation, over streams or ponds, along roadsides, and in or near coniferous or mixed coniferous and deciduous forests. They feed on flies, midges, leafhoppers, moths, mosquitoes, beetles, true bugs and flying ants. Silver-haired bats can live to at least 12 years.

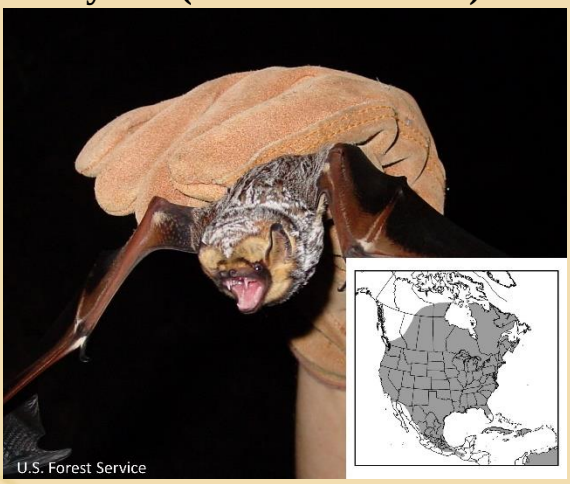
Eastern Red Bat (*Lasiurus borealis*)

Eastern red bats have a reddish-orange coat with white-tipped hairs that give it a frosty appearance and always has white patches of fur on the shoulders and wrists. They are mediums sized and weigh from 0.21 to 0.78 ounces (6 to 22 grams). It is one of the most abundant bats in many parts of its range, but appears to be in decline. Red bats and hoary bats are two species that are most-often killed during migration by turbines at wind farms.

Red bats roost in the foliage of a variety of deciduous trees. Hanging by one foot, wrapped in their furred tail membranes, they are well concealed and resemble dead leaves. They roost alone or in family groups consisting of a mother and her pups, although they form groups for migrating to milder regions where they overwinter. Males and females are thought to migrate in separate groups and may travel with other bat species.

The average litter size is three pups, but a female may have as many as five. In the southeastern and south-central United States, red bats are known to overwinter in deciduous trees that retain leaves, and eastern redcedar, but sometimes move to grass clumps and leaf litter on the forest floor during the coldest parts of winter. They forage in a variety of places, mostly along the edges of pastures, croplands, forest roads, small forest streams, and openings dotted with large deciduous trees. Red bats eat mostly moths, but also feed on beetles, planthoppers, leafhoppers and spittlebugs.

Hoary Bat (*Lasiurus cinereus*)



Hoary bats are larger than big brown bats and weigh 0.74 to 1.48 ounces (21 to 42 grams). They have mahogany-colored fur tipped with white, which gives them a hoary (frosted) appearance. They have a distinctive, yellowish-brown collar under the chin and yellowish ears with black edges. They occupy the widest range and variety of landscapes of any North American bat, from Argentina to Canada. Hoary bats roost in the foliage of pine- and pine-hardwood forests of the eastern United States, and in deserts and ponderosa pine forests of the Southwest. They are most abundant in mixed deciduous forests and croplands of the Great Plains and in coniferous forests of northern areas.

The hoary bat roosts alone or in family groups consisting of a mother and her young, except during migration. These bats are seldom seen. In winter, a few have been found in Spanish moss, squirrel nests, woodpecker holes, and on tree trunks. During summer, they prefer rooting along edges or in open forests close to foraging areas. Hoary bats hunt relatively large insects, mostly moths, in open areas, meadows, over streams and rivers, or above the forest canopy. They are highly territorial and return to the same feeding sites each night. From August through October, hundreds of hoary bats may migrate together. In the U.S., most hoary bats apparently overwinter in coastal areas. These bats are believed to live 6 to 7 years. Hoary bats are the bat most often killed at wind turbine farms, which occurs during their migration in spring and fall.

Tricolored Bat (*Perimyotis subflavus*)

The tricolored bat is one of the smallest bats in the North America and weigh 0.14 to 0.28 ounces (4 to 8 grams). Its fur color is typically blonde, but ranges from pale yellow to a gray brown.

Tricolored bats range from southern Canada to Mexico and from Texas to Minnesota eastward. Their range includes eastern Mexico, Central America, and the Yucatan peninsula. During summer, females roost alone with their pups or in small maternity colonies, but males roost alone. In forested areas, they typically roost in dead leaves suspended in the canopies of deciduous trees, especially oaks. They will also roost in dead pine needles suspended in branches and the bole of large pine trees, in Spanish moss, and within lichens suspended in tree canopies. Tricolored bats also roost in caves, abandoned mines, old houses, sheds, barns, wells, road culverts, and other manmade structures during summer.

During winter, tricolored bats usually hibernate alone and not in clusters like most cave-hibernating species. They are typically found scattered around on the walls of caves, mines, tunnels, and road culverts with a few feet between each individual. Populations of tricolored bats have been especially reduced by WNS and some sites that previously held hundreds of hibernating bats now contain only a few individuals.

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

Rafinesque's big-eared bats are grayish-brown with very long ears (1 to 1.5 inches or 25 to 38 mm), white bellies, and large facial glands on each side of their snout.

They are non-migratory. In coastal plain regions of the Southeast, they usually roost in large hollow trees in mature lowland pine and hardwood forests. They are often found in cypress-gum stands near water or sometimes in upland oak-hickory. Because bottomland hardwood forests have been greatly reduced, mostly due to conversion to agriculture, many colonies now roost under concrete bridges or in abandoned buildings that are prone to human disturbance and structural collapse. Artificial roosts may be required to provide alternatives in areas where natural roosts have been lost. In southern areas, most appear to remain active year-round, except during the coldest periods.

Outside of the coastal plain in summer, this species is often found in sandstone rock shelters along cliff lines, in small caves, and abandoned buildings. They hibernate in caves, abandoned mines, wells and old cisterns, either singly or in clusters. They are very agile flyers, capable of picking insects off foliage. They often forage within three feet (1 meter) of the ground. Moths are their most common prey, but other insects, including horseflies, are also taken.

SOURCES OF ASSISTANCE

A variety of federal, state, private and nonprofit organizations can provide landowners with financial and technical assistance to manage or improve forests for fish and wildlife. Many state wildlife and conservation agencies employ private lands biologists to work with landowners to improve wildlife habitat on their lands. The following is a partial list of agencies or organizations with programs specifically tailored to forestry and wildlife conservation.

Government Agencies

U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS): Since 1935, the Natural Resources Conservation Service (originally called the Soil Conservation Service) has provided leadership in a partnership effort to help private-land owners and managers in the U.S. conserve their soil, water and other natural resources. NRCS employees provide technical assistance based on sound science and suited to each landowner's specific needs. NRCS provides financial assistance for many conservation activities. Participation is voluntary. **https://www.nrcs.usda.gov/wps/portal/nrcs/site/national/home/**

U.S. Department of Agriculture, Forest Service: The Forest Service was established in 1905 to sustain the health, diversity, and productivity of the nation's forests and grasslands for present and future generations. The mission of the Forest Service is to achieve quality land management under the sustainable, multiple-use management concept to meet the diverse needs of people. The Forest Service provides technical and financial assistance to state and private forest agencies and landowners, encouraging them to practice good stewardship and quality land management to meet their specific objectives. **https://www.fs.fed.us/**

U.S. Department of Interior, U.S. Fish and Wildlife Service: The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The U.S. Fish and Wildlife Service is responsible for protecting and recovering threatened and endangered species, as well as managing and protecting migratory birds. **https://www.fws.gov/**

Non-Government Organizations

The American Tree Farm System (ATFS): The ATFS certifies owners of tree farms and NIPF lands in the United States that maintain strict sustainable forestry-management practices. Certification requires that landowners pass an inspection every five years. In addition to producing timber, landowners must protect watershed quality, wildlife habitat and soil and provide recreational opportunities. For information, see the American Forest Foundation's website at **https://www.forestfoundation.org/.**

Forest Landowners Association (FLA): Founded in 1941, FLA is the national representative for the economic interests of family forest landowners and their natural resource assets. FLA's goal is preserving America's tradition of private forest ownership, promoting the importance of forest resources, and securing a legacy that can be passed to future generations. **https://www.forestlandowners.com/**

Longleaf Alliance (LLA): LLA was established in 1995 to coordinate a partnership between private-land owners, forest industries, state and federal agencies, conservation groups, researchers and others interested in managing and restoring longleaf pine forests for their ecological and economic benefits. The LLA provides information on restoring and managing longleaf pine forests for timber and wildlife in the southeastern U.S. **https://longleafalliance.org/**

Sustainable Forestry Initiative® (SFI): A comprehensive system of principles, objectives and performance measures developed by professional foresters, conservationists and scientists that combines perpetual growing and harvesting of trees with the long-term protection of wildlife, plants, soil and water quality. The SFI Program is overseen by the Sustainable Forestry Board (SFB), an independent 501(c)3 organization, which is responsible for maintaining and enhancing the SFI standard and verification procedures. **https://www.sfiprogram.org/**

Forest Stewardship Council (FSC): FSC is an international network that promotes responsible management of the world's forests. FSC brings people together to find solutions to problems created by poor forestry practices and to reward good forest management. Landowners and companies that sell timber or forest products seek certification as a way to verify to consumers that they have practiced forestry consistent with FSC standards. Independent certification organizations are accredited by FSC to carry out assessments of forest management to determine if standards have been met. **https://fsc.org/en**

Helpful guides

The Decayed Wood Advisor (DecAID): DecAID is a tool to help you manage snags, down wood and partially dead trees for biodiversity. The online advisor can help you to determine how much and what size of decayed wood to leave, what matches general "unharvested" conditions, and what insects and pathogens create dead wood. It also provides a synthesis of literature and statistics on wildlife use and an inventory of snags and down wood.
https://apps.fs.usda.gov/r6_decaid/views/index.html

A Guide to Creating Vernal Ponds: Biebighauser, Thomas R. 2003. USDA Forest Service, 33 pages. Information for building and maintaining an ephemeral wetland.
https://www.nyfoa.org/application/files/3514/7948/6007/GuidetoCreateVernPonds.pdf

For detailed information about bat species, habitat and conservation needs of bats, forest management, upcoming conferences, workshop opportunities, recent research and much more, visit Bat Conservation International online at: **www.batcon.org**

WHITE-NOSE SYNDROME
RESPONSE TEAM