

# Managing Forests for Fish and Wildlife

December 2002

Fish and Wildlife Habitat Management Leaflet

Number 18



U.S. Forest Service, Southern Research Station

Forested areas can be managed with a wide variety of objectives, ranging from allowing natural processes to dictate long-term condition without active management of any kind, to maximizing production of wood products on the shortest rotations possible. The primary purpose of this document is to show how fish and wildlife habitat management can be effectively integrated into the management of forestlands that are subject to periodic timber harvest activities. For forestlands that are not managed for production of timber or other forest products, many of the principles in this leaflet also apply.

## Introduction

Forests in North America provide a wide variety of important natural resource functions. Although commercial forests may be best known for production of pulp, lumber, and other wood products, they also supply valuable fish and wildlife habitat, recreational opportunities, water quality protection, and other natural resource benefits. In approximately two-thirds of the forest land (land that is at least 10% tree-covered) in the United States, harvest of wood products plays an integral role in how these lands are managed. Sustainable forest management applies biological, economic, and social principles to forest regeneration, management, and conservation to meet the specific goals of landowners or managers.

Much of the forest land in the western U.S. is managed by public agencies, whereas most eastern forests are privately owned or under a combination of private/public ownership. National forests cover only 19% of forested land in the United States. Non-industrial private landowners own 59% of the forested land in the U.S., making private lands management critically important to the welfare of the fish and wildlife communities associated with forested landscapes.

## Succession of Forest Vegetation

In order to meet both timber production and wildlife management goals, landowners and managers need to understand how forest vegetation responds following timber management, or silvicultural prescriptions, or other disturbances. Forest vegetation typically progresses from one plant community to another over time. This forest succession can be described in four stages:



*Forests produce a variety of tangible and intangible “products.”*

### 1) Stand initiation

- Begins when grasses, forbs, tree seedlings, and shrubs become established in an open space created by natural (flood, tornado, fire, etc.) or artificial (timber harvest, land clearing) disturbances.

### 2) Stem exclusion

- Sapling and pole-size trees compete for light, growing space, and nutrients.

### 3) Understory reinitiation

- Many trees die due to overcrowding, disease, insect blights, or other causes.
- New vacancies allow young plants to grow in understory gaps.
- Saw-timber and mature forest structure are characteristic of this stage.

### 4) Old-growth

- Old-growth forests generally contain large and overmature trees, snags and downed logs, and a developed but patchy understory.

Regeneration occurs when disturbance creates new space, and forest succession begins again.

Wildlife habitat conditions shift in response to changes in stand age, structure, size, and species composition. As a result, the assemblage of wildlife species inhabiting the forest typically shifts as the stand moves



U.S. Forest Service

*Only five weeks after the Fish Day Fire in Croatan National Forest, stand initiation began with ferns and other herbaceous vegetation.*



USDA, NRCS

*Forested wetlands provide food and cover for many species of wildlife.*

through each successional stage. Birds and other wildlife frequently play an important role in the dispersal of heavy-seeded and fleshy-fruited tree species, contributing to the re-establishment of trees in disturbed areas.

## Forest Wildlife Habitat Requirements

Forest structure affects habitat quality for many wildlife species. Tree density, canopy height, percent canopy closure, and the number of standing and fallen dead trees are some key structural features that affect habitat quality. Each wildlife species responds differently to changes in forest structure. Whereas general habitat requirements are discussed in this leaflet, specific habitat management practices for particular wildlife species may be obtained from other sources (see Hoover and Wills 1984, DeGraaf et al. 1992, USDA Forester Service 2001).

Some wildlife species are dependent on a particular forest type or successional stage. Kirtland's warbler is an extreme example of a habitat specialist, inhabiting

only extensive stands of jack pine (a fire-dependent species) six to 20 feet tall with low ground cover. These habitat conditions occur where frequent fire keeps the forest in early successional stages. The fire also releases jack pine seeds from mature cones, which allows regeneration of new trees. The warblers nest only in young trees and abandon stands that exceed a certain height.

### **Food**

Wildlife food availability depends on the forest successional stage, season, local climate, and other factors. The stand initiation stage produces seeds and soft mast (berries and fleshy fruits) that are important wildlife foods. Tree seedlings and shrubs such as sumac, juniper, blueberry, hazelnut, elderberry and blackberry, and herbaceous forbs, legumes, and grasses provide food for songbirds and small mammals. The buds, twigs, and leaves of woody plants are browsed by deer, elk, moose, rabbits, hares and grouse, and also provide food for the insect prey of birds, bats and other wildlife.

As the forest progresses through successional stages, wildlife responds to the variety of food types available. Birds and mammals associated with stem exclusion, understory reinitiation, and old-growth stages use both hard mast (nuts and seeds) and soft mast of aspen, cedar, birch, cherry, oak, hickory, maple, pine, and beech trees.



C. Rewa

***Viburnums and other fruit-producing shrubs are important wildlife food sources in early successional forests.***



***The rose-breasted grosbeak is found in open deciduous woodlands and forest edges of the northeastern and mid-western United States.***

Food quantity often varies seasonally, and careful forest management can help ensure its availability year-round. For example, thinning that preserves mast-producing trees and shrubs can help sustain songbirds, deer, black bear, wild turkey, and small mammals through the winter months. Landowners and managers should understand the seasonal changes in food availability for the wildlife species of concern.

### **Cover**

Cover refers to physical features that provide animals with shelter from weather, resting places, or concealment from predators. Wildlife uses a variety of cover types depending on season and local climate. Grass-forb vegetation in the stand initiation stage provides ground cover for game birds such as ruffed grouse and woodcock, and for small mammals like voles, mice, and shrews. Many wildlife species benefit from canopy cover. In northern regions, closed, dense canopies of conifers in the understory provide thermal cover for deer (“deeryards”) and other species during winter months.

Snags (standing dead trees) supply foraging sites for woodpeckers and cavities for nesting and resting birds and denning mammals. Fifty-five species of cavity nesting birds in North America use snags, as do nearly half of North America’s 45 bat species. Invertebrates in dead wood are a rich food source. Bats roost in cavities and under the sloughing bark. Bald eagles, goshawks, spotted owls, pine martens, flying squirrels,

tree voles, red-backed voles, and some bat species prefer cover provided by old-growth woodlands. Dead trees, limbs, and litter on the forest floor provide cover and invertebrate foods for woodpeckers and other wildlife.

### Water

Wildlife water requirements vary by species. Water is obtained from plant and animal foods consumed, as well as from free water in ponds, lakes, streams, and wetlands.

### Timber Harvest Management

Even-aged and uneven-aged forest management are two common silvicultural systems used to produce timber. Harvest and regeneration methods define each approach. In even-aged stands, most trees belong to one age class. Uneven-aged stands have trees of three or more age classes that are mixed, or in small groups. Combinations of even- and uneven-aged systems can be used in an area to enhance wildlife habitat and timber production. Table 1 presents basic characteristics of timber harvest management systems.

One potential result of timber harvest and regeneration practices is a high level of human activity, including construction and frequent use of logging roads and skid trails. Comprehensive timberland management includes measures to limit disturbance, soil erosion, and discharge of sediments and pollutants into waterways.



U.S. Forest Service

*Snags are standing dead or dying trees that provide nesting sites for cavity nesting species and roosting and foraging sites for raptors, bats, and other wildlife.*

Nonpoint source pollution degrades stream water quality, impacting aquatic life. In 1981, the Forestry Nonpoint Source Pollution Technical Task Force developed Best Management Practices, or BMPs, to minimize nonpoint source pollution, such as sedimentation and pollution of waterways caused by timber harvest and other land use activities. BMPs were recently revised to include considerations for nonpoint source pollution abatement in wetlands. Forest management BMPs include:

- Permanent and temporary access roads should follow land contours and minimum grade

**Table 1. Characteristics of even-aged and uneven-aged harvest methods.**

	Even-aged	Uneven-aged
Harvest method	Clearcut, shelterwood, and seed-tree.	Single-tree and group selection.
Tree type	Shade-intolerant.	Shade-tolerant.
Stand appearance	Uniform tree height within stands.	Variation in tree height. If group selection used on groups larger than 0.4 hectares, appears similar to even-aged stands.
Forest appearance	Patchwork of stands at various ages.	Uniformly mixed tree sizes.
Wildlife use	Species adapted to early and mid-successional stages and mature forest conditions, depending on stand age.	Species adapted to mature forests as well as early and mid-successional conditions.

guidelines.

- Water control structures should be installed on roads with highly erosive soils.
- Landowners should limit the number, width, and length of access roads, especially at stream crossings.
- Road construction should take place under dry conditions
- Dips, water bars, and water turnouts should be installed on roads to provide proper surface drainage on roadways.
- Hay bales, rocks, or silt fences should be strategically placed to help prevent sedimentation.
- Wildlife-friendly vegetation should be planted to stabilize exposed soil and supply wildlife food and cover.

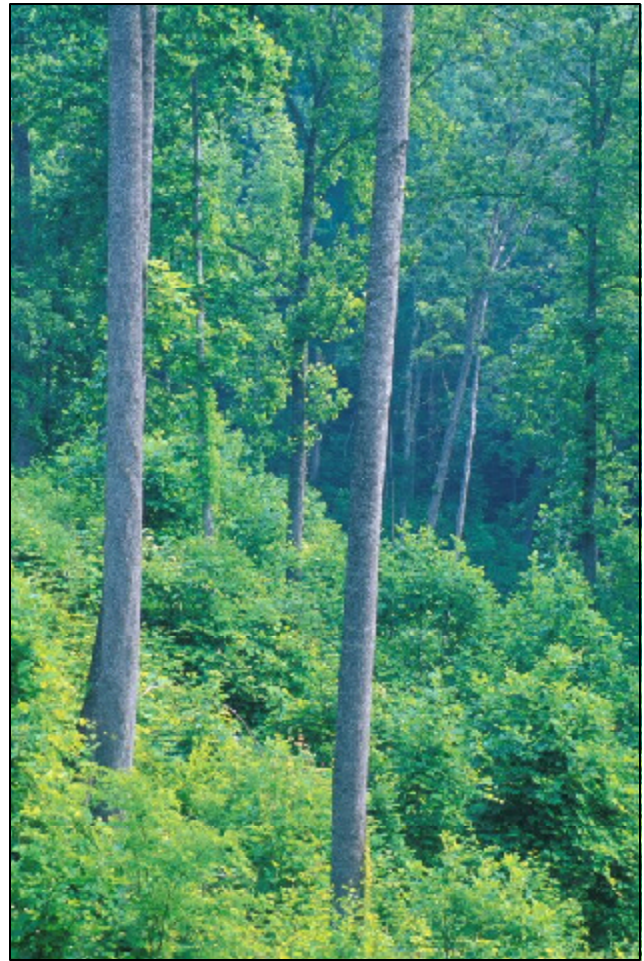
In general, landowner compliance with voluntary BMPs is high. BMP specifications for timber harvest and road construction vary from state to state. Some states enforce BMPs while others rely on voluntary compliance. Landowners should contact their state forest management agencies for specific information on local BMPs.

### ***Even-aged management***

Under even-aged management systems, most of the trees within the stand are approximately the same age. Small stands of different age classes can form a diverse assemblage of wildlife habitats. Even-aged timber stand management often begins with the complete, or



*Moose forage on lush vegetation in clearcut areas.*



Southern Research Station, U.S. Forest Service

*The shelterwood cut in this southern mixed forest leaves mature trees on-site to produce seed and maintain some mature habitat structure for woodpeckers and other wildlife.*

nearly complete, removal of existing timber. Clearcutting removes all marketable trees, dramatically changing the composition of wildlife in the area. Usually, mature forest flora and fauna are replaced by early successional species. Small clearcuts (1 to 15 acres) are generally more beneficial to wildlife than larger clearcuts. The flush of herbaceous growth in clearcut areas lasts for several years and provides big game animals such as white-tailed deer, elk, and moose with nutritious browse, and early successional birds and small mammals with food and cover. The shrub layer succeeds the grasses and forbs and supports “thicket” species like the yellow-breasted chat, willow flycatcher, mourning warbler, and many small mammals. Herbaceous growth and shrubs also provide rich sources of food for lepidopteran larvae and other insects that are preyed on by foraging bats. The size,



U.S. Forest Service

*Even-aged timber harvests in Deer Lodge National Forest.*

shape, and location of clearcuts affects the wildlife habitat quality (see discussion on edge habitat below) and the species associated with clearcut and surrounding areas. Clearcuts with irregularly shaped boundaries have more edge than clearcuts with linear boundaries. Snags, den trees, and mast-producing trees left standing can add wildlife habitat value to clearcut areas.

Both shelterwood and seed-tree cuts leave some mature trees on-site as seed sources to help establish new stands. These treatments help conserve some mature forest structure required by forest birds like nuthatches and woodpeckers. Nuts and seeds produced by the mature trees also provide a source of wildlife food during the fall and winter months. Forests that contain several successional stages of even-aged stands can provide quality wildlife habitat.

Plantations are stands of trees that are established by planting or artificial seeding. Although single species plantations seem dependable timber producers, they can require intensive management at considerable expense. Insect blights, disease, high winds, and other natural disturbances can destroy susceptible trees. Conifers such as ponderosa pine, red pine, loblolly pine, slash pine, and longleaf pine are often used in



U.S. Forest Service

*Eastern even-aged pine monocultures typically provide limited wildlife habitat quality due to the lack of plant diversity.*

plantations because they are fire-resistant and produce marketable timber in short rotations.

Tree species with serotinous cones (species like lodgepole, jack, and sand pine) usually regenerate successfully following burning of clearcut areas. Serotinous cones remain tightly closed until extremely high temperatures, or fire, causes the resin to melt and the cones to open, releasing the seeds. The open ground created in burned areas provides suitable sites for seeds to germinate.



*The Swainson's thrush nests in low-growing shrubs or just above the ground in conifers, especially in damp areas, including riparian buffer zones excluded from timber harvest.*

**Even-aged harvest and regeneration practices:**

**Clearcut.**—Removal of all trees in a stand; reserve trees may be left to accomplish management objectives other than regeneration.

**Shelterwood cut.**—Removal of most trees in a stand, but leaving enough trees to provide shade for the regenerating age class; trees can be cut in groups, strips, or in a uniform manner to reduce competition for regeneration.

**Seed-tree cut.**—Removing all trees except for a small number of widely distributed trees for seed production; seed trees usually removed after regeneration is established.

In even-aged systems, the rotation is the period between regeneration establishment and final cutting.

**Uneven-aged harvest and regeneration practices:**

**Single-tree selection cut.**—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.

**Group selection cut.**—Small groups of trees removed for regeneration of new age classes; width of cut rarely exceeds twice the height of the mature trees.

In uneven-aged systems, the cutting cycle is the interval between partial harvests.

***Uneven-aged management***

Under uneven-aged systems the age of the trees within the stand varies greatly. Unevenaged forests can produce quality timber while providing largely continuous canopy cover. Single-tree and group selection cuts maintain mixed age classes within one stand. The high percentage of canopy closure (often 70% or greater) can limit herbaceous ground cover, and wildlife species associated with those vegetation types. Although mid-story levels may develop, brushy ground cover required by some wildlife species can be limited or altogether missing. Some wildlife species benefit from the continuous forest cover associated with uneven-aged systems (e.g., some forest interior birds), but others do not.

The single-tree selection method removes designated trees from one or more age classes every five to 30 years, depending on stand density and growth rates. The harvest of individual trees at periodic intervals creates space for adjacent tree crowns to expand. Sin-

gle-tree and group selection methods create small canopy gaps, which are similar to gaps formed by natural forest disturbances. Group selection treatments remove groups of trees from one or more age classes. Moderately shade-intolerant species can benefit from this harvesting method because larger openings are created. In the Midwest, forest interior birds like the hooded warbler and Kentucky warbler take advantage of canopy gaps for food and cover.

**Improving Fish and Wildlife Habitat with Forest Management Practices**

Successful forest management for wildlife requires an understanding of how specific timber management treatments affect the targeted fish and wildlife species. Characteristics of effective management strategies include:

- A thorough inventory and description of forest management areas, including vegetation species composition and age structure.
- An understanding of how the managed area fits

into the surrounding landscape.

- Clearly defined timber management objectives for the management area.
- Clearly defined fish and wildlife management objectives for the management area, such as managing target species or increasing biodiversity.
- A thorough evaluation of the quality and quantity of habitat available for the targeted species.
- Continuous evaluation and modification of timber stand treatments and other management practices.

### Regeneration

Regeneration establishes new growth in an open space created by natural or artificial disturbance. Stands can be regenerated artificially using mechanical treatments, prescribed burning, herbicide applications and planting tree seeds, seedlings or cuttings. Stands can also be regenerated by relying on germination of existing seeds and sprouting of stumps. Regeneration of native trees and shrubs provide food and cover for many wildlife species.

### Thinning

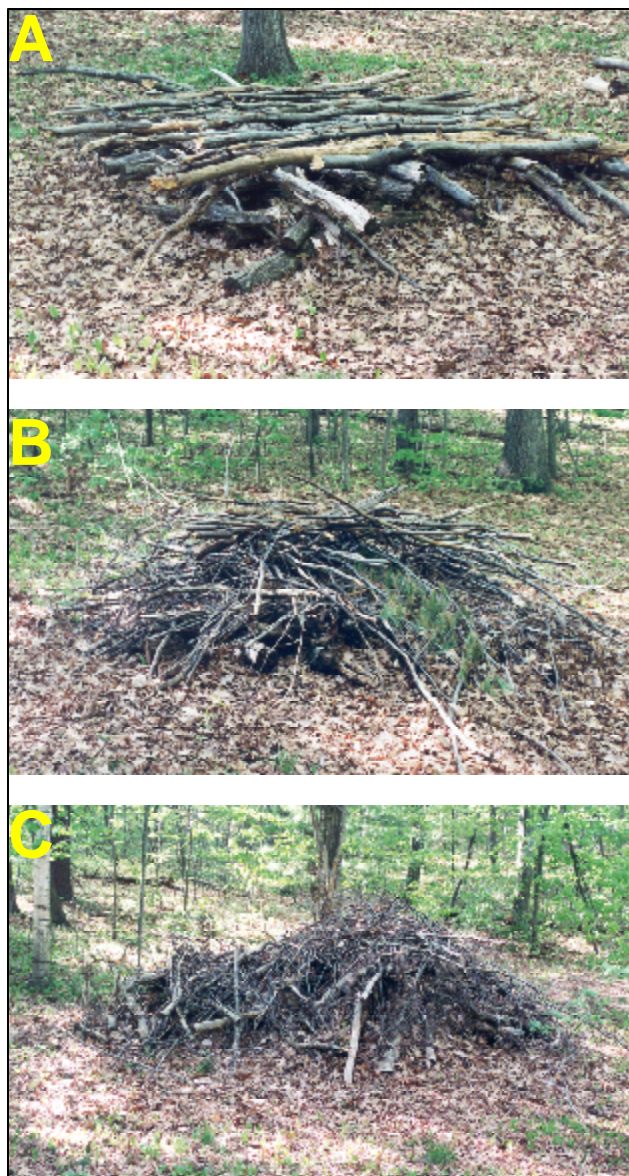
Thinning removes weak or suppressed trees and opens growing space for the remaining healthy trees. Periodic thinning treatments help reduce the risk of insect infestations, disease, and catastrophic fires. The timing and intensity of thinning regimes is as important as selecting which trees to remove. Thinning works best as part of a comprehensive forest management plan. There are four common methods used to select individual trees for thinning:

- **Low thinning** removes trees from lower crown levels to enhance upper crown level growth; soft mast, seeds, and grasses typically increase after low thinning.
- **Crown thinning** removes trees from the mid- to upper crown classes to favor growth of larger trees.
- **Selection thinning** harvests trees from upper crown levels and promotes growth in lower canopies of uneven-aged stands.
- **Free thinning** removes trees with no preference to crown level, but cutting patterns are used to improve growth.

Thinning can improve wildlife habitat by stimulating new growth in the understory and improving mast production by overstory trees, and by increasing flight space under the canopy for foraging bats and forest raptors.

### Brush piles

Small mammals, amphibians, reptiles and other wildlife of the forest floor use brush piles for escape, resting and nesting cover. Effective brush piles are built on a base of coarse materials so openings are available at ground level for wildlife movement. A few piles of



Brush piles should be constructed with heavy material at the base (A) with increasingly finer material on top (B and C) to provide cover for small mammals, reptiles and other wildlife.

C. Rewa



large rocks at least 12 inches wide and 2 feet tall, and several crisscrossed logs at least 6 feet long and 6 inches in diameter make good brush pile bases. Stumps can also make good bases. Progressively smaller limbs and brush are piled onto the base until the brush pile is about 6 feet tall. Living brush piles can be made by partially cutting small trees near the base and pushing them to the ground using the bark left intact at the base as a hinge. The partial severing of the tree allows it to remain alive, providing dense live foliage near the ground.

**Prescribed fire**

Fire is a natural disturbance element of many native ecosystems. However, fire suppression efforts have largely eliminated the regular occurrence of fire from many forested areas. Prescribed fire can be an economically and ecologically beneficial forest management tool when applied properly. Prescribed burning is conducted to achieve specific management goals such as increasing timber production, eliminating undesirable vegetation, improving wildlife habitat, or reducing fire hazards. Fire type, frequency, and intensity are three important factors to consider when planning a prescribed burn. Most prescribed fires are carried out under cool, moist conditions to reduce the chance of wildfire. With careful planning and consultation with the proper authorities, prescribed fire can be an indispensable element of forest management for wildlife.



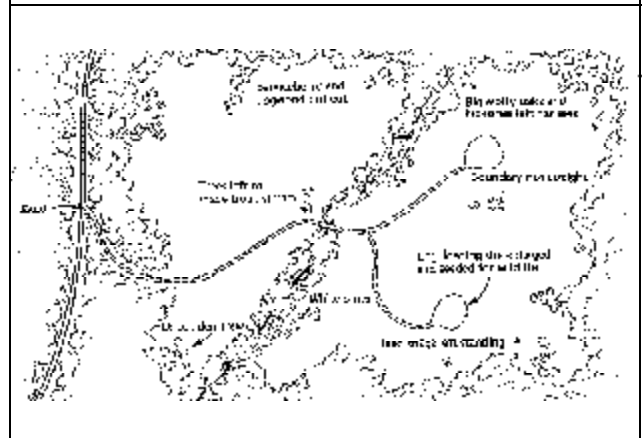
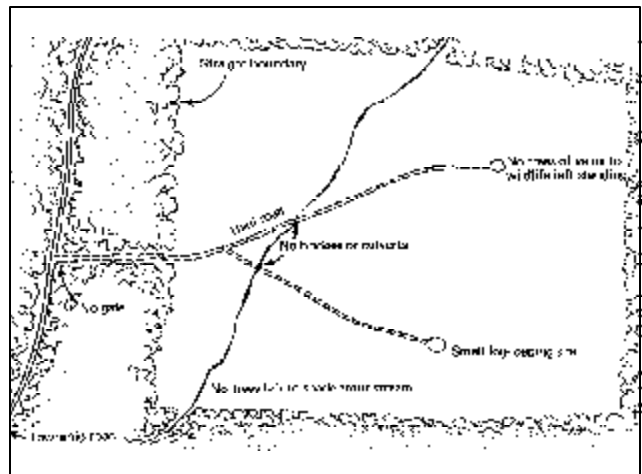
Southern Research Station, U.S. Forest Service

*Prescribed burns that simulate natural fire regimes can stimulate new herbaceous growth that benefits deer, turkeys, and other wildlife.*

Studies show that most wildlife escapes direct mortality from fire. For many wildlife species, habitat quality is improved by fire, especially for species adapted to early successional vegetation. Surface fires stimulate new herbaceous growth used by deer, elk, moose and other herbivores, and enhance production of berries used by black bears, songbirds and other wildlife. Small mammal populations generally increase in response to new vegetation growth, providing a food source for carnivores. Studies have shown that populations of wild turkeys, northern bobwhites and Bachman’s sparrows increased after prescribed fires in forests of the southeastern United States.

**Edge habitat**

Edge is the boundary where two different plant communities meet. There is generally diverse



*Top: Clearcut timber harvest without considerations for wildlife. Bottom: Clearcut timber harvest that takes into account the needs of wildlife associated with edge habitats. From Hassinger et al. (1981).*

vegetation associated with edge habitats, where some animals take advantage of the close proximity of different forest successional stages for food and cover. In the past, forest wildlife managers have tried to produce the maximum amount of edge to increase habitat for game species. However, edge does not benefit all wildlife. Many populations of forest interior birds are declining due to fragmentation of forested habitats into smaller patches and the increasing amount of edge and the associated effects of predation and nest parasitism (see section on forest interior birds below). Forest interior species typically avoid edge habitats and require large tracts of contiguous forest. Wildlife species adapted to edge conditions readily outcompete forest interior species for resources along forest margins.

Creation of edges has the following general effects on forest wildlife:

- Habitat quality for **edge-generalist species** (those species whose fitness is enhanced near edge habitats) is improved.
- Habitat quality for **area-sensitive species** (those species requiring large blocks of contiguous forest) is reduced.
- Habitat quality for **edge-sensitive species** (those forest species whose survival and reproductive capacity is reduced near edges) is reduced.

Clearcuts often create abrupt edges, and cutting patterns determine the amount of edge habitat created.



C. Rewa

*The dam-building activities of beavers can result in productive habitat for invertebrates, fish, bats, and waterfowl.*

### *Corridor Functions and Benefits:*

#### **Wildlife habitat**

- ◆ connect habitat remnants to increase habitat area for plants and animals
- ◆ increase opportunities for emigrating and immigrating wildlife, such as increasing travel lanes for migrating or juvenile animals
- ◆ may serve as home range for corridor “dwellers” such as insects, amphibians, reptiles, small mammals, and birds
- ◆ increase foraging opportunities and cover for some wildlife species

#### **Other environmental functions**

- ◆ reduce flooding
- ◆ reduce soil erosion and stabilize stream banks
- ◆ improve water quality and quantity
- ◆ help improve air quality

#### **Social and economic functions**

- ◆ recreational and educational opportunities
- ◆ aesthetics
- ◆ introduced corridors can help increase crop yields and quality, decrease energy consumption, and increase property values

Circular cuts produce the least amount of edge. Landowners and managers can increase edge by elongating circles or creating several smaller circles. Irregularly shaped cuts containing islands of residual trees significantly increase edge, whereas straight linear cuts minimize edge.

Managers should be aware of the effect of edges on target wildlife species and plan clearcut sizes and shapes accordingly.

### *Forest fragmentation*

Forest fragmentation is a process in which contiguous forested landscapes are broken up into smaller islands of forest. Forest fragmentation is a major concern because noncontiguous forest cover can negatively impact some wildlife populations. Besides forest interior birds, many wide-ranging carnivores (e.g., bobcat, lynx, black bear, fisher, wolverine) need large blocs of contiguous forest habitat. Adverse affects of forest fragmentation include:

- Increased predation and nest parasitism on forest

interior birds.

- Abandonment of otherwise suitable habitat by area-sensitive species due to close proximity of forest edges.
- Increased interspecific competition.
- Overall habitat loss.

Single-tree and small group selection cuts help preserve areas of contiguous forest by imitating natural forest disturbance processes. Clearcuts and large group selection cuts should be avoided in areas managed for area-sensitive species.

Maintenance or establishment of forested corridors linking forest habitat patches can mitigate the effects of fragmentation to some extent. As forest fragmentation and urban sprawl increase, corridors become increasingly important habitat elements for many species of forest wildlife. Natural corridors include strips of woody riparian vegetation along waterways, and artificial corridors include windbreaks, shelterbelts, and other plantings.

### ***Vernal pools***

Vernal pools, also called ephemeral or snowmelt pools, in forest lands of the eastern U.S. are shallow depressions on the forest floor that fill with water when groundwater levels are high, particularly in the spring. Some herbaceous wetlands in California are also known as vernal pools, however, the focus here is on



K. Cook

***Woodland vernal pools provide important spring breeding habitat for wood frogs, salamanders and other amphibians.***

***Conserving vernal pools*** includes managing adjacent upland habitat. In forested areas, the loss of surrounding trees and vegetation around vernal pools reduces shade, increases water temperatures, and increases evaporation causing the pools to dry up more quickly. Natural, undisturbed buffers approximately 300 yards wide around pools should help protect animal movements to and from the pools. Forested corridors connecting pools should be preserved, and debris or fill should not be dumped into vernal pools. Roads can be lethal barriers for animals trying to reach vernal pools. Drainage containing road salt, roadside pesticides, and other chemicals can have negative effects on vernal pool habitats. Habitat alterations that must take place should be carried out from November through March to minimize disturbance to breeding and resident animals. Classified as temporary wetlands in many states, landowners and managers should check with their state natural resources agencies for state and federal laws pertaining to vernal pools and associated plants and animals.

the vernal pools in forested areas. There are several common characteristics of woodland vernal pools: 1) generally occur on ancient soils, usually with an impermeable hardpan, claypan, or volcanic basalt base/substrate, 2) ground is covered by shallow water for variable periods of time from winter through spring, and pools are typically dry summer through fall, and 3) lack fish populations, which reduces the threat of predation for amphibians and other animals that breed exclusively in the pools. During drought years, water may be absent year-round.

These unique habitats provide a safe haven for some specialized breeding populations of amphibians and invertebrates and food and cover for migrating birds and other wildlife. Many species that inhabit vernal pools are adapted to harsh conditions. High nutrient levels produced by decaying organic material support rapid development of amphibian larvae and other organisms before pools dry up. Animals that breed exclusively in vernal pools and require those habitats for survival are called vernal pool obligate species. The wood frog, a terrestrial amphibian, breeds only in vernal pools as do several species of mole salamanders (including the spotted salamander, blue-spotted salamander, Jefferson salamander, marbled salamander, and others). Other species that use vernal pools in

conjunction with permanent aquatic habitats include the spring peeper, green frog, American toad, Fowler's toad, four-toed salamander, red-spotted newt, spotted turtle, painted turtle, snapping turtle, water scorpions, diving beetle larvae, whirligig beetle larvae, dobsonfly larvae, damselfly larvae, fingernail clam, amphibious snails, and others.

Vernal pools are easily overlooked when dry, and are often unknowingly destroyed by land use and management activities. Depressions on the forest floor with dark gray, mottled soils and damp, blackened leaf litter are indicators of vernal pools. The area may also have a strong smell of decomposing organic matter or sulfur. The bases of trees may exhibit watermarks. State wildlife agencies may have lists of possible vernal pool sites.

### **Riparian zones**

Riparian zones are terrestrial areas adjacent to and influenced by perennial or intermittent bodies of water. Riparian zones provide transition areas between terrestrial and aquatic ecosystems, which create unique and highly valuable fish and wildlife habitats. Riparian vegetation provides essential nesting habitat for songbirds, and foraging habitat for songbirds and bats, especially in arid western environments. Forested riparian zones adjacent to streams and rivers provide a variety of important ecological functions, including the following:



*Raccoons inhabit wooded areas near streams, lakes, and marshes. Preserving vegetation in riparian zones provides habitat for fish, amphibians, and other wildlife while filtering pollutants and reducing stormwater runoff.*



C. Rewa

*Riparian vegetation provides shade and a source of organic matter and large wood to stream ecosystems.*

- **Stream shading:** Many fish species, especially salmonids and other “cold water” species, cannot tolerate elevated water temperatures. Riparian areas that are heavily vegetated can moderate stream temperatures by shading the stream in summer and providing a buffer from extreme cold in winter.
- **Large wood:** Riparian forests are a source of large wood, which when it falls into the stream, provides structural complexity to stream channels. In-stream wood often results in the development of pools which can slow down stream flow and provide fish refuge from high velocity water, hiding cover and over-wintering habitat. Also, in-stream wood increases the retention time of smaller organic detritus by capturing leaves and twigs in branches and roots. This allows more time for aquatic invertebrates to break down the detritus, supporting the food chain that sustains fish and other vertebrate species. In-stream wood is also habitat to some aquatic insects.
- **Organic matter input:** In upland streams that are shaded by streamside forests, as much as 75 percent of the organic food base is supplied by dissolved organic compounds or detritus such as fruit, limbs, leaves and insects that fall from the riparian canopy. Benthic detritivores, the stream bottom bacteria, fungi and invertebrates that feed on the detritus, form the basis of the aquatic food chain.



C. Rewa

*Wolf trees typically have broad, spreading crowns with many natural cavities used by wildlife.*

They pass on this energy when they are consumed by larger benthic fauna and eventually by fish.

- **Minimize sediment input:** Riparian ground vegetation acts as a very efficient filtration system by removing sediment and other suspended solids, as well as sediment bound nutrients and pesticides from surface runoff. This function is critical for maintaining good water quality.
- **Nutrient assimilation:** Riparian areas function as a sink when nutrients are taken up by plants and stored in plant tissues. In wetter areas, nutrients in leaf litter may be stored for long periods as peat. Also, sediments filtered out by vegetation remain in the riparian sink to become incorporated into the riparian soils.

Maintaining the integrity of riparian zones in managed forests is a critical aspect of good forest stewardship and integral to providing high quality fish and wildlife habitat. Disturbance of riparian areas during timber harvest operations or other activities should be minimized to the extent possible. The width of non-harvested buffer zones adjacent to streams depends on the stream order, sensitivity of the target species to disturbance, streamside slopes and stream gradient, and many other factors. Managers should consult with local wildlife and natural resource professionals for guidelines concerning the proper width of riparian buffer areas that should be left undisturbed. For all practical purposes, the wider the undisturbed buffer zone, the greater the fish and wildlife habitat benefits that will be maintained.

## Cavity-Nesting Wildlife

Some wildlife species depend on tree cavities for nesting. Although this leaflet does not describe requirements for each individual species, general habitat needs are addressed. Primary cavity-nesters, such as members of the woodpecker family, create cavities by drilling holes in dead trees and branches. Many passerine (perching) birds and owls, a few species of waterfowl, and some mammals, including several species of bats, are secondary cavity-nesters, relying on natural cavities formed by fungus, knots, and insects or cavities abandoned by primary excavators for nesting or hiding. Tables 2 and 3 provide lists of North American cavity nesting mammals and birds.

Competition is high for natural cavities, especially where mature forest stands are removed. Landowners and managers can install artificial nesting structures to increase the availability of suitable nesting sites for cavity-nesting wildlife (see Fish and Wildlife Habitat Management leaflet No. 20, *Artificial Nesting Structures*).

## Snags and den trees

Snags and den trees are important to many species of wildlife, especially cavity-nesters. Dead branches are used for perching and roosting, while the decaying wood provides a rich invertebrate food source. Sloughing bark on snags provides maternity sites for 17 of North America's 45 bat species. Naturally occurring snags should be left standing wherever possible. Girdling live trees is sometimes used to create snags. To do this, a 3- to 4-inch band of bark is removed from the circumference of a live tree trunk, which kills the tree without felling it. Where safety permits, as many snags as possible should be preserved during timber harvest and thinning. Because snags are

**Table 2. Some cavity-nesting mammals in North American forests.**

Yellow-pine chipmunk	Common red-backed vole
Northern flying squirrel	Yellow-necked field mouse
Red squirrel	Ermine
Bushy-tailed woodrat	Big brown bat
Deer mouse	Raccoon

an ephemeral resource, green and dying trees should also be left as future replacements for snags lost naturally. To prevent loss to wind throw, snags can be left in clumps, or in locations less susceptible to prevailing winds.

General recommendations for maintaining snags in most timber stands to benefit wildlife include:

- One snag/acre larger than 20-inch dbh for use by larger woodpeckers and owls.
- Four snags/acre between 10- and 20-inch dbh for small mammals such as flying squirrels and smaller raptors such as American kestrels.
- Two snags/acre between 6- and 10-inch dbh for smaller birds such as chickadees and nuthatches.

Den trees, sometimes referred to a “wolf” trees, frequently contain weather-tight cavities used by wildlife for nesting, food storage, and escape cover. Good den trees do not have broken-off tops, which expose wildlife to the weather. Like snags, den trees

(or a few large, potential den trees) should be preserved during timber harvest or thinning practices.

**Waterfowl, owls, and woodpeckers**

Some species of waterfowl, such as the wood duck, nest in cavities in wooded areas near water. Aquatic vegetation and invertebrates provide food for adults and young. Mast-producing trees (especially oaks) are important adult food sources as well. Natural cavities in snags and stumps or cavities abandoned by large woodpeckers are used for nesting. Vegetated buffer zones around streams and wetlands help protect aquatic foraging areas. For more information on wood duck habitat requirements, see Fish and Wildlife Habitat Management Leaflet No. 1, *Wood Duck*.

Most cavity-nesting owls inhabit mature mixed-conifer or deciduous forests near riparian areas. Individuals of some species use several different cavities within their territories. The spotted owl and flammulated owl are both area-sensitive species, and prefer large tracts

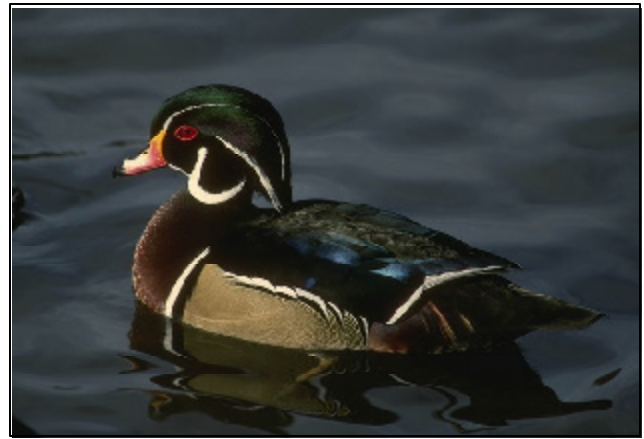
**Table 3. Common names of cavity-nesting birds in forests of North America.**

Primary (excavator)	Secondary (nonexcavator)	Secondary (nonexcavator)
Northern flicker	Brown-crested flycatcher	Barrow's goldeneye
Pileated woodpecker	Dusky-capped flycatcher	Common goldeneye
Red-bellied woodpecker	Great-crested flycatcher	Bufflehead
Gila woodpecker	Ash-throated flycatcher	Common merganser
Red-headed woodpecker	Violet-green swallow	Hooded merganser
Acorn woodpecker	Mountain chickadee	Black-bellied whistling duck
Lewis' woodpecker	Tufted titmouse	Wood duck
Yellow-bellied sapsucker	Oak titmouse	Barn owl
Williamson's sapsucker	Juniper titmouse	Barred owl
Hairy woodpecker	Bridled titmouse	Spotted owl
Downy woodpecker	White-breasted nuthatch	Western screech owl
Ladder-backed woodpecker	Red-breasted nuthatch	Eastern screech owl
Nuttall's woodpecker	Brown-headed nuthatch	Whiskered screech owl
Strickland's woodpecker	Pygmy nuthatch	Flammulated owl
White-headed woodpecker	Brown creeper	Elf owl
Black-backed woodpecker	House wren	Ferruginous pygmy owl
Three-toed woodpecker	Winter wren	Northern pygmy owl
Black-capped chickadee*	Carolina wren	Northern saw-whet owl
Carolina chickadee*	Bewick's wren	Boreal owl
Boreal chickadee*	Eastern bluebird	Northern hawk owl
Chestnut-backed chickadee*	Western bluebird	Prothonotary warbler
	Mountain bluebird	Lucy's warbler
	Tree swallow	American kestrel
		Purple martin

\*Also nests as secondary cavity nester.

of mature coniferous forests. On long rotations, even-aged systems can provide suitable habitat for many owl species. Owls prey on small mammals and birds found in early succession vegetation adjacent to mature forests, and in mature forest canopy gaps.

Woodpeckers (family Picidae: woodpeckers, flickers, and sapsuckers) rely on snags and mature trees found in deciduous and coniferous forests for food and cover. Most species prefer moist environments or riparian habitats, which promote wood decay and prolific insect populations. On a landscape level, mosaics of different age classes created by even-aged management practices can enhance woodpecker habitat quality if snags and mature trees are preserved. Some area-sensitive species, like the red-cockaded woodpecker that inhabits mature pine forests in the southeast, do not inhabit heavily logged areas. Prescribed burning can improve habitat quality for species that rely on fire-tolerant pines, such as Lewis' woodpecker and black-backed woodpecker.



*Wood ducks use cavities in trees for nesting, but will also readily accept nest boxes.*

Woodpeckers may occupy several different cavities simultaneously for several years, increasing the importance of snag quality and availability. Woodpeckers are year-round residents, or move short distances in the winter to find food. Some woodpeckers use storage sites, called granaries, to

**Table 4. Habitat characteristics and management recommendations for some forest interior birds of North America.**

Species	Nest location	Feeding location	Min. forest size*	Management recommendation
Yellow-throated vireo	C	C	250	selective cutting to maintain partially open canopy.
Red-eyed vireo	C	C	50	harvest techniques that retain at least 70% canopy closure.
Northern Parula	C	C	250	retain 60-70% canopy closure and increase shrubs.
Black-and-white warbler	G	M	750	maintain early successional forest.
American redstart	U	M	80	maintain closed canopy and thin understory trees.
Prothonotary warbler	S	G	250	maintain old-growth stands with dead/dying trees.
Worm-eating warbler	G	G	750	maintain dense understory and low tree basal area.
Louisiana waterthrush	G	G	250	maintain wooded streambanks and thick undergrowth.
Ovenbird	G	G	250	maintain closed canopy and open understory.
Barred owl	S	OU	250	maintain large areas on 150-yr. or longer rotations.
Whip-poor-will	G	O	300	pole-sized even-aged stands, retain decaying trees.
Hairy woodpecker	S	T	10	retain decaying and healthy trees during timber harvest.
Pileated woodpecker	T	T	125	retain dead/decaying trees, 150 yr. or greater rotations.
Acadian flycatcher	S	LC	80	maintain tall closed canopy; thin understory trees.
Kentucky warbler	U	G	80	dense understory with well-developed ground cover.
Hooded warbler	U	U	80	maintain canopy closure and dense shrub layer.
Scarlet tanager	C	C	25	maintain pole-size stands, well-developed canopy.
Red-shouldered hawk	C	O	250	maintain mature forest at 140 to 400 trees/acre.

\* Minimum forest size in acres. (Compiled from Bushman and Therres 1988.)

C = canopy, G = ground, U = understory, S = snag, M = mid-story, SH = shrub, T = trunk, LC = lower canopy, O = open areas, OU = open understory.

cache surplus mast. Trees in the center of a bird's territory are often used as granaries. Woodpeckers play an important role by reducing the number of tree disease-causing insects found under mature tree bark. Most woodpeckers eat the larvae and adults of wood-boring beetles, ants, flies, caterpillars, and other insects. Some drill holes and forage under bark for insects, while others feed on the wing. Flickers eat invertebrates from the forest floor or fallen logs. Sapsuckers drill small holes in live trees and feed on insects that become trapped in the oozing sap. This resource partitioning allows several different species to inhabit the same area.

### ***Forest interior birds***

Management for forest interior birds focuses on maintaining large tracts of contiguous forest in different age and structural classes. Table 4 provides a list of forest interior birds with general habitat management recommendations. Forested landscapes managed on even-aged systems can support viable populations of forest interior species, providing advantages of both early succession and late succession habitats. Harvest management strategies should avoid forest fragmentation and minimize edge. In areas where snags are scarce (<1/acre), landowners can provide nest



USDI, USGS

***Brown-headed cowbirds are more likely to parasitize nests of forest birds in edge habitats than in forest interior regions. Here, two cowbird eggs in this wood thrush nest will hatch before the others, favoring the cowbird chicks.***

boxes for cavity-nesting species.

Habitat loss caused by fragmentation is the major cause of reduced forest interior bird populations. This includes deforestation of the winter habitats of neotropical migrants. In areas of agricultural and urban development, forest interior species are forced to compete with other birds that are better adapted to forest edges and early successional vegetation. During the nesting season, from late April through early August, landowners and managers should minimize disturbance. Individual treatments will depend on forest types, local bird species, and the objectives of the landowner or manager.

### ***Nest parasitism***

Nest parasites are birds that lay their eggs in the nests of other species. After hatching, the parasite young typically pushes the other eggs and nestlings out of the nest and is then raised by its "foster" parents. Nest parasitism, particularly in edge habitats, threatens the reproductive success of many forest birds. The brown-headed cowbird, the most common nest parasite, benefits from increased edge created by timber harvest, agriculture, and urban development. Cowbirds prefer early successional vegetation. In landscapes with tall, continuous forest cover, cowbird numbers are generally low. If preliminary monitoring shows that forest interior birds are declining because of nest parasitism by cowbirds, then forest management should include cowbird control measures. However, perhaps the most effective means of controlling the effects of nest parasitism is by limiting forest fragmentation.

### ***Nest predation***

Increased nest predation is another consequence of forest fragmentation. Blue jays, American crows, common grackles, squirrels, mice, snakes, and domestic pets are frequent nest predators in edge habitats. Studies show that predation rates for nesting birds in large, forested tracts (managed or unmanaged) are significantly lower than for forest birds that are forced to nest in edge areas.





*Blue jays are common nest predators in edge habitats.*

### **Bats**

Many North American bats roost in dead and dying trees, especially beneath loose bark, in cavities, decaying hollows, and lightning strike crevices. Others roost exclusively in the foliage of living trees. Bats also use old stumps or downed logs. All of these roosts are required for rearing young, as migratory stopover sites, and occasionally for hibernation. Bats typically select the largest snags and live trees available. Snags in the early stages of decay, with much of their bark remaining, appear to be the most important. Roost trees often receive increased sun exposure, either by extending above the canopy or because they are located in small forest openings, along forest edges, or in more open stands. In landscapes with steeper topography and cold-air drainage, some evidence suggests that upland and ridge top roosts may be used more frequently than roosts in drainage bottoms. Most species move frequently between several roosts during the course of a season, often within a relatively small area. Bats may return to the same roost or group of roosts in subsequent years. Maternity roosts are usually located close to water, as lactating females require frequent access to drinking water.

In the eastern United States, the northern myotis and the endangered Indiana bat rely on exfoliating bark for maternity sites; so do the long-eared myotis and long-legged myotis in the West. Other species, such as the big-brown bat, silver-haired bat, and pallid bat,

seem to prefer cavities. In bottomland hardwood forests of the southeastern United States, the Rafinesque's big-eared bat and southeastern myotis form maternity colonies in the hollow trunks of gum, tupelo, and beech trees with basal cavities. Red bats and hoary bats roost primarily in the foliage of deciduous and coniferous trees, while Seminole and northern yellow bats are often found in clumps of Spanish moss.

Bats feed on a variety of night-flying insects, including many forest pests. Bats forage along forest edges, over riparian areas, along forest roads and trails, and in natural forest gaps or small harvest-created openings. Feeding strategies vary greatly among forest-dwelling species, with some foraging around ground-level shrubs while others prefer subcanopy, canopy, or above-canopy locations.

Because snags are an ephemeral resource, and roost switching appears to be essential for most species, forests should be managed where possible to maintain consistent roost availability over time. As many dead, damaged, and dying trees and defective (cull) live trees



Bat Conservation International

*Nearly half of North American bat species use forested habitats for foraging, roosting and maternity sites in tree cavities on under sloughing bark.*

should be left as safety and silvicultural objectives permit. Retain less-decayed snags in favor of more-decayed snags, large diameter snags in favor of small diameter snags, and snags with greater bark cover in favor of snags with little bark cover. Leaving small groups of green trees around snags, or groups of snags, can help protect them from wind throw. Leave as many hardwoods as possible that have natural or woodpecker-excavated cavities. In intensively managed forests, snags can be maintained in stream side management zones, the habitat matrix separating managed stands, forested corridors, and other less intensively managed habitats. Where possible, maintain well-distributed, variable-sized patches of mature and old-growth forest through extended harvest rotations. Thinning overstocked stands can improve foraging habitat by increasing flight space beneath the canopy.

### Forest Classification

The U.S. Forest Service has developed a system to classify forests in the United States. Seven broad forest regions were designated based on geography and major forest types. In this leaflet, the continental U.S. is divided into eastern and western forest types by the 100th meridian. Dominant vegetation of the major forest types in eastern and western forest type groups are listed in Tables 9 and 11, respectively.

Forests of the eastern United States are primarily deciduous or mixed conifer-deciduous forests, while the western U.S. has mostly coniferous forests. The basic progression of vegetation ranges from evergreen, needle-leaved trees in the far north to deciduous, broad-leaved trees to mixed deciduous and evergreen broad-leaved trees in the deep south. Combinations of broad- and needle-leaved trees are widespread.

Each forest region has unique fish and wildlife species that depend on native forest vegetation types. The type of on-site vegetation depends on climate, geology and soil, fire, competing vegetation, and human influence (land-use development and timber management). The tables on the following pages describe flora and fauna characteristic of eastern and western forest types and management

recommendations based on forest wildlife objectives. These tables are intended to guide local decision-making for managing forests for wildlife.

**Table 5. Some common mammals of eastern forests.**

Virginia opossum	Short-tailed shrew
Big brown bat	Beaver
Little brown bat	Gray squirrel
Eastern mole	Long-tailed weasel
Eastern chipmunk	Mink
Northern and southern flying squirrels	River otter
Red squirrel	Red fox
Deer mouse	Gray fox
White-footed mouse	White-tailed deer
Striped skunk	Black bear
Raccoon	Bobcat

**Table 6. Some common birds of eastern forests.**

Red-tailed hawk	Broad-winged hawk
Ruffed grouse	Whip-poor-will
Great horned owl	Ruby-throated hummingbird
Eastern screech owl	Great crested flycatcher
Common flicker	Eastern wood-pewee
Pileated woodpecker	Wood thrush
Downy woodpecker	Red-eyed vireo
Hairy woodpecker	Ovenbird
American crow	Blue jay
Brown creeper	White-breasted nuthatch
Northern cardinal	

**Table 7. Some common mammals of western forests.**

Elk	Mountain lion
White-tailed deer	Coyote
Mule deer	Black bear
Long-eared myotis	Grizzly bear
Collared peccary	

**Table 8. Some common western forest birds.**

Williamson's sapsucker	Band-tailed pigeon
Western tanager	Pine siskin
Townsend's solitaire	Blue grouse
Mountain chickadee	Yellow-rumped warbler
Hairy woodpecker	Dark-eyed junco
Steller's jay	White-crowned sparrow

**Table 9. Indicator plant species for eastern forest type groups.**

Forest group	Trees	Shrubs	Herbaceous
White-red-jack pine	White spruce, black spruce, balsam fir, paper birch, red pine, white pine, jack pine, Fraser fir, eastern hemlock, and aspens.	Mountain maple, green alder, mountain ash, mountain holly, low-bush blueberry, elderberry.	Red baneberry, nodding trillium, bunchberry, Canada mayflower, creeping wintergreen.
Loblolly-shortleaf pine	Shortleaf pine, loblolly pine, various oak and hickory species.	Saw-palmetto, southern bayberry, odorless bayberry, winged sumac.	Little bluestem grass, yellow stargrass, wiregrass, Spanish moss, colicroot.
Longleaf-slash pine	Longleaf pine, slash pine, loblolly pine, shortleaf pine, red oak, blackjack oak, water oak.	flowering dogwood, gallberry, yaupon, bayberry, shining sumac, blueberry huckleberry	blustem grasses, panic grasses, wiregrass
Oak-pine	Pitch pine, Virginia pine, various oak species, eastern red cedar.	Bearberry, huckleberries, inkberry, broom crowberry, lowbush blueberry.	Blazing-star, butterflyweed, pinesap, poverty grass, rough hawkweed, wild lupine.
Oak-hickory	Various oak spp., various hickory spp., flowering dogwood, sassafras, hop-hornbeam.	Mountain laurel, high-bush blueberry, lowbush blueberry, mapleleaf viburnum.	Wintergreen, spotted pipissisewa, wild sassa-parilla, violet wood-sorrel.
Oak-gum-cypress	Black gum, water tupelo, sweetgum, red maple, swamp hickory, eastern sycamore, oaks.	Swamp-privet, spicebush, buttonbush, hobblebush, swamp dogwood, wild-raisin.	Spanish moss, virgin's bower, heartleaf ampelopsis, wild grapes.
Elm-ash-cottonwood	Eastern cottonwood, black willow, American elm, slippery elm, green ash, black ash, eastern sycamore, river birch.	American elder, moonseed, river grape, poison-ivy, trumpet-creeper, peppervine.	Green dragon, sweet flag, ostrich fern, wood nettle, American black currant, jewelweed.
Maple-beech-birch	Yellow birch, sugar maple, American beech, eastern hemlock, red pine, pin cherry.	Striped maple, hobblebush, nannyberry, mountain laurel.	Painted trillium, goldthread, hairy beard-tongue, common wood-sorrel.



Dot Paul, USDA NRCS

**Table 10. Indicator wildlife species of eastern forest type groups.**

Forest group*	Birds	Mammals
White-red-jack pine forest Table 10A	Gray jay, common raven, boreal chickadee, white-winged crossbill, red-winged crosbill, pine grosbeak, evening grosbeak, pine siskin, red-breasted nuthatch, winter wren, ruby-crowned kinglet, black-backed woodpecker, northern three-toed woodpecker, blackburnian warbler, Cape May warbler, Wilson's warbler, Swainson's thrush.	Moose, red squirrel, beaver, porcupine, snowshoe hare, lynx, marten, fisher.
Loblolly-shortleaf pine forest Table 10B	Brown-headed nuthatch, pine warbler, yellow-throated warbler, northern parula, red-cockaded woodpecker, red-headed woodpecker, Bachman's sparrow, wild turkey, northern bobwhite, loggerhead shrike, painted bunting, eastern bluebird, black vulture.	Virginia opossum, white-tailed deer, gray fox.
Longleaf-slash pine Table 10C	Brown-headed nuthatch, pine warbler, chipping sparrow, Bachman's sparrow, red-cockaded woodpecker, tufted titmouse, blue grossbeak, northern bobwhite, American kestrel, wild turkey.	fox squirrel, pocket gopher, southern flying squirrel, Florida mouse, white-tailed deer.
Oak-pine forest Table 10D	Pine warbler, prairie warbler, rufous-sided towhee, chipping sparrow, great horned owl, common flicker, brown thrasher, northern bobwhite.	Gray squirrel, eastern chipmunk.
Oak-hickory forest Table 10E	Blue jay, wild turkey, scarlet tanager (north), summer tanager (south), rose-breasted grosbeak.	Gray squirrel, fox squirrel, northern and southern flying squirrel, Indiana bat.
Oak-gum-cypress forest Table 10F	Prothonotary warbler, northern parula, herons and egrets, barred owl, wood duck, wood stork, white ibis, limpkin (deep south only), pileated woodpecker, Acadian flycatcher.	Marsh rabbit, raccoon, Rafinesque's big-eared bat, southeastern myotis.
Elm-ash-cottonwood forest Table 10G	Belted kingfisher, bank swallow, spotted sandpiper, green heron, wood duck, yellow-throated vireo, blue-gray gnatcatcher.	Mink, river otter.
Maple-beech-birch forest Table 10H	White-throated sparrow, northern junco, purple finch, northern waterthrush, mourning warbler, Canada warbler, black-throated warbler, blue-throated warbler, green-throated warbler, American redstart, blue-headed vireo, cedar waxwing.	Red-backed vole, snowshoe hare, red squirrel, pocupine, white-tailed deer, northern long-eared bat.

\* Forest group and wildlife management recommendations table number (see following pages).

Eastern forests



C. Rewa



Dan Sudia CVIIOG/GeorgiaInfo

*The brown thrasher is commonly found in oak-pine forests.*

**Table 10A. Eastern white-red-jack pine forests: general habitat management recommendations by wildlife management objective.**

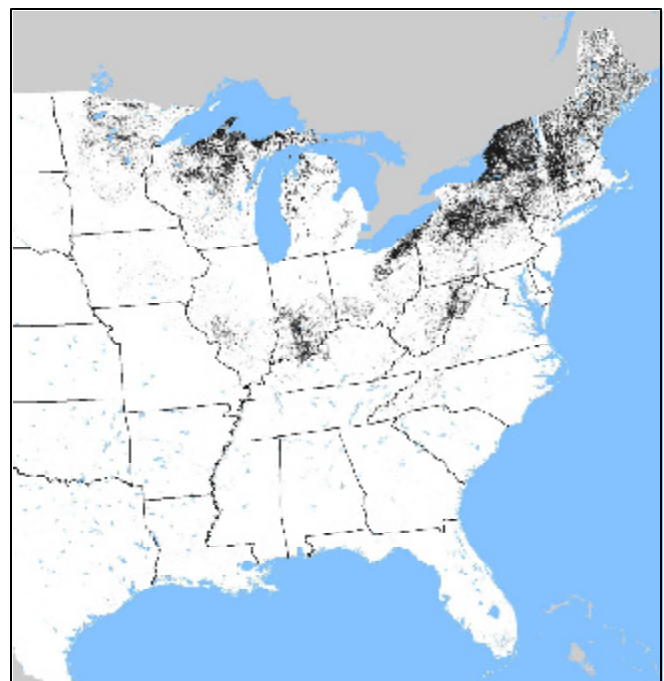
Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	Gray jay, boreal chickadee, white-winged crossbill, red crossbill, pine grosbeak, pine siskin, ruby-crowned kinglet, moose, red squirrel, beaver, snowshoe hare, porcupine	For even-aged management, use high-density shelter-wood cuts, in short cycles (5-10yrs) and use prescribed burns to simulate herbaceous growth to benefit deer, ruffed grouse, and other wildlife.
		For uneven-aged management, practice group selection cuts up to one acre if maintaining some hardwoods.
		Preserve existing snags to provide at least 2-4 large snags (>12-inch dbh) per acre of forest.
		Maintain no-harvest buffer zones along streams to protect riparian and in-stream aquatic habitats.
Forest interior birds	Blackburnian warbler, red-breasted nuthatch	In highly fragmented landscapes, maintain large blocks of contiguous forest.
		In mostly forested landscapes, minimize fragmentation effects by conducting uneven-aged timber management practices.
		If clearcutting, minimize the amount of edge by keeping clearcut openings as close to a circular shape as possible.
Early successional species	Wilson's warbler, Swainson's warbler	Use even-aged management practices to provide patches of brushy habitat.
		If uneven-aged practices must be used, apply group selection cuts to create openings 1-2 acres in size.
		Leave snags and stubs with cavities for cavity nesters.
Late successional species	Black-backed woodpecker, northern three-toed woodpecker	Both black-backed and northern three-toed woodpeckers prefer spruce-fir stands with burned-over areas.
		Maintain no less than 10 percent of the stand in old-growth to ensure availability of snags and den trees.
Specific rare, threatened and endangered species	See U.S. Fish and Wildlife Service Endangered Species Homepage and individual state listing.	Provide specific habitat conditions required by the identified species.

This boreal forest is an evergreen, needle-leaved forest consisting of white-red-jack pine and spruce-fir forest type groups. Red spruce and Fraser fir dominate the Appalachian extension of the boreal forest and replace white spruce and balsam fir, which are often harvested for lumber, pulpwood, and commercial Christmas trees.



Deanna Dawson

*Immature blackburnian warbler.*

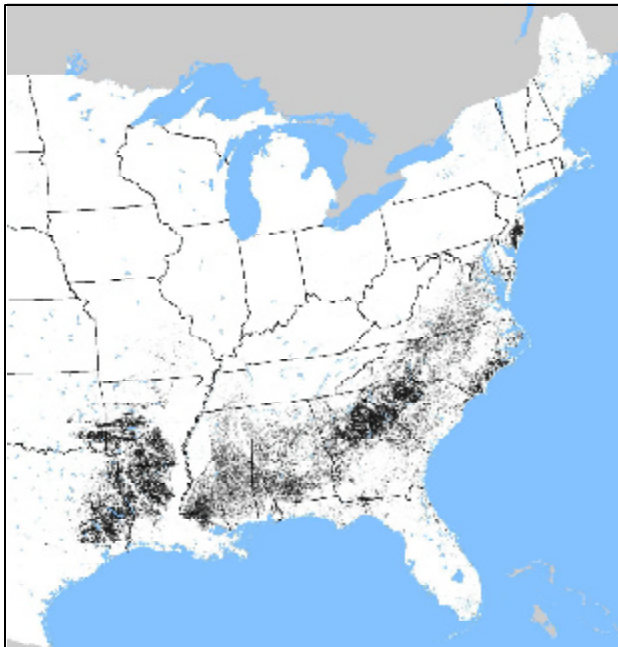


Eastern red-white-jack pine forests

**Table 10B. Loblolly-shortleaf pine forests: general habitat management recommendations by wildlife management objective.**

Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	Brown-headed nuthatch, pine warbler, yellow-throated warbler, northern parula, red-headed woodpecker, wild turkey, northern bobwhite, painted bunting, opossum, white-tailed deer, gray fox	For even-aged management, provide several timber age classes in close proximity.
		For uneven-aged management, provide a variety of dominant tree species and encourage development of overstory, mid-story, and understory vegetation.
		Retain mast-producing trees (oaks, hickory, walnut).
		Preserve existing snags to provide at least 2-4 large snags (>12-inch dbh) per acre.
		Maintain no less than 10 percent of stand in old-growth.
Forest interior birds	Brown-headed nuthatch, red-cockaded woodpecker, Bachman's sparrow, Kentucky warbler, worm-eating warbler.	Maintain no-harvest buffer zones along riparian areas.
		In fragmented landscapes, maintain large blocks of forest.
		Minimize effects of fragmentation by conducting uneven-aged timber management practices.
Early successional species	Bewick's wren, painted bunting, prairie warbler, northern bobwhite	Minimize the amount of edge created by clearcuts by keeping openings as close to a circular shape as possible.
		Use even-aged management practices and provide patches of brushy habitat.
		If uneven-aged practices must be used, apply group selection cuts to create openings of 1-2 acres in size.
Late successional species	Yellow-throated vireo, Acadian flycatcher, wood thrush, Swainson's warbler, Louisiana waterthrush.	Leave snags with natural and excavated cavities for wildlife.
		Maintain no-harvest sanctuaries of old-growth.
		Maximize stand rotation length and maintain at least 50 percent of the forested area as mature stands (>100 yrs old).
Specific rare, threatened, or endangered species	See U.S. Fish and Wildlife Service Endangered Species web site and individual state listings.	Position long-rotation stands around contiguous and mature forest reserves; do not remove standing snags or downed logs.
		Provide habitat conditions specific to the needs of identified species.

Eastern loblolly-shortleaf pine forests



*Mixed loblolly pine forest.*

U.S. Forest Service, Southern Research

**Table 10C. Longleaf-slash pine forests: general habitat management recommendations by wildlife management objective.**

Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	Brown-headed nuthatch, pine warbler, yellow-throated warbler, northern parula, red-headed woodpecker, wild turkey, northern bobwhite, painted bunting, opossum, white-tailed deer, gray fox	For even-aged management, provide several timber age classes in close proximity.
		For uneven-aged management, provide a variety of dominant tree species and encourage development of overstory, mid-story, and understory vegetation.
		Retain mast-producing trees (oaks, hickory, walnut).
		Preserve existing snags to provide at least 2-4 large snags (>12-inch dbh) per acre.
		Maintain no less than 10 percent of stand in old-growth.
Forest interior birds	Brown-headed nuthatch, red-cockaded woodpecker, Bachman's sparrow.	Maintain no-harvest buffer zones along riparian areas.
		In fragmented landscapes, maintain large blocks of forest.
		Use prescribed fire to manage understory and encourage longleaf pine regeneration.
Early successional species	Bewick's wren, painted bunting, prairie warbler, northern bobwhite	Minimize the amount of edge created by clearcuts by keeping openings as close to a circular shape as possible.
		Use even-aged management practices and provide patches of brushy habitat.
		If uneven-aged practices must be used, apply group selection cuts to create openings of 1-2 acres in size.
Late successional species	Yellow-throated vireo, Acadian flycatcher, wood thrush, Swainson's warbler, Louisiana waterthrush.	Leave snags with natural and excavated cavities for wildlife.
		Maintain no-harvest sanctuaries of old-growth.
		Maximize stand rotation length and maintain at least 50 percent of the forested area as mature stands (>100 yrs old).
Specific rare, threatened, or endangered species	See U.S. Fish and Wildlife Service Endangered Species web site and individual state listings.	Position long-rotation stands around contiguous and mature forest reserves; do not remove standing snags or downed logs.
		Provide habitat conditions specific to the needs of identified species



J. and K. Hollingsworth

*The endangered red-cockaded woodpecker nests in mature stands of southern pines with open understories.*



Eastern longleaf-slash pine forests

**Table 10D. Eastern oak-pine forests: general habitat management recommendations by wildlife habitat management objective.**

Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	Pine warbler, rufous-sided, towhee, chipping sparrow, common flicker, brown thrasher, northern bobwhite, wild turkey gray squirrel, eastern chipmunk, white-tailed deer	Oak-pine forest types regenerate best under even-aged management practices such as moderate, dense shelterwood cuts and small clearcuts.
		Retain pines to serve as escape, thermal, and roosting cover.
		Preserve existing standing snags to provide 2 to 4 large snags (>12-inch dbh) per acre of forest.
		Maintain no less than 10 percent of old-growth stands to ensure availability of natural snags and den trees.
		Maintain no-harvest buffer zones along streams to protect riparian and in-stream aquatic habitats.
Forest interior birds	Brown-headed nuthatch, wood thrush, worm-eating warbler, Kentucky warbler, cerulean warbler, Canada warbler	Maintain large blocks of contiguous forest with varied vegetation structure.
		Minimize the amount of edge produced by clearcuts by keeping openings as close to circular shape as possible.
Early successional species	Eastern bluebird, loggerhead shrike, blue-winged warbler, golden winged warbler, Tennessee warbler, meadow vole, long-tailed weasel, meadow jumping mouse	Use even-aged management practices to provide patches of brushy habitat.
		If uneven-aged management practices must be used, apply group selection to create openings 1 to 2 acres in size.
		Leave snags and stubs with cavities in openings for cavity nesting species.
Late successional species	Great blue heron, osprey, bald eagle, red-headed woodpecker red-bellied woodpecker	Maintain no-harvest sanctuaries of old-growth forest.
		Maximize rotation length in timber stands managed for harvest, and maintain at least 50 percent of the forested area as mature stands (>100 years old).
		While conducting intermediate thinnings of oak, maintain hardwood snag and den trees as well as hard mast-producing trees.
Specific rare, threatened or endangered species	See U.S. Fish and Wildlife Service Endangered Species Homepage and individual state listing.	Provide habitat conditions specific to the needs of identified species.

Eastern oak-pine forests



Southern Research Station, U.S. Forest Service

*The eastern mixed oak-pine forest supports a unique mix of flora and fauna in each successional stage. Oaks and hickories are common hard mast-producing species found in the mixed forest type. Nuts are an important food source for many wildlife species, including wood ducks and tree squirrels.*



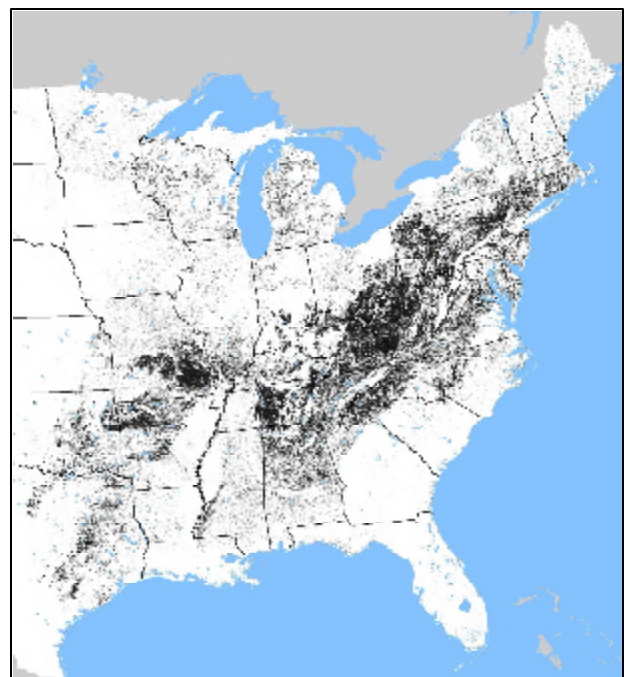
**Table 10E. Oak-hickory forests: general habitat management recommendations by wildlife management objective.**

Wildlife objective	Indicator species	Management recommendations
Forest wildlife species diversity	Blue jay, wild turkey, scarlet tanager, rose-breasted grosbeak, ruffed grouse, blue-winged warbler, gray squirrel, fox squirrel, northern and southern flying squirrels, little brown bat	For even-aged management, provide several timber stand age classes in close proximity.
		For uneven-aged management, provide a variety of dominant tree species and encourage development of overstory, mid-story, and understory vegetation.
		Preserve existing snags to provide approximately 2 to 4 large snags (>12-inch dbh) per acre of forest.
		Maintain no less than 10 percent of the stand in old-growth to ensure availability of snags and den trees.
		Maintain no-harvest buffer zones along streams to protect riparian and in-stream aquatic habitats.
Early successional species	Brown thrasher, prairie warbler, yellow-breasted chat, indigo bunting, rufous-sided towhee, blue-winged warbler	Use even-aged management practices and promote disturbance (such as prescribed burns) to open canopy and allow light to reach the forest floor to increase advanced oak regeneration and herbaceous growth.
Forest interior birds	Cerulean warbler, wood thrush, ovenbird, red-eyed vireo, worm-eating warbler, Kentucky warbler, Acadian flycatcher, yellow-billed cuckoo	In highly fragmented landscapes, maintain large blocks of contiguous forested habitat and establish forested corridors to link forest patches.
		In forested landscapes, minimize fragmentation effects by conducting uneven-aged timber management.
		Minimize the amount of edge created in clearcuts by keeping openings in the forest as close to circular in shape as possible.
Late successional species	Cerulean warbler, pileated woodpecker, Rafinesque's big-eared bat	Identify and restore the largest tracts of old-growth and mature forest.
		Don't remove snags or downed logs from stand; maintain large gum and cypress trees with basal cavities.
Specific rare, threatened, or endangered species	See U.S. Fish and Wildlife Service Endangered Species Homepage and individual state listing.	Provide habitat conditions specific to the needs of the identified species.



Lynn Betts

*The oak-hickory forest is the largest eastern deciduous forest type group and produces hard mast (acorns and hickory nuts) eaten by turkeys and other wildlife. Oak and hickory species mix with other forest types, and are replaced by American elm, sweetgum, tuliptree, and red maple on mesic sites. Sugar maple invades disturbed sites where fire is suppressed and climatic extremes are limited. American chestnut may be found in the understory.*



Eastern oak-hickory forests

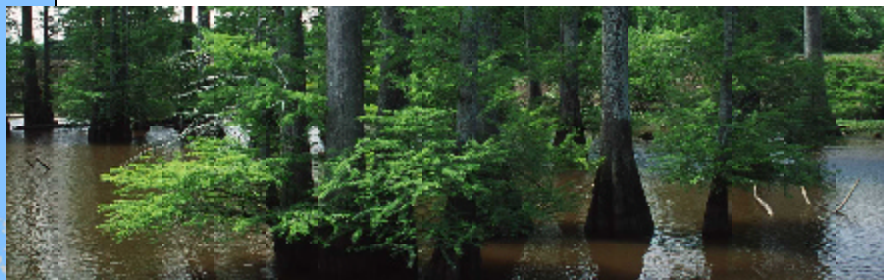
**Table 10F. Eastern oak-gum-cypress forests: general habitat management recommendations by wildlife management objective.**

Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	White-tailed deer, Carolina chickadee, black bear, wild turkey, American alligator, cotton-mouth, tufted titmouse	For even-aged management, provide several timber age classes in close proximity.
		For uneven-aged management, provide a variety of dominant tree species and encourage development of overstory, mid-story, and understory vegetation.
		Preserve existing snags to provide 2 to 4 large snags (>12-inch dbh) per acre of forest.
		Maintain no less than 5 percent of the stand in old-growth to ensure availability of snags and den trees.
Forest interior birds	Summer tanager, Kentucky warbler, Swainson's warbler, red-shouldered hawk, Acadian flycatcher	In highly fragmented landscapes, maintain large blocks of contiguous forested habitat.
		In mostly forested landscapes, minimize fragmentation effects by conducting uneven-aged timber management practices.
		Minimize the amount of edge by keeping clearcut openings as close to circular shape as possible.
Late-successional species	Pileated woodpecker, barred owl, cerulean warbler, red-eyed vireo	Maintain no-harvest sanctuaries of old-growth forest.
		Maximize rotation length in timber stands and maintain at least 50 percent of the forested area as mature stands (>100 years of age).
		Position long-rotation stands around contiguous and no-harvest forest reserves.
		Maintain no-harvest areas at least 300 feet wide along riparian areas.
		Do not remove snags or downed logs from stand.
Early-successional species	Yellow-breasted chat, Indigo bunting, painted bunting, white-eyed vireo, orchard oriole	Use even-aged management to provide patches of brushy habitat.
		If uneven-aged techniques must be used, apply group selection to create openings 1 to 2 acres in size.
		Leave snags and stubs with cavities for quality nesting sites in open areas for cavity-nesting species.
Specific rare, endangered, or threatened species	See U.S. Fish and Wildlife Service Endangered Species Homepage and individual state listing.	Provide habitat conditions specific to the needs of the identified species.

Eastern oak-gum-cypress forests



*Southern mixed bottomland hardwood swamp is another name for the oak-gum-cypress forest. Although there are several different combinations of indicator flora, tupelos are usually found in most swamp forests. Dense understories, vines, and the presence of water-resistant oaks are also good indicators.*



**Table 10G. Eastern elm-ash-cottonwood forests: general habitat management recommendations by wildlife management objective.**

<b>Wildlife objective</b>	<b>Indicator species</b>	<b>Habitat recommendations</b>
Forest wildlife species diversity	House wren, great-crested flycatcher, indigo bunting, Kentucky warbler, blue-gray gnatcatcher, common yellowthroat, yellow warbler, mink, river otter, northern and southern flying squirrels	Maintain continuous SMZs, at least 100 feet in width along all streams and rivers in forest-dominated ecoregions.
		Avoid unnecessary alterations of hydrology (dams, levees, channelization) to maintain natural meandering and oxbow sloughs, which provide diverse habitat for wildlife.
Forest interior birds	American redstart, prothonotary warbler, Acadian flycatcher, eastern wood-peewee, yellowthroated vireo	Restore large floodplain forests along major rivers, remove dams and levees where possible to restore natural habitat diversity.
Late successional species	Cerulean warbler, pileated woodpecker, red-shouldered hawk, bald eagle	Retain and restore large floodplain tree species such as cottonwood, sycamore, and swamp white oaks to provide tall tree species.
Specific rare, threatened, or endangered species	See U.S. Fish and Wildlife Service Endangered Species Homepage and individual state listing.	Provide habitat conditions specific to the identified species.

*The eastern elm-ash-cottonwood forest group is also referred to as the northern floodplain forest. Spring floods are common after winter snow and ice melts. Floodplains are also fertile from the nutrient-laden sediment deposits, and promote quick tree growth. Cottonwoods and ashes are more abundant in the midwest, while sycamores and maples are more common in north-eastern floodplain forests.*

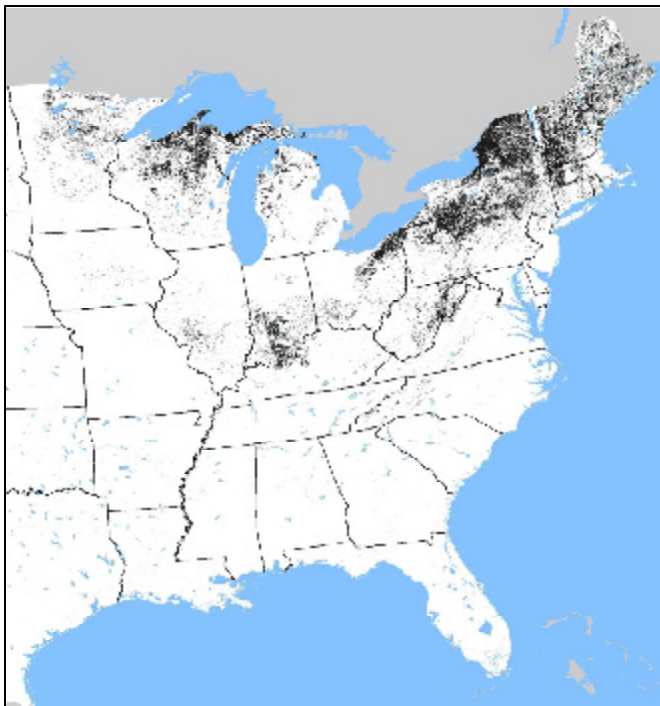


Eastern elm-ash-cottonwood forests

**Table 10H. Eastern maple-beech-birch forests: general habitat management recommendations by wildlife management objective.**

<b>Wildlife objective</b>	<b>Indicator species</b>	<b>Habitat management recommendations</b>
Forest wildlife species diversity	White-tailed deer, chipmunk, ruffed grouse, black-capped chickadee	For even-aged management, provide several timber age classes in close proximity.
		For uneven-aged management, provide a variety of dominant tree species and encourage development of overstory, mid-story, and understory vegetation.
		Preserve existing snags, at least 2-4 large snags (>12-inch dbh) per acre of forest.
		Maintain no less than 5 percent of the stand in old-growth to ensure availability of natural snags and den trees.
		Maintain no-harvest buffer zone along streams to protect riparian and in-stream habitats.
Forest interior birds	Scarlet tanager, eastern wood-pewee, black-throated blue warbler, Canada warbler, ovenbird, goshawk	In fragmented landscapes, maintain large blocks of contiguous forest habitat and establish plantings to link forest patches.
		In forested landscapes, minimize fragmentation effects by conducting uneven-aged management practices.
		If clearcutting, minimize the amount of edge by keeping openings as close to circular shape as possible.
Late successional species	Pileated woodpecker, barred owl, fisher	Maximize no-harvest areas of old-growth forest whenever possible.
		Maximize rotation length in timber stands managed for harvest, and maintain at least 50 percent in mature forests (>100 years old).
		Establish long rotation stands around contiguous or no-harvest old-growth forest reserves.
		Do not remove standing snags or downed logs from the stand.
Specific rare, threatened, or endangered species	See U.S. Fish and Wildlife Service Endangered Species Homepage and individual state listing.	Provide habitat conditions specific to the identified species.

Eastern maple-beech-birch forests



*Northern hardwood forest is another name for the maple-beech-birch forest group, and includes aspen species as well. The northern hardwood forest is transitional, frequently containing plant species of both the boreal red-white-jack pine forest to the north and the oak-hickory forest to the south.*



Greg Lasley CVIIOG/GeorgiaInfo

*The ruffed grouse is a common inhabitant of early-successional northern hardwood forests.*

**Table 11. Indicator plant species in western forest type groups.**

Forest group	Trees	Shrubs	Herbaceous
Douglas-fir	Douglas-fir, western hemlock bigleaf maple, tanoak, silver fir, western cedar, ponderosa pine.	Salal, Oregon grape, devil's club, various gooseberries, thimbleberry, Nootka rose, vine maple.	Hooker's fairy bell, calypso orchid, twinflower, bunchberry, pipissisewa.
Hemlock-sitka spruce (temperate rain forest)	Sitka spruce, western hemlock, western redcedar, red alder Douglas-fir, grand fir, silver fir, white fir, western larch, bigleaf maple.	Vine maple, devil's club, salmonberry, Pacific rhododendron, ocean spray, Pacific red elderberry, salal.	Western sword fern, twinflower, vanilla leaf, trail plant, beadlily, deer fern, licorice fern, single sugar scoop.
Ponderosa pine	Ponderosa pine, quaking aspen, lodgepole pine, Douglas-fir gambel oak, Rocky Mountain juniper.	Antelopebrush, mountain-mahogany, desert buckbrush, snowbush, wax currant, common juniper.	Curlycup gumplant, various paintbrushes, blanket-flower, miner's candle, wild geranium.
Lodgepole pine	Lodgepole pine, quaking aspen, Douglas-fir, western white pine, whitebark pine, Engelmann spruce.	Snowbrush, kinnikinnick, grouse whortleberry, red elderberry, Canada buffalo-berry.	Heartleaf arnica, Wyoming paintbrush, pinedrops, red fireweed, pipissewa, common yarrow.
Spruce-fir	Engelmann spruce (white spruce in far north), subalpine fir (balsam fir in far north), blue spruce, white fir, lodgepole pine.	Grouse whortleberry, myrtle blueberry, tundra dwarf birch, Canada buffalo-berry, Colorado currant.	Jacob's ladder, explorer's gentian, broadleaf arnica, pipissewa, monkshood, twinflower, starflower.
Redwood	Redwood, western hemlock, Douglas-fir, bigleaf maple sugar pine, California bay, Pacific madrone.	Pacific rhododendron, western azalea, evergreen huckleberry, salal, salmonberry.	Redwood sorrel, single sugar scoop, western trillium, redwood violet.
Pinyon-juniper	Two-needle pinyon, Utah juniper, Rocky Mountain juniper, gambel oak, oneseed juniper.	Big sagebrush, alderleaf cercocarpus, curleaf cercocarpus, bitterbrush, desert buckbrush.	Sego lily, Indian paintbrush, scarlet globemallow, various lupines, golden aster, wild zinnia.
Aspen	Quaking aspen, lodgepole pine, Douglas-fir, blue spruce, subalpine fir, white fir.	Roundleaf snowberry, Rocky Mountain maple, common chokeberry, common juniper, ninebark.	Colorado columbine, showy daisy, red fireweed, showy loco, common lupine, sego lily.



Wendell Gilgert

**Table 12. Indicator wildlife species of western forest groups.**

Forest type*	Reptiles and amphibians	Birds	Mammals
Douglas-fir Table 12A	Pacific giant salamander, northwestern salamander, western toad, and Ensatina.	Spotted owl, Vaux's swift, white-winged crossbill, winter wren, great horned owl.	Red tree vole, northern flying squirrel, Townsend chipmunk, mountain beaver.
Hemlock-Sitka spruce Table 12B	Pacific tree frog, Ensatina, western red-backed salamander, dunn salamander, Oregon slender salamander.	Winter wren, Townsend's warbler, chestnut-backed chickadee, pileated woodpecker, varied thrush, spruce grouse.	Townsend chipmunk, yellow pine chipmunk, red squirrel, western gray squirrel, marten, bobcat.
Ponderosa pine Table 12C	Fence lizard, many-lined skink, woodhouse toad, sagebrush lizard.	Hepatic tanager, western bluebird, pygmy nuthatch, band-tailed pigeon, Steller's jay.	Tassel-eared squirrel, golden-mantled squirrel, Colorado chipmunk, porcupine.
Lodgepole pine Table 12D	Pacific giant salamander, western toad, Pacific tree-frog, northern leopard frog, western skink.	White-breasted nuthatch, blue grouse, western woodpeewee, Steller's jay, red crossbill, and others.	Red (pine) squirrel, marten, hoary bat, least chipmunk, snowshoe hare, and others.
Spruce-fir Table 12E	Ensatina, western red-backed salamander, western toad, northern leopard frog, Pacific treefrog, common garter snake.	Gray jay, ruby-crowned kinglet, red-breasted nuthatch, black-backed woodpecker, golden-crowned kinglet.	Snowshoe hare, red (pine) squirrel, red fox, mountain vole, lynx, bighorn sheep, longtail weasel.
Redwood Table 12F	Northern alligator lizard, western whiptail, rubber boa, western skink, western racer.	Anna's hummingbird, Wilson's warbler, western screech-owl, rufous hummingbird, northern flicker.	Western gray squirrel, deer mouse, Sonoma chipmunk, raccoon.
Pinyon-juniper Table 12G	Collared lizard, eastern fence lizard, bullsnake, short-horned lizard, western rattlesnake.	Bushtit, pinyon jay, plain titmouse, black-chinned hummingbird, rock wren, canyon towhee.	Blacktail jackrabbit, ringtail, Colorado chipmunk, pallid bat, gray fox.
Aspen Table 12H	Smooth green snake, boreal toad, western terrestrial garden snake.	Violet-green swallow, mountain bluebird, red-naped sapsucker, broad-tailed hummingbird.	Beaver, porcupine, masked shrew, dusky shrew, long-legged myotis.

\* Forest group and wildlife management recommendations table number (see following pages)



*Snowshoe hare.*

**Table 12A. Western Douglas-fir forests: general recommendations by wildlife management objective.**

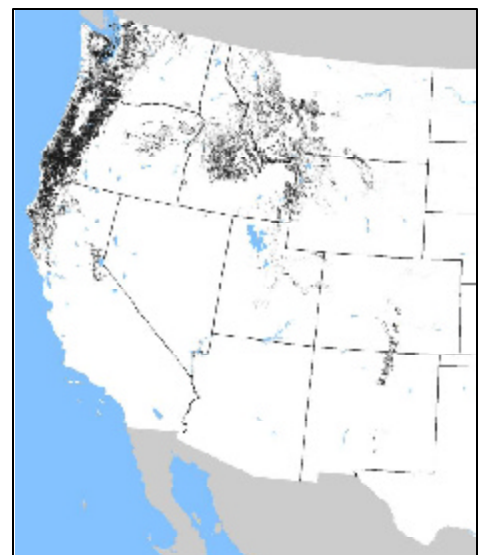
Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	Spotted owl, Vaux's swift, white-winged crossbill, winter wren, great horned owl, red tree vole, northern flying squirrel, chickaree (Douglas squirrel), Townsend chipmunk, porcupine, black bear, mountain beaver, mule deer	For even-aged management, clearcut in small blocks or strips 10-40 acres in size, and provide several timber stand age classes in close proximity; prescribed burns to reduce slash and favor Douglas fir regeneration, leave some slash for wildlife cover.
		For uneven-aged management, provide a variety of dominant tree species and encourage development of overstory, mid-story, and understory vegetation (if western larch desirable).
		Maintain at least 10 percent of stand in old-growth to ensure availability of natural snags and den trees; preserve soft mast species.
		Preserve existing snags to provide approximately 2-4 large snags (>12-inch dbh) per acre of forest.
		Maintain no-harvest buffer zones along streams to protect riparian and in-stream aquatic habitats.
Forest interior birds	Ruby-crowned kinglet, hermit thrush, western wood-pewee, mountain chickadee, hermit warbler, Townsend's warbler, pine siskin, blue grouse, evening grosbeak	In fragmented landscapes, maintain large blocks of contiguous habitat.
		Minimize effects of fragmentation by conducting uneven-aged timber management practices.
		Minimize the amount of edge created by clearcuts by keeping openings in the forest as close to a circular shape as possible.
Late successional species	Spotted owl, hermit warbler, red-breasted nuthatch, brown creeper	Maintain no-harvest sanctuaries of old-growth forest.
		Maximize rotation length in timber stands managed for harvest, and maintain at least 50 percent of the forested area as mature stands (>100 yrs old).
		Position long-rotation stands around contiguous and no-harvest old-growth reserves; do not remove standing snags or downed logs.
		Maintain no-harvest areas at least 300 feet wide along riparian areas.
Specific rare, threatened, or endangered species		Provide habitat conditions specific to the needs of the identified species.

*Douglas-fir forests are found throughout the Pacific Northwest and are present in nearly all but the highest elevations. Douglas-firs often occupy drier sites than those of the hemlock-spruce forest.*



**Black bear.**

CVIOG/GeorgiaInfo



**Western Douglas-fir forests**

**Table 12B. Western hemlock-sitka spruce forests: general habitat management recommendations by wildlife management objectives.**

Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	Winter wren, Townsend's warbler, chestnut-backed chickadee, pileated woodpecker, varied thrush, spruce grouse, Townsend's chipmunk, yellow pine chipmunk, red squirrel, western gray squirrel, marten, bobcat	For even-aged management, provide several timber age classes in close proximity.
		For uneven-aged management, provide a variety of dominant tree species and encourage development of overstory, mid-story, and understory vegetation.
		Preserve existing standing snags to provide approximately 2-4 large snags (>12-inch dbh) per acre of forest.
		Maintain no less than 10 percent of the stand in old-growth to ensure availability of snags and den trees.
		Maintain no-harvest buffer zones along streams to protect riparian and in-stream aquatic habitats.
Forest interior birds	Ruffed grouse, blue grouse, fox sparrow, western wood-pewee, Hammond's flycatcher, olive-sided flycatcher, golden-crowned kinglet	In fragmented landscapes, maintain large blocks of contiguous forest habitat.
		Minimize effects of fragmentation by conducting uneven timber management practices.
		Minimize the amount of edge created keeping clearcut openings as close to circular shape as possible.
Late successional species	Pileated woodpecker, spotted owl, red-breasted sapsucker, hairy woodpecker, brown creeper, red-breasted nuthatch, hermit warbler	Maintain no-harvest sanctuaries of old-growth forest.
		Maximize rotation length in timber stands managed for harvest, and maintain at least 50 percent of the forested area as mature stands (>100 years of age).
		Position long-rotation stands around contiguous and no-harvest mature forest reserves.
		Maintain no-harvest areas at least 300 feet wide along riparian areas.
Specific rare, threatened, or endangered species	See U.S. Fish and Wildlife Service Endangered Species Homepage and individual state listing.	Provide habitat conditions specific to the needs of the identified species.

Western hemlock-sitka spruce forests



*The hemlock-spruce forest is also called the temperate rain forest. Due to the ample rainfall, trees in the hemlock-spruce forest can reach 200 feet and live almost 1,000 years. The oldest forests are also called old-growth forests and many mosses, lichens, and other epiphytes grow on tree branches and the forest floor.*



Richard Baetsen USFWS

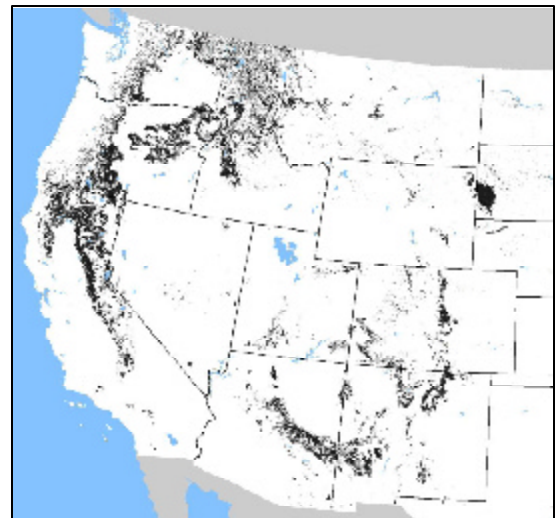
*The spruce grouse prefers mature, old growth coniferous forests.*



**Table 12C. Western ponderosa pine forests: general habitat management recommendations by wildlife management objective.**

Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	Hepatic tanager, western bluebird, pygmy nuthatch, band-tailed pigeon, Steller's jay, dark-eyed junco tassel-eared squirrel, golden-mantled squirrel, least chipmunk, black bear, coyote, elk, mule deer	For even-aged management, provide several timber age classes in close proximity.
		For uneven-aged management, provide a variety of dominant tree species and encourage development of overstory, mid-story, and understory vegetation.
		Preserve existing snags to provide approximately 2-4 large snags (>12-inch dbh) per acre of forest.
		Maintain no less than 10 percent of the stand in old-growth to ensure availability of snags and den trees.
		Maintain no-harvest buffer zones along streams to protect riparian and in-stream aquatic habitats.
Forest interior birds	Red-breasted nuthatch, white-breasted nuthatch, brown creeper, Grace's warbler, yellow-rumped warbler	In highly fragmented landscapes, maintain large blocks of contiguous forest.
		Use uneven-aged timber harvest practices to minimize the effects of forest fragmentation.
		Minimize the amount of edge by keeping clearcut openings as close to a circular shape as possible.
Late successional species	White-headed woodpecker, flammulated owl, Lewis's woodpecker, black-backed woodpecker	Practice frequent, low-intensity prescribed burns to maintain park-like structure dominated by very large trees (primarily ponderosa pine).
		Maintain no-harvest sanctuaries of old-growth.
		Maximize rotation length in timber stands managed for harvest, and maintain at least 50 percent of the forested area as mature stands (>100 years old).
		Position long-rotation stands next to contiguous and no-harvest mature forest reserves.
		Maintain no-harvest areas at least 300 feet wide along riparian areas.
		Do not remove snags or downed logs from stands.
Specific rare, threatened, or endangered species	See U.S. Fish and Wildlife Service Endangered Species Homepage and individual state listing.	Provide habitat conditions that meet the needs of the identified species.

*Ponderosa pine forests are found throughout the southern and central Rocky Mountains. Ponderosa pine is the most widely distributed pine species in the west. At lower elevations and south-facing slopes, Rocky Mountain juniper mixes with ponderosa pine forests. At higher elevations, shrub cover is dense and quaking aspen and lodgepole pine mix with ponderosa pine.*

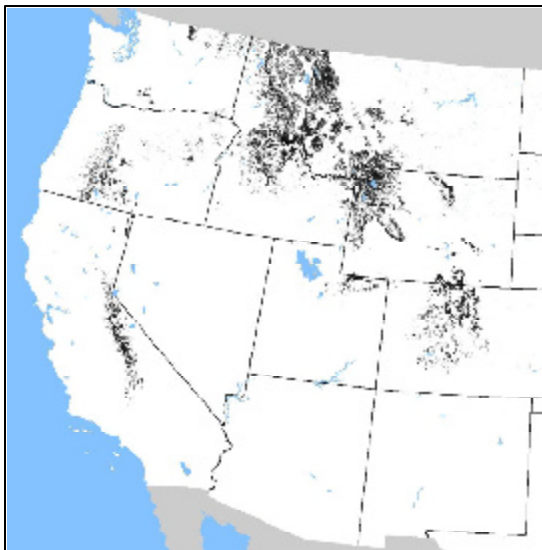


Western ponderosa pine forests

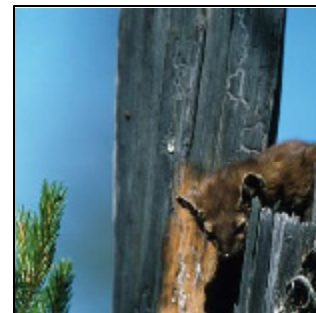
**Table 12D. Western lodgepole pine forests: general habitat management recommendations by wildlife management objective.**

Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	Blue grouse, western wood-pewee, white-breasted nuthatch, Steller's jay, red cross-bill, pine grosbeak, calliope hummingbird, red squirrel, marten, least chipmunk, southern red-backed vole, elk	For even-aged management, provide several timber age classes in close proximity; clearcut overmature stands in blocks up to 40 acres in size.
		Keep clearcut blocks or strips less than 200-300 feet wide and separate cut areas by untreated strips 100-400 feet wide.
		Retain inclusions of Douglas-fir, spruce-fir, ponderosa pine, and aspen; prescribed burns promote seed dispersal.
		Preserve existing standing snags to provide approximately 2-4 large snags (>12-inch dbh) per acre of forest.
		Maintain at least 10 percent of the stand in old-growth to ensure availability of natural snags and den trees.
		Maintain no-harvest buffer zones along streams to protect riparian and in-stream aquatic habitats.
Forest interior birds	Northern saw-whet owl, sharp-shinned hawk, Cassin's finch, ruby-crowned kinglet, hermit thrush, Clark's nutcracker	In highly fragmented landscapes, maintain large blocks of contiguous forest.
		Preserve snags and downed logs in forest stands.
Late successional species	Black-backed woodpecker, three-toed woodpecker, red-breasted nuthatch, brown creeper	Maintain no-harvest sanctuaries of old-growth forest.
		Maximize rotation length in timber stands managed for harvest, and maintain at least 50 percent of the forested area as mature stands (>100 years old).
		Position long-rotation stands around contiguous and no-harvest mature forest reserves.
		Maintain no-harvest areas at least 300 feet wide along riparian areas.
Specific rare, threatened, or endangered species	See U.S. Fish and Wildlife Service Endangered Species Homepage and individual state listing.	Do not remove snags or downed logs from stands.
		Provide habitat conditions that meet the specific needs of the identified species.

Western lodgepole pine forests



*Lodgepole pines can occur in pure, even-aged stands and often show signs of previous fires around trunks. Many bark gleaning birds use lodgepole pines for food sources, especially nuthatches and woodpeckers. Mountain chickadees, yellow-rumped warblers, and western wood-pewee take advantage of the ample insect populations of lodgepole stands. The black-backed, three-toed, and Lewis' woodpeckers all prefer the habitat of recently burned lodgepole pine forests. Pine martens and red squirrels (also called pine squirrels) are common lodgepole pine forest inhabitants.*



John and Karen Hollingsworth  
**Pine marten**

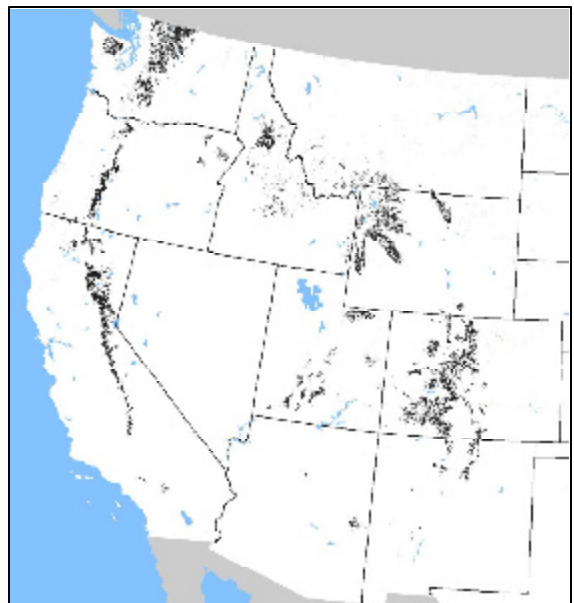
**Table 12E. Western spruce-fir forests: general habitat management recommendations by wildlife management objective.**

Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	Gray jay, hermit thrush, red-breasted nuthatch, yellow-rumped warbler, northern goshawk, hairy woodpecker, snowshoe hare, red (pine) squirrel, porcupine, lynx, bobcat, mule deer, bighorn sheep	For even-aged management, provide several timber age classes in close proximity.
		For uneven-aged management, provide a variety of dominant tree species and encourage development of overstory, mid-story, and understory vegetation.
		Preserve existing snags to provide approximately 2-4 large snags per acre of forest.
		Maintain no less than 10 percent of the stand in old-growth to ensure availability of snags and den trees.
		Maintain no-harvest buffer zones along streams to protect riparian and in-stream aquatic habitats.
		Spruce seem to establish more quickly on sites newly opened up by fire.
Forest interior birds	Boreal owl, northern saw-whet owl, ruby-crowned kinglet, golden-crowned kinglet	In highly fragmented landscapes, maintain large blocks of contiguous forest.
		Use uneven-aged timber harvest practices to minimize the effects of forest fragmentation.
		Minimize the amount of edge by keeping clearcut openings as close to a circular shape as possible.
Late successional species	Pine siskin, red crossbill, black-backed woodpecker, three-toed woodpecker, brown creeper, Clark's nutcracker	Maintain no-harvest sanctuaries of old-growth.
		Maximize rotation length in timber stands managed for harvest, and maintain at least 50 percent of the forested area as mature stands (>100 years old).
		Position long-rotation stands next to contiguous and no-harvest mature forest reserves.
		Maintain no-harvest areas at least 300 feet wide along riparian areas.
Specific rare, threatened, or endangered species	See U.S. Fish and Wildlife Service Homepage and individual state listing.	Do not remove snags or downed logs from stands.
		Provide habitat conditions that meet the needs of the identified species.



Al and Betty Schneider, Southwest Colorado  
Wildflowers, Ferns, and Trees

*Engelmann spruce.*



Western spruce-fir forests

**Table 12F. Western redwood forests: general habitat management recommendations by wildlife management objective.**

Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	Anna's hummingbird, Wilson's warbler, western screech-owl, rufous hummingbird, varied thrush, western flycatcher, Vaux's swift, northern pygmy owl, Swainson's thrush, Douglas squirrel, Sonoma chipmunk, mule deer, elk	For even-aged management, provide several timber age classes in close proximity.
		For uneven-aged management, provide a variety of dominant tree species and encourage development of overstory, mid-story, and understory vegetation.
		Preserve existing standing snags.
		Maintain no less than 10 percent of the stand in old-growth to ensure availability of snag and den trees.
		Maintain no-harvest buffer zones along streams to protect riparian and in-stream aquatic habitats.
Forest interior birds	Golden-crowned kinglet, spotted owl, varied thrush, western flycatcher	In fragmented landscapes, maintain large blocks of contiguous, mature forested habitat.
		Minimize the effects of fragmentation by conducting uneven-aged timber management practices.
Late successional species	Spotted owl, hairy woodpecker, brown creeper, pygmy nuthatch, black-backed woodpecker	Maintain no-harvest sanctuaries of old-growth forest.
		Maximize rotation length in timber stands managed for harvest, and maintain at least 50 percent of the forested area as mature stands (>100 years old).
		Do not remove snags or downed logs from stands.
		Position long-rotation stands around contiguous and no-harvest mature forest reserves.
		Maintain no-harvest areas at least 300 feet wide along riparian areas.
Specific rare, threatened, or endangered species	See U.S. Fish and Wildlife Service Endangered Species Homepage and individual state listing.	Provide habitat conditions specific to the needs of the indentified species.

Western redwood forests



*Redwood forests contain the tallest trees on Earth, and require the moist, well-drained soils found along the Pacific coast from central California to southwestern Oregon. Wildlife that depend on old-growth or mature forests, such as spotted owls, northern pygmy owls, and western screech owls can be found in redwood stands. Many species of salamanders inhabit the dense litter layer of the moist forest floor.*



John and Karen Hollingsworth USFWS  
*Spotted owl*

**Table 12G. Western pinyon-juniper forests: general habitat management recommendations by wildlife management objective.**

Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	Bushtit, pinyon jay, juniper titmouse, black-chinned hummingbird, rock wren, prairie falcon, golden eagle, greater roadrunner, white-throated swift, scrub jay, sage thrasher, blacktail jackrabbit, ringtail, spotted skunk, gray fox	Avoid large block clearcuts and intersperse small clearcuts and natural woodland openings with blocks of pinyon-juniper, maintain irregular boundaries.
		Remove individual pinyon or juniper trees with a chainsaw or bulldozer, and reseed native grasses and forbes in openings.
		Where pinyon-juniper invades grasslands, cabling or chaining possible if cleared area immediately reseeded with native vegetation.
		Retain vegetation buffer strips along riparian areas and highways.
		Preserve large and mature pinyon and juniper trees, preserve existing snags and mast-producing trees.
		Retain browse species like mountain mahogany, bitterbrush, and sagebrush. Use prescribed burns to open canopies.
Forest interior species	Mountain quail, black-throated gray warbler, gray vireo, Scott's oriole, Lawrence's goldfinch	Maintain large tracts of contiguous forest whenever possible.
		Restrict selective removal of pinyon pine.
		Use prescribed burns to reduce fuel buildup.
Late successional species	Gray vireo, gray flycatcher, pinyon jay, Cassin's kingbird, juniper titmouse, Virginia's warbler	Do not remove standing snags or downed logs from stands.
		Retain no-harvest sanctuaries of mature and old-growth forest.
		Maintain no-harvest areas at least 300 feet wide along riparian areas.
Specific rare, threatened, or endangered species	See U.S. Fish and Wildlife Service Endangered Species Homepage and individual state listing.	Provide habitat conditions specific to the needs of the identified species.

*The pinyon-juniper forest is found in the upper Sonoran desert and the arid slopes of the southern and central Rocky Mountains. The forest consists mostly of small pines and junipers with sparse herbaceous groundcover. Prickly pear cacti are also present, along with characteristic desert reptiles. The pinyon cones contain large seeds that are important food sources to many wildlife species found in pinyon-juniper woodlands.*



Western pinyon-juniper forests

**Table 12H. Western aspen forests: general habitat management recommendations by wildlife management objective.**

Wildlife objective	Indicator species	Habitat recommendations
Forest wildlife species diversity	Violet-green swallow, mountain bluebird, red-naped sapsucker, broad-tailed hummingbird, ruffed grouse	For even-aged management, use clearcuts (limit to 40 acres) with irregular edges alone or in combination with prescribed burns and herbicide applications to encourage regeneration.
		Preserve mast-producing shrubs and trees for wildlife food.
		Preserve existing standing snags to provide 2-4 large snags (>12-inch dbh) per acre of forest.
		Maintain no-harvest buffer zones along streams to protect riparian and in-stream aquatic habitats.
Forest interior (closed canopy inclusion) species	Red-breasted nuthatch, hermit thrush, gray catbird, rufous-sided towhee	In highly fragmented landscapes, maintain large blocks of contiguous forest habitat.
		Minimize effects of fragmentation by conducting uneven-aged timber management practices.
		Minimize amount of edge created by clearcuts by keeping openings as close to a circular shape as possible.
Early successional species	Swainson's thrush, Wilson's warbler, Lincoln's sparrow, dark-eyed junco, black-billed and yellow-billed cuckoo, gray catbird	Use even-aged management practices to provide patches of brushy habitat.
		Leave snags and stubs with cavities in openings for cavity-nesting species.
Specific rare, threatened, or endangered species	See U.S. Fish and Wildlife Service Endangered Species Homepage and individual state listing.	Provide habitat conditions specific to the needs of the identified species.

*Aspens often grow in dense, pure stands and are common in most elevations and forest regions of the west. Firs, spruces, and junipers are sometimes found in aspen stands. Aspen stands provide food and cover for gamebirds such as ruffed grouse, and beavers and porcupines. Chokecherry and Rocky Mountain maple can be found in the understory of many mature aspen forests.*

Western aspen forests



W. Gilgert

## **Forest and Timberland Management Plans and Programs**

There are a variety of federal, state, private and non-profit organizations that provide landowners with financial and technical assistance to improve fish and wildlife habitats in forests.

### ***Landowner assistance programs***

Landowner assistance programs help private landowners develop forest management plans. These programs are part of the U.S. Forest Service Cooperative Forestry department. Cooperative Forestry coordinates partnerships with forestry organizations and federal funding helps support forest recreation, fish and wildlife resources, and timber management. Some forest product companies also offer landowner assistance programs.

The Forest Legacy Program (FLP) is a voluntary federal program. It forms partnerships between landowners and states to protect privately owned forest lands. FLP supports conservation easements, which are legally binding agreements that transfer property rights from one party to another, but the property remains under private management. The landowner negotiates property use with the states. Conservation easements restrict development and require sustainable forestry practices. Landowners must prepare a resource management plan in order to qualify as part of the easement acquisition. The federal government may fund up to 75% of the costs, and the other 25% can come from private, state, or local sources. Tax breaks are another incentive for landowners to participate in the FLP. Program information and guidelines can be found at the U.S. Forest Service website: <http://www.fs.fed.us/spf/coop/flp.htm>. Landowners can call the Cooperative Forestry Unit at (202)-205-1389.

The Forest Stewardship Program (FSP) is designed to promote multiple-use attitudes to natural resource management on non-industrial private forest lands (NIPF). The FSP develops partnerships with natural resource professionals and NIPF landowners to successfully manage private timberlands for wildlife

habitat, recreation, and water quality. State foresters and wildlife biologists help landowners implement management plans that include landowner goals and natural resource issues. Individuals and non-commercial landowners can participate in FSPs if they agree to maintain the plan for at least 10 years. If a landowner wants cost sharing assistance through the Stewardship Incentives Program (SIP), then landowners must complete the FSP. For additional program information, landowners can contact their state forester's office, the Cooperative Forestry Unit, or the U.S. Forest Service website.

The Stewardship Incentives Program (SIP) gives cost share support for NIPF landowners to help them design Forest Stewardship Plans. SIPs encourage long-term management of natural resources, like timber and wildlife, while providing economic incentives. Financial support (as part of FSPs) includes the following forest management activities: reforestation, soil and water protection and improvement, riparian and wetland protection and improvement, fisheries habitat enhancement, wildlife habitat enhancement, and others. The federal government may reimburse the landowner up to 75% of approved expenses, to a maximum amount of \$10,000 per year per landowner. This financial support depends on the landowner's commitment to maintain SIP funded practices for at least 10 years. For more information on this program, landowners should contact their state forester's office, the Cooperative Forestry Unit, or the U.S. Forest Service website.

### ***Forestry Incentives Program***

Forestry Incentives Program (FIP) is part of the 1996 Farm Bill, and share up to 65% of the costs for tree planting, timber stand improvements (TSI), and other actions on non-industrial private lands. FIP is designed to help non-industrial private landowners maintain forestry practices that protect natural resources and future timber supplies. As with SIP, the federal cost share has a \$10,000 limit per landowner per year, but no more than 65% of the cost can be paid. State foresters give NIPF landowners technical advice to develop forest management plans, and certify completed projects for cost shares. To find out about

**Table 26. Programs that provide technical and financial assistance to develop fish and wildlife habitat on private lands.**

<b>Program</b>	<b>Land eligibility</b>	<b>Type of assistance</b>	<b>Contact</b>
Conservation Reserve Program (CRP)	Highly erodible land, wetland and certain other lands with cropping history. Stream-side areas in pasture land.	50% cost-share for est. permanent cover and conservation practices, and annual rental payments for land enrolled in 10 to 15 year contracts. Additional financial incentives available for some practices.	NRCS or FSA state or county office
Environmental Quality Incentives Program (EQIP)	Cropland, range, grazing land and other agricultural land in need of treatment.	Up to 75% cost-share for conservation practices in accordance with 10 to 15 year contracts. Incentive payments for certain management practices.	NRCS state or county office
Partners for Fish and Wildlife Program (PFW)	Most degraded fish and/or wildlife habitat.	Up to 100% financial and technical assistance to restored wildlife habitat under a minimum 10 year cooperative agreement.	Local office of the U.S. Fish and Wildlife Service
Waterways for Wildlife	Private lands.	Technical and program development assistance to coalesce habitat efforts of corporations and private landowners to meet common watershed level goals.	Wildlife Habitat Council
Wetlands Reserve Program (WRP)	Previously degraded wetland and adjacent upland buffer, with limited amount of natural wetland and existing or restorable riparian areas.	75% cost-share for wetland restoration under 10 year contracts and 30 year easements, and 100% cost-share on restoration under permanent easements. Payments for purchase of 30 year or permanent conservation easements.	NRCS state or county office
Wildlife at Work	Corporate lands.	Technical assistance on developing habitat projects into programs that allow companies to involve employees and the community.	Wildlife Habitat Council
Wildlife Habitat Incentives Program (WHIP)	High-priority fish and wildlife habitats.	Up to 75% cost-share for conservation practices under 5 to 10 year contracts.	NRCS state or county office

*State fish and wildlife agencies as well as private groups may have assistance programs or other useful opportunities through state and local contacts.*

qualifications and FIP county participants, landowners should contact their state forester’s office, local conservation district, local Cooperative Extension office, or the NRCS.

recreational opportunities. For more information on the American Tree Farm System, landowners should contact the American Forest Foundation’s website at <http://www.affoundation.org> or call 1-888-889-4466.

***The American Tree Farm System***

The American Tree Farm System certifies owners of tree farms and NIPF lands in the U.S. that maintain strict sustainable forestry management practices. Landowners must pass an inspection every five years by a volunteer forester to become certified. In addition to producing timber, landowners must protect watershed quality, wildlife habitat, and soil, and provide

***Non-governmental contacts***

There are many non-governmental and non-profit organizations that landowners can contact for up-to-date information on forest and wildlife management, consulting contacts, publications, taxes, and current issues. Included are some available internet resources. These websites also have contact information and links to related topics.



**Conclusion**

**Some forest conservation organizations.**

Organization	Website address
Society of American Foresters	<a href="http://www.safnet.org">http://www.safnet.org</a>
American Forests	<a href="http://www.americanforests.org">http://www.americanforests.org</a>
Association of Consulting Foresters of America, Inc.	<a href="http://www.acf-foresters.com">http://www.acf-foresters.com</a>
National Association of State Foresters	<a href="http://www.stateforesters.org">http://www.stateforesters.org</a>

Comprehensive forest management can conserve, preserve, or improve fish and wildlife habitat on forested lands while meeting other landowner objectives. Effective forest management plans incorporate silviculture systems that combine several forestry practices suited to local conditions that fit the individual goals of the landowner or manager. Although this leaflet describes basic timber harvest strategies and associated wildlife management techniques, it should not be considered as a definitive answer to every problem. Silvicultural treatments change over time as the goals of landowners and managers shift

**Sources of forest wildlife habitat management assistance.**

Agency or Group	Assistance Provided	Contact
State Fish & Wildlife Agency	Educational materials, technical guidance, and cost-sharing of habitat management in some cases.	Regional, state or county office
USDA Natural Resources Conservation Service	Technical, financial and educational assistance provided directly to landowners at the local level. Help plan, apply and maintain conservation systems that are site-specific and environmentally and economically sound.	Local county office
USDA Cooperative State Research, Education and Extension Service	Information and educational materials on forest and wildlife management.	Regional, state or county office; partner universities
U.S. Fish and Wildlife Service	Technical, educational, and in some cases financial assistance for habitat restoration and management.	State or local office
National Association of Conservation Districts	Through local conservation districts, educate and assist local land managers conserve soil, water, wildlife, forests, and other natural resources.	Local conservation district office
Private Conservation Organizations	A variety of conservation organizations provide Technical, educational, and in some cases financial assistance for habitat restoration and management. Groups include: Bat Conservation International Ducks Unlimited Longleaf Alliance National Fish and Wildlife Foundation National Wild Turkey Federation Quail Unlimited Quality Deer Management Association Rocky Mountain Elk Foundation Ruffed Grouse Society The Wildlife Society Wildlife Habitat Council Wildlife Management Institute	State or local contacts

and management techniques improve. It is important for landowners and managers to enroll the technical expertise of natural resource professionals. These cooperative relationships help conserve natural resources while conducting sustainable forest management practices in the future.

## References

### Internet sources

Audubon Society of New Hampshire. 1998. Conservation fact sheet: vernal pools. New Hampshire Audubon Society.  
<http://www.nh Audubon.org/conservation/vernal.htm>.

Center for Environmental Literacy. 2000. Vernal Pools. Mount Holyoke College.  
<http://www.mtholyoke.edu/proj/cel/habitat/vernal.html>.

Environmental Protection Agency. Vernal pools.  
<http://www.epa.gov/owow/wetlands/types/vernal.html>.

Messmer, T. A., M. A. Johnson, and F. B. Lee. 1989. Homemade nest boxes for cavity nesting ducks. NDSU Extension Service, Fargo, ND. Jamestown, ND: Northern Prairie Research Center Homepage. <http://www.npwrc.usgs.gov/resource/tools/nestbox.htm> (Version 15AUG97).

O' Guinn, M. Ephemeral life in the Pioneer Valley. Entomology Department, University of Massachusetts.  
<http://www.bio.umass.edu/biology/conn.river/vernal.html>.

The Nature Conservancy, 2000, Wings of the Americas, *in* <http://www.tnc.org/wings/wingsresource/>.

U.S. Fish and Wildlife Service, Endangered Species Listing Program Homepage. 2000. <http://endangered.fws.gov/listing/index.html>.

### Printed sources

Barber, D. R., T. E. Martin, M. A. Melchoirs, R. E. Thill, and T. B. Wigley. 2001. Nesting success of birds in silvicultural treatments in southeastern U.S. pine forests. *Conservation Biology* 15(1):1-12.

Barnes, B. V., D. R. Zak, S. R. Denton, and S. H. Spurr. 1998. *Forest ecology*, fourth ed. John Wiley & Sons, New York, New York, USA.

Bates, A. L., S. S. Harper, K. R. Kelley, and D. H. Webb. 1997. *Banks & buffers: a guide to selecting native plants for streambanks and shorelines*. Tennessee Valley Authority, Chattanooga, Tennessee, USA.

Bellrose, F. C., K. L. Johnson, and T. U. Meyers. 1964. Relative value of natural cavities and nesting houses for wood ducks. *Journal of Wildlife Management* 28:661-676.

Bock, W. M., and L. A. Brennan. 1970. The ecology and behavior of Lewis' Woodpecker (*Asyndesmus lewis*). University of California Publication Zoology Number 92.

Bolen, E. G. and W. L. Robinson. 1995. *Wildlife ecology and management*, third ed. Prentice Hall, Upper Saddle River, New Jersey, USA.

Bookhout, T. A., ed. 1996. *Research and management techniques for wildlife and habitats*. The Wildlife Society, Bethesda, Maryland, USA.

Carey, A. B., S. P. Horton, and B. L. Biswell. 1992. Northern spotted owls: influence of prey base and landscape characteristics. *Ecological Monographs* 62:223-250.

Chandler, C., P. Cheyney, P. Thomas, L. Traub, and D. Williams. 1983. *Fire in forestry*. 2 vols. Wiley, New York, New York, USA.

Conner, R. N., S. D. Jones, and G. D. Jones. 1994. Snag condition and woodpecker foraging ecology in a bottomland hardwood forest. *Wilson Bulletin* 106:242-257.

Cowardin, L. M. 1969. Use of flooded timber by waterfowl at the Montezuma National Wildlife Refuge. *Journal of Wildlife Management* 33(8):829-842.

DeGraaf, R. M., V. E. Scott, R. H. Hamre, L. Ernst, and S. H. Anderson. 1991. *Forest and rangeland birds of the United States: natural history and habitat use*. U.S. Department of Agriculture, Forest Service, Agriculture handbook 688.

Droege, S. 1993. Monitoring neotropical migrants on managed lands: when, where, why. Pages 189-191 *in* D. Finch and P. Stangel, eds., *Status and Management of Neotropical Migratory Birds*. USDA Forest Service Rocky Mountain Forest and Range Experiment Station, Gen. Tech. Rep. 229, Fort Collins, Colorado, USA.

Faaborg, J., M. Brittingham, T. Donovan, and J. Blake. 1993. Habitat fragmentation in the temperate zone: a perspective for managers. Pages 331-338 *in* D. Finch

- and P. Stangel, eds., Status and Management of Neotropical Migratory Birds. USDA Forest Service Rocky Mountain Forest and Range Experiment Station, Gen. Tech. Rep. 229, Fort Collins, Colorado, USA.
- Georgia Environmental Protection Division. 1991. Georgia's best management practices for forestry.
- Hamilton, R. J. 1981. Effects of prescribed fire on black bear populations in southern forests. Pages 129-134 in G. W. Wood, ed. Prescribed fire and wildlife in southern forests. Clemson University, Georgetown, South Carolina, USA.
- Helms, J. A. ed. 1998. The dictionary of forestry. Society of American Foresters. Bethesda, Maryland, USA.
- Hobson, S. S., J. S. Barclay, and S. H. Broderick. 1993. Enhancing wildlife habitats: a practical guide for forest landowners. Northeast Regional Agricultural Engineering Service, Ithaca, New York, USA.
- Hoover, R. L. and D. L. Wills, ed. 1984. Managing forested lands for wildlife. Colorado Division of Wildlife and U.S. Department of Agriculture Forest Service.
- Hunter, M. L., Jr. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Prentice Hall, Englewood Cliffs, New Jersey, USA.
- Kaminski, R. M., R. W. Alexander, and B. D. Leopold. 1993. Wood duck and mallard winter microhabitats in Mississippi hardwood bottomlands. *Journal of Wildlife Management* 57(3):562-570.
- Kricher, J. C. and G. Morrison. 1988. A field guide to eastern forests. Houghton Mifflin, New York, New York, USA.
- Kricher, J. C. and G. Morrison. 1993. A field guide to the ecology of western forests. Houghton Mifflin, New York, New York, USA.
- Mills, L. S., R. J. Fredrickson, and B. B. Moorehead. 1993. Characteristics of old-growth forests associated with northern spotted owls in Olympic National Park. Allen Press, Lawrence, Kansas, USA.
- Missouri Conservation Commission. 1985. Brushpiles, No. 1, Timber and wildlife benefits on private land. Missouri Conservation Commission, USA.
- Payne, N. F., and F. C. Bryant. 1994. Techniques for wildlife habitat management of uplands. McGraw-Hill, New York, New York, USA.
- Roach, B. A. 1974. Scheduling timber cutting for sustained yield of wood products and wildlife. Pages 33-43 in J. P. Slusher and T. M. Hinckley, eds. Timber-wildlife management symposium. University of Missouri, Columbia, USA.
- Robbins, C. S., D. K. Dawson, and B. A. Dowell. 1989. Habitat area requirements of breeding forest birds of the middle Atlantic states. *Wildlife Monographs* 103:1-34.
- Robinson, S. K., J. A. Grzybowski, S. I. Rothstein, M. C. Brittingham, L. J. Petit, and F. R. Thompson. 1993. Management implications of cowbird parasitism on neotropical migrant songbirds. Pages 93-102 in D. Finch and P. Stangel, eds., Status and Management of Neotropical Migratory Birds. USDA Forest Service Rocky Mountain Forest and Range Experiment Station, Gen. Tech. Rep. 229, Fort Collins, Colorado, USA.
- Rodieck, J. E. and E. G. Bolen. 1991. Wildlife and habitats in managed landscapes. Island Press, Washington, D.C., USA.
- Rosenberg, K. V., R. W. Rohrbaugh, Jr., S. E. Barker, J. D. Lowe, R. S. Hames, and A. A. Dhondt. 1999. A land managers guide to improving habitat for scarlet tanagers and other forest-interior birds. The Cornell Lab of Ornithology.
- Saab, V. A. and J. G. Dudley. 1998. Responses of cavity-nesting birds to stand-replacement and salvage logging in ponderosa pine/Douglas-fir forests of southwestern Idaho. USDA Forest Service Rocky Mountains Research Station Research Paper RMRS-RP-11, Ogden, Idaho, USA.
- Smith, D. M., B. C. Larson, M. J. Kelty, and P. M. S. Ashton. 1997. The practice of silviculture: applied forest ecology, ninth ed. John Wiley & Sons, New York, New York, USA.
- Stebbins, R. C. 1985. Western reptiles and amphibians. Second edition. Houghton Mifflin, New York, New York, USA.
- Thompson, F. R., W. D. Dijak, T. G. Kulowiec, and D. A. Hamilton. 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. *Journal of Wildlife Management* 56(1):23-30.

**Wildlife Habitat Management Institute**

100 Webster Circle, Suite 3  
Madison, Mississippi 39110  
(601) 607-3131

In cooperation with partners, the mission of the Wildlife Habitat Management Institute is to develop and disseminate scientifically based technical materials that will assist NRCS field staffs and others to promote conservation stewardship of fish and wildlife, and deliver sound habitat management principles and practices to America's land users.



[www.whmi.nrcs.usda.gov](http://www.whmi.nrcs.usda.gov)

**Wildlife Habitat Council**

8737 Colesville Road, Suite 800  
Silver Spring, Maryland 20910  
(301) 588-8994

The mission of the Wildlife Habitat Council is to increase the amount of quality wildlife habitat on corporate, private, and public land. WHC engages corporations, public agencies, and private, non-profit organizations on a voluntary basis as one team for the recovery, development, and preservation of wildlife habitat worldwide.



[www.wildlifehc.org](http://www.wildlifehc.org)

**Acknowledgements**

Primary author: Holly L. May, Wildlife Habitat Council. Drafts of this leaflet were reviewed by Richard DeGraaf, USDA, Forest Service Northeastern Research Station; Melinda Knutson, USGS Upper Midwest Environmental Sciences Center; Dan Taylor, Bat Conservation International; Dan Twedt, USGS Patuxent Wildlife Research Center; Bruce C. Wight, NRCS National Agroforestry Center; and T. Bently Wigley, National Council for Stream and Air Improvement, Inc. Edited by Charlie Rewa, NRCS Wildlife Habitat Management Institute.

The United States Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, sexual orientation, and marital or familial status. (Not all prohibited bases apply to all programs.) Person with disabilities who require alternate means for communication of program information (Braille, large print, audiotape, etc.) should contact the USDAs TARGET Center at (202) 720-2600 (voice and TDD).

To file a complaint of discrimination, write USDA, Office of Civil Rights, Room 326W, Whitten Building, 14th and Independence Avenue, SW, Washington, DC 20250-9410 or call (202) 720-5964 (voice and TDD). USDA is an equal opportunity provider and employer.