Healthy Forests

A Bird-based Silvicultural Guide for Forestry Professionals

Audubon
PENNSYLVANIA

Acknowledgements

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Technical Review Committee

Emily H. Domoto, CWB®, Ecological Services Section Chief, Bureau of Forestry, PA Department of Conservation and Natural Resources

Todd Fearer, PhD, Coordinator, Appalachian Mountains Joint Venture

Peter Hoagland, CF, State Forester, U.S. Department of Agriculture, Natural Resources Conservation Service

David R. Jackson, Forest Resources Educator, Penn State Extension

Madeline Jennison, Northern Conservation Manager, American Forest Foundation

Calvin Norman, Forestry and Wildlife Extension Educator, Penn State Extension

Greg Sanford, Supervisory Forester, U.S. Department of Agriculture, Forest Service

Cecile Stelter, District Forester, PA Department of Conservation and Natural Resources

Lisa M. Williams, Wildlife Biologist – Ruffed Grouse, Woodcock, Webless Game Birds, PA Game Commission

Kevin Yoder, Conservation Forester, The Nature Conservancy

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Cover

Black-throated Blue Warbler (*Setophaga caerulescens*). Photo Lorraine Minns/Audubon Photography Awards

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Table of Contents

Using This Guide

This forester's guide and its companion pocket guide are intended for consulting foresters, agency-based foresters, natural resource professionals, and decision makers. Together, they focus on:

1. Teaching the basic natural history of priority forest birds and describing their habitat needs.
2. Reviewing the stand- and landscape-scale forest management practices that can be used to create the desired habitat conditions, while still meeting timber, recreation, and other types of goals.
3. Working with landowners who are interested in birds and finding ways to financially support non-commercial management actions.
4. Providing example scenarios that show "real life" context for bird-friendly forest management.

This document is part of Audubon Pennsylvania's Healthy Forests Initiative, which is part of a larger program by the same name implemented by the National Audubon Society throughout the Atlantic Flyway. Within the flyway, Audubon connects with foresters and forest owners to provide information and assistance to improve forest habitat for birds in need of conservation and help create healthy forested landscapes that meet other societal needs, including carbon sequestration, watershed protection, flood control, forest products, and recreation. The Healthy Forests Initiative is part of Audubon's Working Lands conservation strategy, aimed at improving habitat on private and publicly managed lands nationwide.

Bird-friendly Forestry = Sustainable Forestry

Win-wins are the rule with sustainable forestry. What's good for the forest is good for birds. It's no accident that the pristine forests, once providing the timber products we needed as a developing nation, also supported the richest, most prolific wildlife populations in our history. Bird-friendly forestry seeks to recreate and mimic these conditions to capitalize on the natural win-wins that bring us forest products, ecosystems services, recreation, and an abundance of wildlife, including birds.

~ Ron Rohrbaugh

Wood Thrush. Photo: Juan Zamora/CC BY 2.0

Background and Overview

Birds are integral parts of forest ecosystems. Worldwide, insectivorous birds consume 400-500 million tons of insects each year, while other species cache seeds that promote tree regeneration and pollinate flowering plants. In so doing, forest dwelling birds provide ecosystems services that support overall forest health. For instance, studies have shown that birds increased growth rates of white oak (*Quercus alba*) and bark-foraging birds in particular helped to slow the spread of Emerald Ash Borer (*Agrilus planipennis*). There are hundreds of other papers in the scientific literature that illustrate the importance of birds in maintaining both ecological and socioeconomic systems.

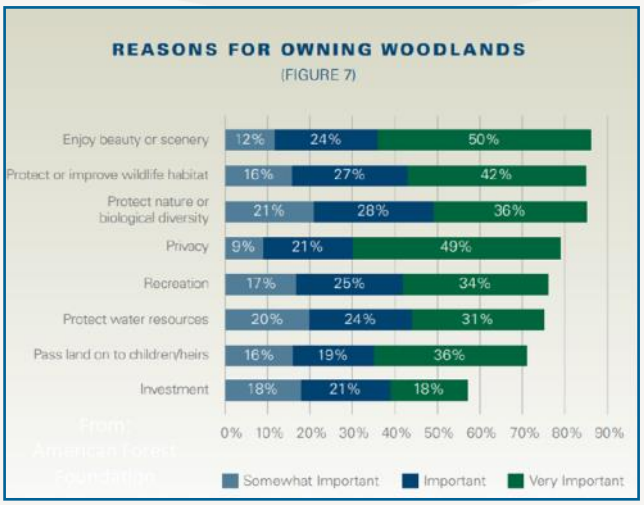
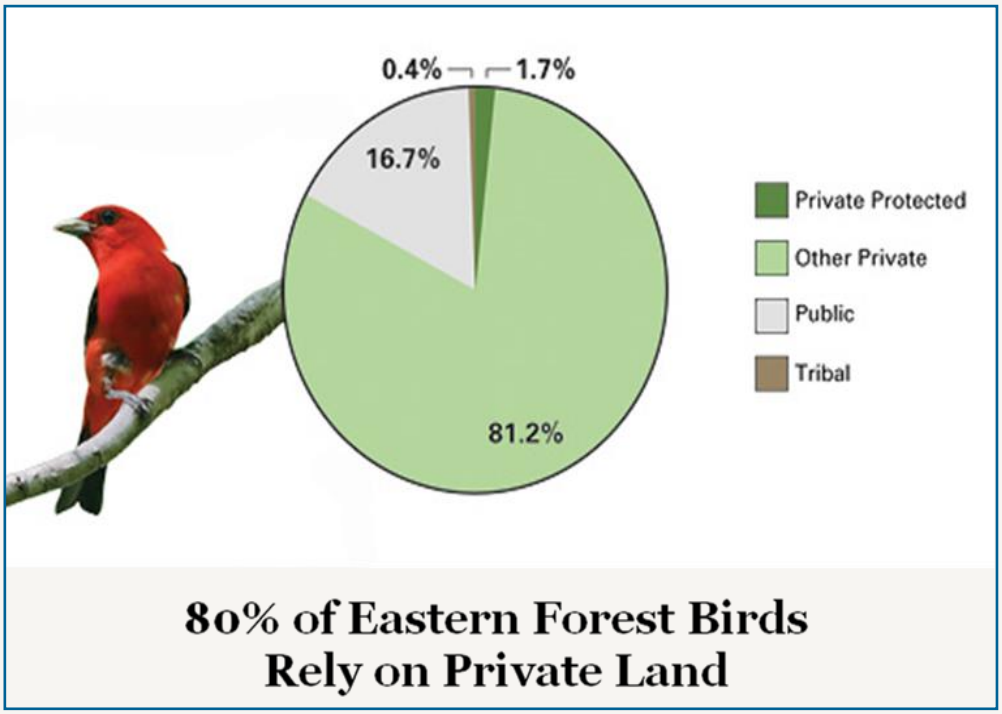


Figure 1. Results of 2016 American Forest Foundation survey of family woodland owners in 13-state northeast region.

Christopher Whelan and his colleagues summed it up well in their 2015 paper saying "Birds devour pests, pollinate flowers, disperse seeds, scavenge carrion, cycle nutrients, and modify the environment in ways that benefit other species. Investigation of these ecosystem functions directly as ecosystem services has grown immensely over the last two decades and the ecological relevance of birds is well established." It's safe to say that without robust bird populations, forests could not exist in a healthy state. It's also safe to say that stable, resilient bird populations cannot persist without adequate amounts of healthy forest to support all phases of their lifecycles.

In addition to the importance of birds in maintaining ecosystem services, recent studies reveal the intense and widespread interest in managing private lands and the important role those lands play in supporting birds (Figures 1 and 2).



A common misconception is that forest management on behalf of birds is ill-aligned with goals related to the production of timber and other forest products. Nothing could be further from the truth. With only minor adjustments, sustainable forestry practices enhance bird habitat, while still meeting financial and recreational goals. Furthermore, sustainable forestry on behalf of birds often attracts new clients for consulting foresters, drives landscape-scale management on public lands, and opens new sources of funding.

Figure 2. The 2013 State of the Birds report found that more than 80% of eastern forest birds are distributed on private lands.

The Importance of Pennsylvania Forests

In the past 50 years, birds of eastern forests have declined by 17% (Figure 3) or about 170 million individuals. With 60% forest cover in Pennsylvania, the forest management strategies we choose can have significant positive or negative impacts on bird populations. Pennsylvania forests provide important breeding, migratory stop-over, and wintering habitat for more than a hundred species of forest birds. For instance, each breeding season Pennsylvania has responsibility for about 1.2 million Wood Thrushes (*Hylocichla mustelina*), which is about 10% of the global population. Management strategies that improve Wood Thrush habitat in Pennsylvania can help to buoy the entire population. In fact, one of the most important functions of our forests is to provide breeding habitat for several dozen bird species, many of which are experiencing population declines due to a number of factors, including too little forest age-class diversity and a loss of adequate vertical structure and plant species diversity within stands. Quality forest habitat for birds and other wildlife means intact, healthy, resilient, regenerating, and diverse forested landscapes. With more than 3.3 million acres under public management and 70% (12 million acres) of the state's overall forests in private ownership, there is opportunity to manage at all scales—from woodlots to landscapes.

Figure 3. A 2019 study published in the Journal Science, documented a loss of nearly 3 billion birds in the last 50 years, including 170 million from eastern forests.

Where and How to Work

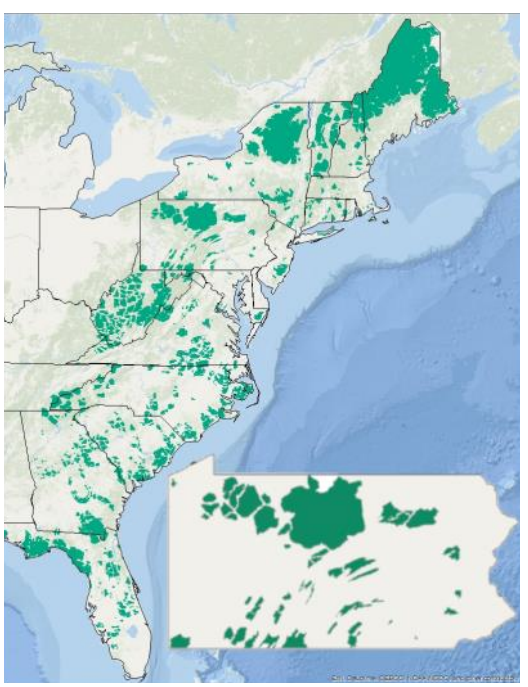


Figure 4. Audubon Priority Forest Blocks in the Atlantic Flyway and Pennsylvania (Esri, DeLorme, GEBCO, NOAA, NGDC, and other contributors.

Where to Work

Forests across Pennsylvania are not uniform in their ecological type, degree of healthiness, or types of stressors. But, in most cases forests throughout the state, and the birds that depend upon them, can benefit from science-based management. For example, in the state's highly developed southeast and southcentral regions, dealing with fragmentation is paramount, while in the northcentral region addressing age-class diversity and structure are more important. This guide is intended to be applicable statewide, as ample opportunities exist in every region.

The most important thing to consider is that effective, bird-friendly forestry can be implemented anywhere. See *Silvicultural Options and Scenarios* section for ideas.

Even though forest management opportunities exist nearly everywhere, it's helpful to understand existing landscape prioritization schemes, as working within these areas helps to achieve a broader conservation mission and can sometimes lead to funding sources. See *Resources* section for opportunities.

Audubon has identified priority forest areas from Maine to Florida that are composed of large, contiguous tracts of forest, supporting rich and abundant populations of priority forest bird species (Figure 4). For breeding forest birds, these areas represent the most important habitats in eastern forests, and they serve as focus areas for Audubon's Healthy Forests initiative. In Pennsylvania, there are over 40 Audubon priority forest areas distributed throughout the state (Figure 4).

In addition to Audubon's priority forest areas, other conservation groups and agencies have identified their own landscape priorities. It would be impossible to cover them all here, but please see the list below for more information.

- The Department of Conservation and Natural Resources Conservation Landscapes
- The Pennsylvania Game Commission's Grouse Prioritization Area Siting Tool (G-PAST)
- Pennsylvania Game Commission Conservation Opportunity Area Tool
- The Natural Resources Conservation Service's, Working Lands for Wildlife, Golden-winged Warbler Focal Areas
- The National Fish and Wildlife Foundation's Central Appalachia Stewardship Program Focal Areas
- The Western Pennsylvania Conservancy/RK Mellon Focal Geographies
- Appalachian Mountains Joint Venture Focal Landscapes

How to Work

During the past couple of decades, there have been many guides and Best Management Practices produced for individual bird species or groups of birds. In many cases, these guides assume that the primary goal for a proposed project is to improve habitat for the focal bird species. In other words, the impetus for managing a 100-acre patch of timber might be for American Woodcock (*Scolopax minor*) and Golden-winged Warbler (*Vermivora chrysoptera*) nesting habitat. A focus on birds is great when it happens and helps to keep the objectives clear. If birds are the chief goal, we recommend following the guidance provided in whatever Best Management Practice guide you are using. See Appendix A in the *References* section for a list of some of the most commonly used Best Management Practice guides for eastern forest birds.

In reality, however, the impetus for management is rarely bird conservation alone, but rather a host of other objectives, such as timber removal, stand regeneration, or development like a pipeline right of way. This is perfectly fine. Sustainable forestry practices are almost always beneficial for birds and other wildlife. **When the primary management is focused on achieving goals other than bird conservation, we simply recommend adjustments to whatever silivicultural practices are being used.** For example, it's often easy to modify shelterwood prescriptions or overstory removals to benefit birds. See *Silvicultural Options and Scenarios* section for details and ideas.

A Day in the Life: The American Woodcock

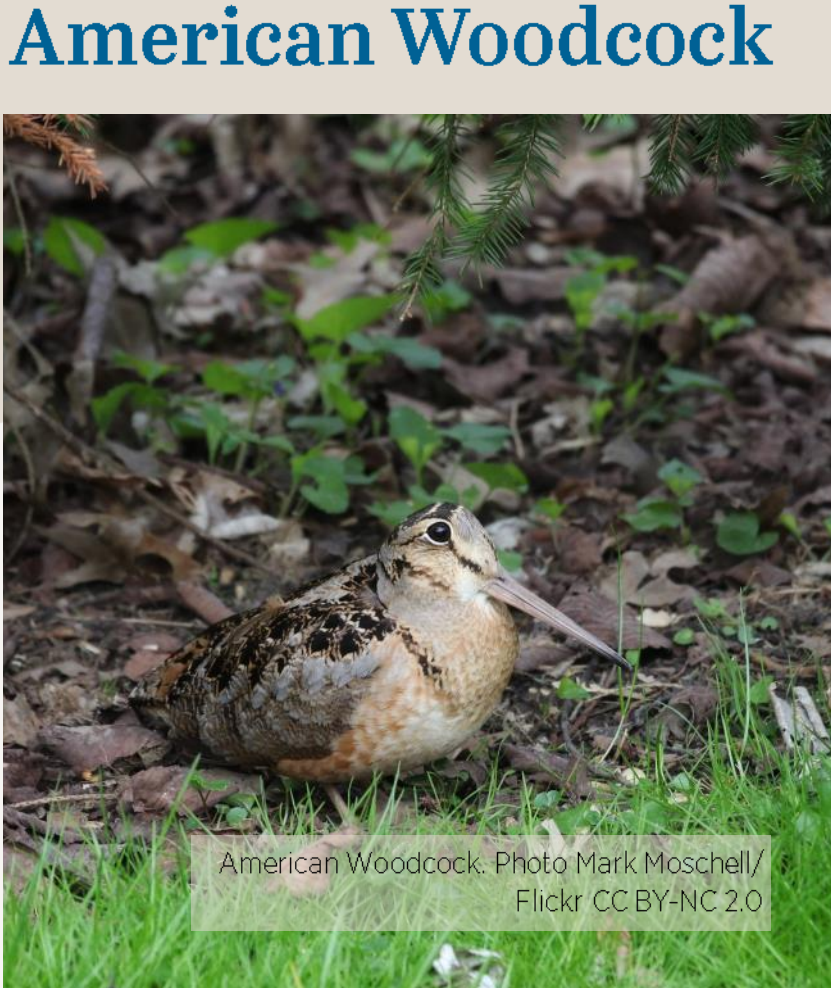
The American Woodcock requires multiple types of forest habitat from season to season and even day to night. Woodcocks arrive in Pennsylvania for their breeding season in early March, migrating from their wintering grounds in the southern United States.

Earthworms make up 60% of their diet, which makes moist, young hardwood stands or thickets an excellent feeding area.

During mating season, they take advantage of log landings, roads, old fields, pastures, and hayfields. As the sun begins to set, they perform their "sky dance" to attract a mate.

Woodcocks need yet another forest type for successful nesting. Searching for ample ground cover, woody stems, and young trees, the female will seek out a nesting area near the mating grounds and slightly uphill from her moist feeding grounds.

Healthy forest management ensures that each part of the woodcock habitat is accessible and viable.



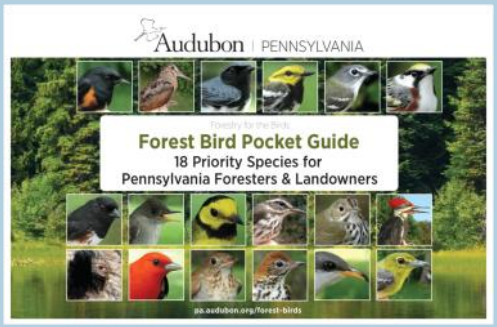
American Woodcock. Photo Mark Moschell/ Flickr CC BY-NC 2.0

Forest Birds And Their Habitats

Forest Bird Pocket Guide:

A Companion Resource for Forest-bird Management

The Forest Bird Pocket Guide (pa.audubon.org/forest-bird-pocket-guide) serves as a companion to this publication (Figure 5). The pocket guide covers 18 priority bird species that are helpful for foresters to know. The species include a mix of game and non-game birds, with the majority being Neotropical migrants that overwinter in Central and South America. For each species, the pocket guide provides pointers on identification, including sounds and field marks. In the habitat diagrams, the pocket guide shows where each species forages (pink shaded area), where it places its nest (height along right side), and what structural or compositional features within the forest are most important.



Knowing how to identify birds by sight and sound isn't necessary to manage for them, but if you are a consulting forester, it does help in talking with landowners who are interested in birds (Figure 6). The pocket guide is a good start, but we recommend also utilizing the Audubon phone app (Audubon.org/app), investing in a quality field guide, such as a Peterson's, and following the guidance provided at Audubon's online Guide to North American Birds (www.audubon.org/bird-guide).

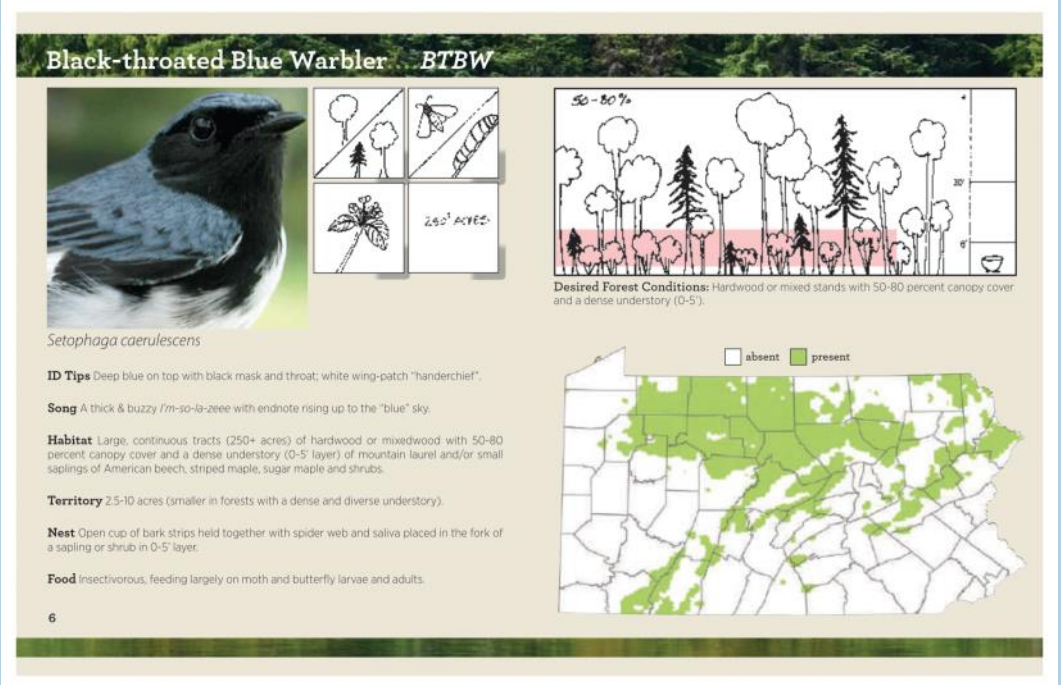


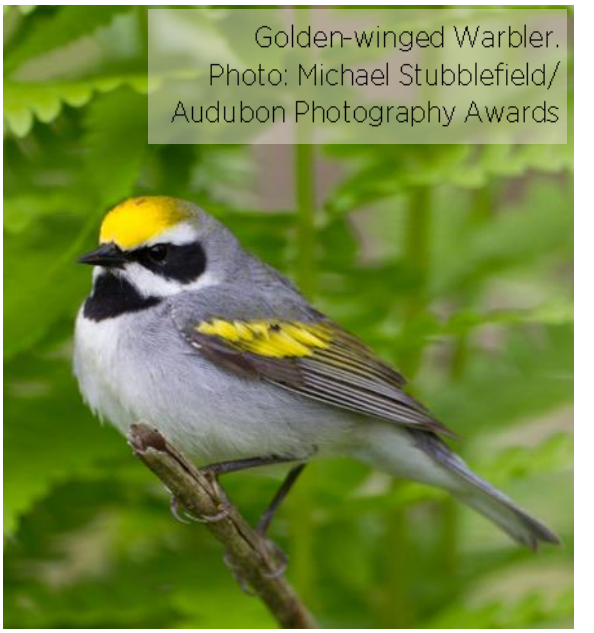
Figure 5. (Above) Cover of Forest Bird Pocket Guide.

Figure 6. (Left)

Species profile from the Forest Bird Pocket Guide. The Pocket Guide, used in combination with this forester's guide, will provide adequate information to manage for most species. Included in the Pocket Guide are 18 of the most common forest-dwelling species across the Commonwealth.

Habitat Needs of Forest Birds

Each species of forest-dwelling bird has its own specific habitat requirements that can be approached on an individual species basis or by suites of species that have similar needs. Some birds prefer to nest in mature forests with a relatively closed canopy, while others prefer to nest in young forest habitat that has shrubs and sapling-sized trees with high stem density, thick foliage, and few overstory trees. In addition, there are forest birds that will use both mature and young forest habitats for nesting or at different times in their breeding cycle.



Golden-winged Warbler. Photo: Michael Stubblefield/ Audubon Photography Awards

Nests of various species are built in all vegetation layers, ranging from the Ovenbird's (*Seiurus aurocapilla*) preference for the forest floor to the Scarlet Tanager's (*Piranga olivacea*) natural affinity for the canopy. A diversity of tree and shrub species provides diverse fruits and seeds, and supports numerous insects that forest birds consume and feed to their young. Some birds have particular forest habitat associations, like Magnolia (*Setophaga magnolia*) and Blackburnian (*Setophaga fusca*) warblers, which tend to breed in forests with a significant conifer component, whereas Wood Thrushes and Cerulean Warblers (*Setophaga cerulea*) use deciduous forests.

A mixture of forest age classes and forest types in the landscape provides nesting habitat for birds with different needs. This mixture also provides a diverse array of habitats where birds can raise their young after they fledge the nest. Mature forest birds that typically nest within the forest interior will frequently move their fledged young to areas with a dense forest understory or to young forest habitat, where they can seek cover and forage in dense foliage and stems. The converse is also true, birds such as the Golden-winged Warbler nest in young forest, but move their family groups to older forest to forage and prepare for fall migration (Figure 7).

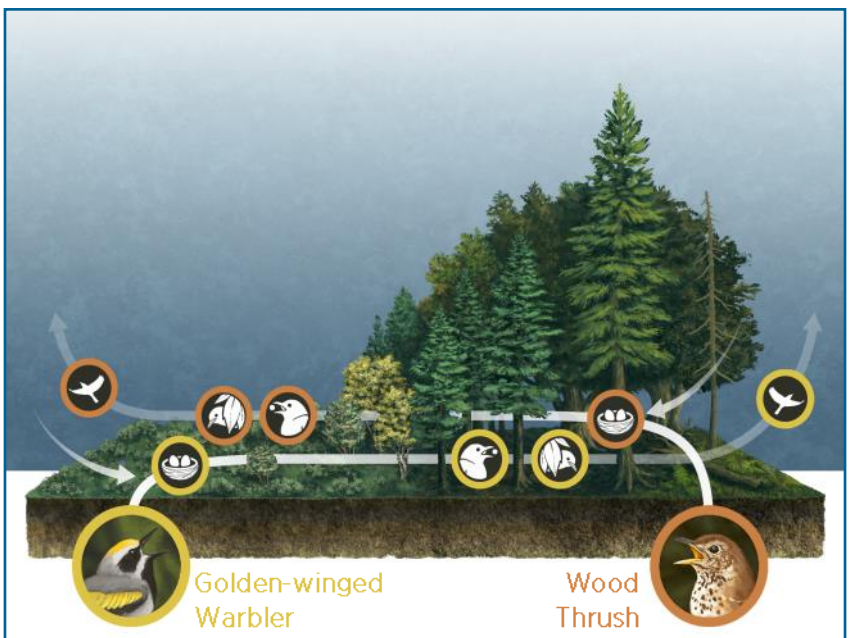


Figure 7. Diagram of age class diversity as it applies to habitat needs of Wood Thrush and Golden-winged Warblers. Courtesy of the Cornell Lab of Ornithology. Graphic by ©Phillip Krzeminski.

To have the greatest impact on a suite of forest birds, quality habitat is needed at both the stand and landscape levels. A variety of successional and developmental stages within the forested landscape and a diversity of key habitat features at the stand-level will meet these needs and can be created and maintained through forest management.

In general, we can divide forest habitat requirements into three primary categories:

1. **Geographic Scale**—what forest conditions are needed at various scales, such as the landscape and stand?
2. **Age Class**—what age forest does a species or suite of species need for the primary phases of its breeding cycle (migration, nesting, and post-fledgling)?
3. **Vertical Structure**—is there vertical layering of vegetation to create structure, such as an understory?

Let's start by talking about scale and then focus on age and vertical structure within stands.

The Landscape Scale

As migratory birds are returning in the spring, they must make a series of choices about where to establish breeding territories and build nests. The first of these choices is made at the landscape scale (See *Silviculture and the Wood Thrush* sidebar on the following page for diagram). Science suggests that settlement patterns of migratory songbirds are linked to roughly 2,500-acre blocks. For the sake of management, the 2,500-acre block can be thought of as roughly a one-mile radius around a forest stand. Ultimately, the conditions within this one-mile radius (2,500-acre block) will determine what species are likely to breed there and if they will be successful in reproducing. Forest birds thrive in landscapes with adequate forest cover (typically ≥70%) and varying forest types and age classes. You can think of this as a shifting mosaic of forest age classes that creates interspersion across the landscape. For non-migratory species, this shifting composition of age classes and forest structure is imperative for population dispersal across the landscape, since most resident species do not move far within their lifetimes.

Forested landscapes that are composed of approximately 10–20% young forest (0–10 years in age) and the remainder in mature forest (>50 years) and intermediate age classes, provide an optimal mix of habitat for a suite of forest birds. For example, some species, like Blue-winged Warblers (*Vermivora cyanoptera*) and American Woodcock, prefer young forest habitats for nesting and raising young, while others like Wood Thrushes and Scarlet Tanagers nest in mature forest. Further, certain species will breed in forests dominated by hardwood tree species, while others prefer a mixed composition of deciduous and coniferous trees, and some species need coniferous forest stands exclusively for breeding. In other words, the interspersion of forest age classes and types provides the greatest opportunity for a diverse community of breeding forest birds.

What does this need for interspersion or landscape heterogeneity mean for management strategies? Landscapes (2,500 acre blocks) with at least 70% forest that are managed on a roughly 100 year even-aged rotation with 10-20% young forest always being present will usually provide the greatest potential to support a healthy suite forest birds.

In landscapes where forest cover is less than 70%, land-use decisions should discourage converting existing forest to non-forest and encourage reforestation of non-forest sites. Within fragmented landscapes, forest management can improve habitat for birds by considering forest patch size and potential edge effects, as well as focusing on improving within-stand structure. See Cultivating Structural Diversity in *Forest Birds and Their Habitats* section for more information.

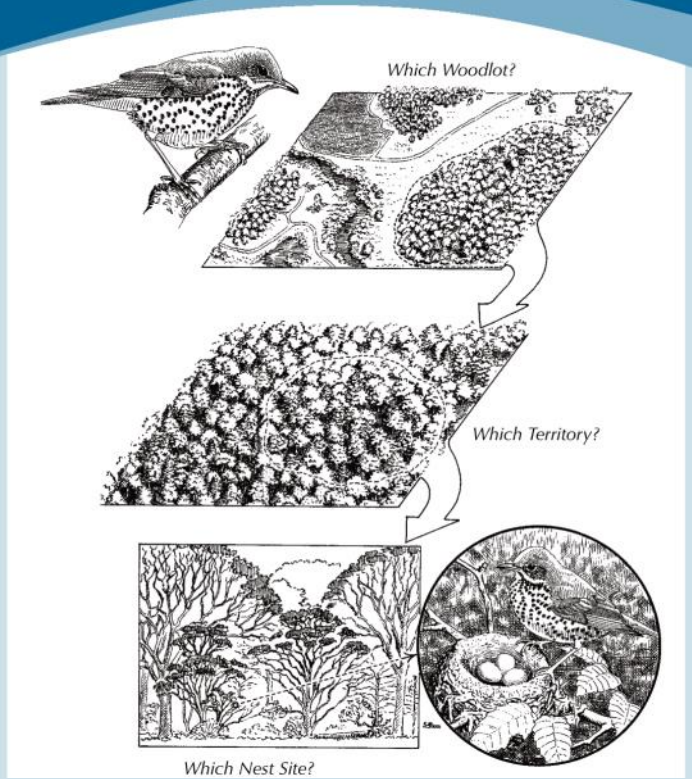
Wood Thrush with two Wood Thrush and one Brown-headed Cowbird nestlings.
Photo: Kelly Colgan Azar/Flickr CC BY-ND 2.0

Forest Patch Size and Edge

In landscapes where forest is fragmented into patches by other land uses, such as agriculture or human development, aim to keep large, contiguous tracts of mature forest intact. These core forest areas are important because many forest birds, like Scarlet Tanagers and Wood Thrushes, are area sensitive, meaning they require large habitat patches to successfully establish breeding territories, nest, and raise their young.

Forest "edge" occurs when there is an abrupt change from forest to non-forest. It's important to remember that a clearcut or regenerating old field represent young forest, not non-forest, and generally do not produce stereotypical edge effects. Edge effects produced by non-forest borders, such as predation from raccoons, cats, and skunks and nest parasitism from Brown-headed Cowbirds (*Molothrus ater*), threaten the survival and reproductive success of forest interior breeding birds. The effects of predators and Brown-headed Cowbirds are more pronounced in landscapes with high levels of forest fragmentation and where remaining forest patches are relatively small and interspersed with non-forest, such as agricultural or developed areas. Within highly fragmented landscapes, edge effects have been observed more than 300 feet inside the forest edge.

Silviculture and the Wood Thrush



Decision chain of the Wood Thrush selecting habitat. The process begins at the patch stage, followed by territory, and finally nesting site. (Rosenberg et al. 2003; Illustration N. John Schmitt)

The springtime melodic song of the Wood Thrush is a welcome occurrence in many Pennsylvania woodlots and forests. In fact, Pennsylvania has high "responsibility" for the Wood Thrush, as it supports nearly 10% of the global breeding population. This species has experienced steady, 2% annual declines for at least the past 50 years, but common silivicultural practices can improve Wood Thrush breeding habitat through establishing vertical structural diversity within mature forest and creating adjacent young forest .

For Wood Thrush, and most Neotropical migrant songbirds, selecting a place to breed involves making choices at several geographic scales. A migrating Wood Thrush returning to its breeding range is first faced with locating a woodlot or forest tract to establish a breeding territory. The woodlot/forest must be of suitable size, age, shape, and distance to key landscape features, such as young forest habitat for pre-migration foraging. After selecting a woodlot, the bird establishes a roughly five-acre territory, composed of mature forest with a well-developed understory of herbaceous plants, shrubs, and young trees. Finally, the bird selects an appropriate place within the territory to build its nest, which is placed on a forked branch of an understory tree or shrub, such as witch hazel (*Hamamelis virginiana*).

But, successful nesting isn't the end of the story. After fledglings leave the nest, Wood Thrush parents move their offspring to young forest habitat to forage and build energy for their southward migration to wintering areas in Mexico and Central America.

Wood Thrush. Photo: Andy Reago & Chrissy McClarren/Flickr CC BY 2.0

Cultivating Structural Diversity

Forest Habitat: Stand-Level Conditions

The following sections describe stand-level habitat components important to forest birds. All of these conditions apply to mature forest stands, and some also pertain to young forest stands. Many of the habitat features described in this section are similar to what you might find in late-successional hardwood forests. Truly late-successional, mature forest with a fully developed vertical structure is rare in Pennsylvania. Depending on landowner goals, forest can be set aside from management to become late-successional forest in approximately 50–150 years, alternatively the complex structure that is characteristic of older forests can be achieved by mimicking natural disturbances, such as wind throw, beaver flooding, and fire. See the companion document, *Forest Bird Pocket Guide,* for specific habitat characteristics that are important for 18 species of priority birds in Pennsylvania.

Vertical Structural Diversity

Vertical structural diversity (vertical structure) refers to the layering of vegetation at multiple heights in a stand. Stands with high vertical structure have overstory, midstory, and understory vegetation layers composed of trees, shrubs, herbaceous plants, and vines. This vertical structure provides different birds with places to nest, perch, forage, seek cover, and raise young. Vertical structure is critical to many species of birds, such as the Wood Thrush and Black-throated Blue Warbler (*Setophaga caerulescens*), and is among the most common missing feature in Pennsylvania forests. Vertical structure has been lost through widespread establishment of mostly even-aged forests with closed canopies and the presence of stressors, including over-browsing by deer and invasive plants that prevent structure from developing. Active forest management is required to overcome these unhealthy conditions and establish vertical structure.

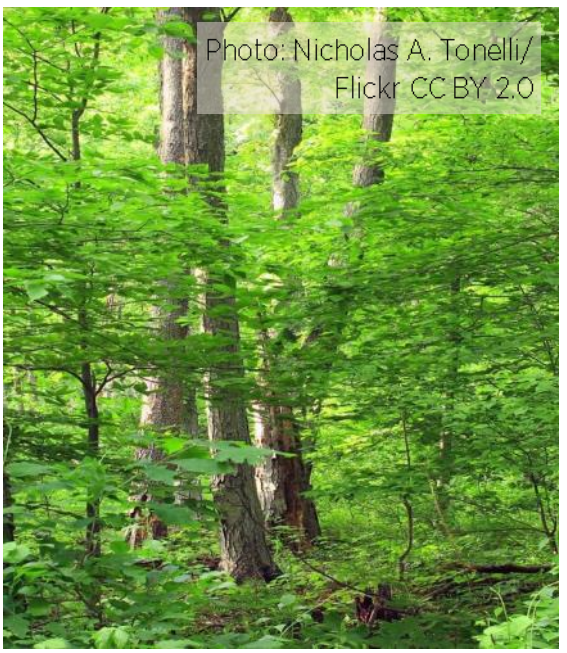


Photo: Nicholas A. Tonelli/ Flickr CC BY 2.0

Late-successional, uneven-aged forests tend to have naturally high vertical structure, exhibiting characteristics that include a tall overstory with small canopy openings (due to individual tree fall) that have allowed for several shorter canopy layers to develop. One easy technique to mimic the vertical structure found in older, uneven-aged forests is group tree selection, where areas of timber from 0.25 to 1.5 acres are removed to open the canopy. Group openings need to be strategically placed (juxtaposed) to create areas large enough to support nesting habitat and cover, but not so close that they are functionally small overstory removals. In group selections, all trees can be removed, but consider retaining those with high timber or wildlife value as reserves. In general, leave at least 100 feet of mature forest between group openings.

Species Diversity and Interfering Vegetation

Native vegetation provides the most habitat value to wildlife, and managing forests to provide a diversity of native trees, shrubs, vines, and herbaceous plants enhances habitat for forest birds. However, some native species, such as American beech (*Fagus grandifolia*) and hay-scented fern (*Dennstaedtia punctilobula*), can dominate a stand, reducing species diversity and vertical structure. Native plants support all or part of the life cycles of our native insects, which are the primary food source for the majority of forest bird species during the breeding season.

Where interfering vegetation is prohibiting the growth of native tree and shrub species, apply control methods, usually prior to harvesting, to release the native species. Increase species diversity of native trees and shrubs by applying silviculture that allows varying amounts of sunlight to reach the area you are managing, thereby creating conditions that foster the growth of shade intolerant, tolerant, and intermediately tolerant species (e.g., group tree selection cuts of varying sizes).

Managing for a diversity of native forest plants will ensure that birds have available food sources, including insects and mast, and having different species will increase the chances of having some mast production from one year to the next.

Large Diameter Trees and Conifers

Hardwood trees at least 24 inches diameter at breast height (DBH) and conifer species at least 20 inches DBH offer nest sites, perches, and places to forage for a number of forest birds, including Red-shouldered Hawks (*Buteo lineatus*) and Northern Goshawks (*Accipiter gentilis*). Large trees with cavities and large dead branches enhance the habitat for many forest birds (see Dead Standing Trees and Cavity Trees below). Where possible, retain a component of large diameter trees. If none are present, select some smaller, high quality trees to leave and become large diameter wildlife trees in the future.

Conifers provide birds with cover and foraging habitat, and some species preferentially select conifers for nesting. In particular, there are a number of forest birds that are associated with eastern hemlocks (*Tsuga canadensis*), and some species, such as Blue-headed Vireos (*Vireo solitarius*), Northern Saw-whet Owls (*Aegolius acadicus*), Hermit Thrushes (*Catharus guttatus*), and Black-throated Green Warblers (*Setophaga virens*), are strongly associated with hemlocks. To benefit forest birds, retain and/or promote at least some conifers where they occur, especially within predominantly hardwood stands. Even clusters of conifers less than an acre have high habitat value to forest birds. These clusters will be used as thermal cover for Ruffed Grouse (*Bonasa umbellus*) and numerous mammal species.

Dead Standing Trees and Cavity Trees

Dead standing trees or "snags" of all sizes provide locations for nesting, roosting, and foraging. Keeping a range of size classes of snags and cavity trees (living or dead) is desirable, but the larger the better. For snags, hardwood species of sawtimber or large sawtimber size will provide the best long-term habitat value as dead standing wood, and eventually as coarse woody material when they fall. Where it's safe to do so, retain at least six snags or cavity trees per acre, with one ≥ 18 inches DBH, and three ≥ 12 inches DBH. If this minimum cannot be met, identify and retain trees that have defects that may develop into cavities over time or create snags through girdling or other methods. In overstory removals or seed tree sites, keep some cavity trees and snags as reserves, especially large diameter snags that can house abundant insects and produce sizeable cavities. Retain clusters of residual trees around large snags to prevent loss from wind.

Pileated Woodpecker. Photo: Michael Reid/ Audubon Photography Awards

Coarse Woody Material

Coarse woody material (CWM), including logs, stumps, and large branches enhances habitat for forest birds by providing places to seek cover, perch, nest, and forage. Larger downed logs (> 18 inches diameter) provide especially important habitat structure for birds and other wildlife that forage or nest on or near the forest floor, and larger logs are used for drumming displays by Ruffed Grouse. In areas where deer over-browsing is excessively high, leaving slash may deter deer browsing and benefit forest regeneration, as it can provide an obstacle that prevents deer from reaching seedlings and saplings.

Leaf Litter and Duff

Leaves, needles, and other decomposing vegetative materials offer foraging habitat for macroinvertebrates, such as worms, centipedes, and beetles. Moist leaf litter has high habitat value to Wood Thrushes, Ovenbirds, American Woodcock, and other ground foragers and nesters. To protect the leaf litter layer, limit skid trails to no more than 10% of the total stand area, and confine skidding and vehicle traffic to these carefully located trails. Avoid harvest operations during times with saturated soils, when rutting and soil compaction may compromise soil structure and drainage. Implement erosion and sediment control Best Management Practices to limit the runoff and the transport of sediments off site. Pennsylvania Department of Environmental Protection erosion and sediment control plan templates are available here (www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=33505).

Working at the Landscape Scale

Landscape-scale Decision Making Framework

This framework can be used to determine what forest habitat components may be absent from the landscape and how the parcel you are managing can provide the missing habitat. To understand how the parcel you are managing may improve habitat for birds, it is important to examine the parcel as well as the surrounding landscape (2,500-acre block or 1-mile radius). The variety of cover types, land ownership, and potential land uses surrounding the parcel will greatly influence the management you prescribe for forest birds.

In particular, we want to underscore the importance of working at the landscape-scale for agency-based foresters and others who manage large forest tracts, yielding opportunities for long-term planning that creates a shifting mosaic of forest age classes to benefit bird species that use everything from young to old forests.

The framework begins with suggestions for assessing landscape-level forest cover, and based on that assessment, suggests next steps for determining forest habitat management that will benefit birds and other wildlife.

For landscapes with at least 70% forest cover, look for opportunities to:

1. Diversify forest age classes within the landscape, such that 10–20% of area is in a young forest condition (typically less then 10-20 years old, depending on rate of succession) and the majority is in a mature and intermediate age classes. For suggestions on creating young forest, see Young Forest Habitat on the next page for more information.
2. Enhance habitat characteristics within mature forest where it is to be retained. See Forest Habitat-Stand-level Conditions in the *Forest Birds and Their Habitats* section for more information.

For landscapes less than 70% forested:

1. Management decisions will largely depend on what is in the surrounding landscape, the level of forest fragmentation, and the size of the parcel you are managing. As forest cover decreases at the landscape level, the minimum patch size needed by forest interior birds increases, which makes the size of the parcel you are managing, as well as any adjacent forest, very important. Thus, considering patch size and the amount of forest in the landscape becomes increasingly important in fragmented forest systems.
2. If you are working in a landscape that is moderately forested (40–70%):
    - Identify the surrounding cover types, and if there appears to be ample young forest habitat (10–20%), retain mature forest and focus on treatments that improve within-stand structural complexity.
    - If there is less than 10% young forest cover in the landscape, and if the forested parcel you are managing is relatively large (at least 200 acres to accommodate area sensitive forest species), patch cuts that create young forest may be feasible. See *Silvicultural Options and Scenarios* section for more information.
    - If forest fragmentation is very high with less than 40% forest in the landscape and your management parcel is large (at least 200 acres), this may represent much needed forest habitat in an area that is lacking forest cover. Focus on retaining mature forest and applying silvicultural practices and systems that will improve vertical structure without compromising species diversity. Exercise caution in recommending patch cuts or other even-aged silviculture, as increased nest predation and nest parasitism by Brown-headed Cowbirds is more likely in a highly fragmented landscape. If even-aged management is needed, minimize potential edge effects by softening forest edges See *Silvicultural Options and Scenarios* section for more information.
    - Within woodlots that are too small (less than 50 acres) for patch cuts, seek to improve forest habitat by opening the canopy to mimic natural disturbance and soften edges where they meet non-forest cover types, such as fields.

Young Forest Habitat

For landscapes with less than 10% young forest cover:

1. New patches cut to create young forest should be at least 5 acres in size to accommodate multiple young forest breeding bird species. Research examining the relationship between patch sizes of young forest and their use by various bird species is limited. However, there is evidence that species abundance plateaus with young forest patches of around 50 acres. Reserve trees (individuals or clusters) should be retained within these patches to enhance structure and provide places to perch. See *Silvicultural Options and Scenarios* for examples of harvest recommendations to create young forest for bird habitat.

2. To determine where to create young forest, look for areas that may benefit from such management to improve forest health and regeneration, such as stands with a high proportion of unacceptable growing stock (UGS), adequate advanced regeneration, and low prevalence of invasive species. When creating multiple areas of young forest within a landscape of mature forest or if there is young forest in the area you are working, place new patches of young forest in close proximity to one another (1,500-3,000 feet when feasible) to aid in habitat connectivity for young forest species. Avoid areas that may be ecologically sensitive and significant, such as vernal pools.

3. To reduce potential predation and nest parasitism by Brown-headed Cowbirds, avoid creating young forest near the outer edges of larger forest patches. This recommendation applies to landscapes that are less forested and highly fragmented, where negative edge effects on breeding birds may be more prevalent. In mostly forested landscapes, improving or expanding young forest habitat that is adjacent to mature forest may be a management option, depending on landowner objectives. See *Silvicultural Options and Scenarios* section for more information.

4. If there is more than 10% young forest cover in the forested landscape, retain and enhance mature forest habitat by partial cutting strategies, such as group selection. These help create complex vertical structure over multiple entries. Over time, allow young forest patches to mature to bring the landscape into a more desired balance of age classes.

A BEAUTIFUL THREAT

Northern Goshawk. Photo: Martha deJong Lantink/ Flickr CC BY 2.0

Hay-scented fern. Photo: Nicholas A. Tonelli/ Flickr CC BY 2.0

When I was a graduate student at Penn State in the 1990s, I helped to conduct a statewide survey for Northern Goshawks. This involved walking miles of transects each day through Pennsylvania forests. Many times throughout the day, I found myself unwinding thick strands of hay-scented fern from my legs, as tentacles of the lush green vegetation entrapped me. My pants and boots became permanently stained an almost neon green. These characteristic fern understories have made Pennsylvania famous for the picturesque beauty they provide to our forests. Most people don't know, however, that these dense fern understories are often biological deserts, lacking plant and wildlife diversity and providing little wildlife food or cover. Fern understories also interfere with the regeneration of hardwood forests and the establishment of shrubs that create vertical structure and species diversity, thus threatening birds and other wildlife. ~Ron Rohrbaugh

Silvicultural Options and Scenarios

As any forest professional who has drafted more than one plan knows, each one is different and the details are dictated by a host of interrelated factors, including:

- The Landscape—how much forest is available, what type is it, and how old is it?
- The Stand—how big is it, what is its shape, are there invasive plants present?
- The Site—is it a dry ridge top, forested wetland, or steep slope?
- The Goals—what are the goals of the landowner and what resources are available?

In a guide such as this, it's impossible to account for all of the variations that can occur in writing any given plan. The purpose of the *Silivcultural Options and Scenarios* section is to consider some of this variation and discuss appropriate management prescriptions that can lead to success. A secondary goal is to stimulate creative thinking to tackle the nearly endless number of conditions and their various permutations.

As you read this section, it's important to remember that forest management is both science and art. For example, the science is captured in knowing what a shelterwood harvest is and how it will impact the forest. The art is understanding that the residual basal area in the shelterwood does not have to be evenly distributed and can be left in islands or concentrated in one area to create habitat diversity within a stand. Birds and other wildlife "don't read the script" laid out in our Best Management Practices. They simply respond based on the evolutionary pressures of their natural history. Our job is not to create a "script-perfect" habitat right down to the last stem. It's to create a general set of conditions that favors the target suite of species. The following *Silvicultural Options and Scenarios* provide examples of how to do this, but it's often up to your experience and skill to do what is practical and best for the stand and wildlife species.

Bird-friendly forest management supports the multiple objectives that are inherent to most projects and landowners. This includes management for timber production, associated wildlife species, and recreation, such as hunting.

The following section provides detailed forest stand descriptions for a variety of forest age classes and conditions, with potential silvicultural prescriptions to be applied, and the expected outcomes resulting from the management. These examples can serve as a reference when integrating silvicultural prescriptions with habitat improvements for forest birds. Please remember the bird habitat objective of creating or maintaining a landscape composed of 10–20% young forest and the remainder in mature and intermediate age classes, such as pole and small sawtimber when considering the following silvicultural options.

Note: In the sections that follow, we mostly use relative density to describe stand stocking levels. Relative density is useful for prescribing treatments in forest types where absolute densities vary because of species composition and stand structure. Relative density is expressed as the ratio of absolute density (basal area per acre) to maximum density (e.g., an undisturbed stand). Relative density can be converted to basal area using species specific conversion factors. We recommend consulting Stout, S. L., D. A. Marquis, and R. L. Ernst. 1987. A relative density measure for mixed-species stands: Tree-area ratios are more accurate than stocking charts. J. of Forestry Vol. 85(7).

Some of the content in this section was excerpted from "Forest Management for New York Birds: A Forester's Guide" and was originally provided by Ralph D. Nyland, Distinguished Service Professor, Department of Forest and Natural Resources Management, SUNY College of Environmental Science and Forestry.

Silvicultural Options

Early Intermediate Forest (Even-aged, 10-30 years old)

Stand Description

- Closed canopy
- Herbs and shrubs few and consisting of shade-tolerant species
- Advanced tree regeneration absent
- Trees in sapling stage, with most 1 to 5 inches DBH
- Often includes a mixture of tree species, with some that die after 35–40 years of age
- Seed and soft mast production limited

Silvicultural Options

- No treatment if the existing stand contributes to needed conditions and age class diversity across the forest or landscape
- Crop tree release, such as timber stand improvement to release preferred trees suppressed by others and:
  - Free selected species of wildlife value to maintain their presence
  - Free selected trees of all species to maintain tree species diversity throughout the stand
  - Free trees with desirable quality and form, including ones of particular wildlife value
- Retain felled material in stand to create woody debris on forest floor

Expected Outcomes

- Crowns of released trees will get taller and wider, increasing tree vigor and growth
- Once released, slower growing species, such as oaks, will remain part of the developing stand
- Added light through canopy gaps will stimulate herbaceous development for a few years post-harvest
- Taller tree crowns and enhanced herbaceous cover will improve vertical structure, or extend it until the crown canopy closes again

Older Intermediate Forest (Even-aged, 30-50 years old)

Stand Description

- Closed canopy
- Herbs and shrubs few and consisting of shade tolerant species
- Advanced tree regeneration absent
- Trees in pole stage, with many 6 to 11 inches DBH
- Includes a mixture of tree species, with short-lived trees having died or beginning to decline
- Seed and soft mast production limited

Silvicultural Options

- No treatment if existing stand contributes to needed conditions and age class diversity across the forest or landscape
- Pre-commercial thinning to:
  - Favor trees of upper-canopy positions with the best growth potential
  - Free selected species of wildlife value to maintain their presence
  - Free selected trees of all species to maintain tree species diversity throughout the stand
  - Free trees with desirable quality and form, including ones of timber value
- Retain a component of trees that have cavities, even with small openings
- Girdle selected trees to create snags, particularly large diameter trees
- Fell select UGS to create drumming logs and coarse woody material (CWM)/ protective cover in stand

Expected Outcomes

- Crown thinning will free trees of upper-canopy positions and with largest diameters, and retain lower and intermediate suppressed trees that do not interfere with the crop trees
- Crowns of released trees will get taller and wider, increasing tree vigor and growth
- Tree mortality will decrease, particularly among those in upper canopy positions
- Slower developing species will remain in stand if released by thinning
- Thinning trees from the main canopy will open larger gaps than waiting for death of trees in sub-canopy positions
- Light will filter through the newly created canopy gaps and stimulate herbaceous understory plant development
- Taller tree crowns, enhanced herb cover, and retention of intermediate and suppressed trees will improve vertical structural diversity, and extend it until the crown canopy closes again

Silvicultural Options

Mature Forest (Even-aged, >50 years old)

Stand Description

- Trees in large-pole and sawtimber stage, with 12–18 inches DBH
- Closed canopy, with some small gaps where trees of intermediate crown positions died
- Crown canopy elevated, with few suppressed trees remaining
- Little vegetation in the middle and understory canopy layers
- Mortality of main canopy trees expected to increase, opening some canopy gaps
- Until mortality opens upper canopy gaps, herbs and shrubs sparse and consisting of shade-tolerant species
- Advanced tree regeneration absent, except beneath the larger canopy gaps
- Often includes a mixture of tree species, but short-lived ones beginning to decline
- Reproductively mature trees of upper canopy positions and understory herbs produce seed and soft mast

Silvicultural Option #1: Grow for Longer Rotation

- No treatment if existing stand contributes to needed conditions and age class diversity across the forest or landscape
- Commercial crown thinning to 60% relative density to:
  - Free selected species of particular wildlife value and maintain their presence
  - Free selected upper canopy trees of all species to maintain tree species diversity throughout the stand
  - Free upper canopy trees with desirable quality and form, including ones of particular timber value
- Retain a component of trees that have cavities, even with relatively small holes
- Retain some trees that have large broken branches where cavities may eventually form
- Girdle selected trees to create snags, particularly ones with large diameters
- Leave a component of large-diameter felled trees for CWM

Expected Outcomes

- Crown thinning will free trees of upper-canopy positions and with largest diameters, but leave suppressed and lower intermediate trees that do not interfere with the crop trees
- Crowns of released canopy trees will get taller and wider, increasing tree vigor and growth
- Residual trees of subordinate positions will improve in vigor, remain alive, but continue to grow slowly
- Tree mortality will decrease, particularly among trees of upper canopy positions
- Slower developing species will remain a part of the stand if released by thinning
- Cutting some trees from the main canopy opens larger gaps than after death of trees in sub-canopy positions
- Appreciable light will filter through the larger gaps, stimulating herbaceous development
- Abundant supplies of tree seed will result in advanced tree regeneration and increased food for wildlife, particularly in canopy gaps
- Taller tree crowns, enhanced herb cover, establishment of advanced tree regeneration, and retention of suppressed trees and understory shrubs will improve vertical structure
- Periodic reentry for subsequent thinning will extend these conditions

Figure 8. A mostly even-aged stand with little structural diversity, except where small canopy gaps exist. Photo. Ron Rohrbaugh.

Silvicultural Options

Mature Forest (Even-aged, >50 years old)

Silvicultural Option #2:
Regenerate a New Even-aged Stand

- If well-developed advanced regeneration of desirable species distributed across ≥ 70% of stand and herbivory or interference not likely:
  - Remove overstory from entire stand to promote growth of advanced seedlings and establish additional seedlings; leave residual seed trees as appropriate
  - Remember to "feather" strip or patch boundaries to eliminate hard edges
  - Leave tops of large-diameter felled trees for CWM
- If advanced tree regeneration is missing, small, or sparse
  - Control herbivory with hunting, culling, or exclusion (fence or brush)
  - Control interfering plants if present, and reduce high deer densities
  - Do shelterwood cutting across the stand, reducing relative density to 50% or lower
  - Schedule removal cutting after regenerating trees have suppressed the raspberries and other herbs, but before new trees exceed 1 inch DBH
  - Leave entire stems where feasible, particularly misshapen, low-value stems to ensure persistence of CWM over longer term (compared to tops), provide drumming logs, and protection from exposure for young broods, herpetofauna and small mammals

Expected Outcomes:
for Even-aged Regeneration Methods

- After cutting, the stand will have abundant coarse and fine woody material due to slash and unused tree boles
- The stand will have no tree seed production after clearcutting, with abundant soft mast from ground-level vegetation produced only until the new trees form a closed canopy
- Tree seed production continues in shelterwood stands while the reserve trees remain
- Following crown canopy closure, ground-level vegetation will diminish in abundance, herb mast production will decline, and only scattered shade-tolerant species remain
- Through time the tree canopy rises higher and higher above the ground, with vertical structure decreasing in the process
- Within 2 years, herbaceous plants and some shrubs will become established in abundance, giving the stand a brushy appearance
- By 3–4 years, raspberries will form a dense cover across the site, and shorter herbs will begin to decline
- By 3–4 years most fine wood material will have decayed or become flattened
- By 5–6 years, mid-tolerant and shade-intolerant tree species will have grown through the raspberries, with the raspberries and most other herbs beginning to decline in the partial shade
- By 10–15 years, the new tree canopy will close and the tallest trees will reach 8–10 feet tall
- By 15–20 years, many shorter and suppressed trees die, the leafy canopy has increased to 15–20 feet above the ground, few herbs or shrubs remain in the understory, and the stand has limited vertical structure
- By 20–25 years, the tree community will have mature forest characteristics with respect to forest bird habitat
- By 20–25 years, CWM will have largely decayed

Figure 9. Dense regeneration and development of vertical structure following a shelterwood harvest. Photo. Ron Rohrbaugh.

Silvicultural Options

Mature Forest (Even-aged, >50 years old)

Silvicultural Option #3: Begin Conversion to a Multi-aged Condition

- Control herbivory and interfering plants as necessary
- Use Grade C thinning (cut suppressed, intermediates, and some co-dominates) from below to reduce stocking to 55–60% relative density, regulating spacing between main canopy trees and removing trees of suppressed and intermediate crown positions
- Leave tops of large-diameter felled trees for CWM
- Alternately create uniformly dispersed canopy openings across 1/3 to 1/5 of the stand area, with patches having a width of one times the height of adjacent trees; or variable sized openings based on the shade tolerance of the preferred tree species. (e.g., sugar maple = ≤ 1x tree height, oak = 1.5x tree height, and tulip poplar/black cherry = 2x tree height)
- If using patches, also thin lightly within the residual stand
- Return at intervals of 10–15 years to repeat the treatment (uniform thinning or patch cutting), thereby establishing 3–5 new age classes during a 50–75 year period
- Thereafter use selection cutting to maintain an uneven-aged condition throughout the stand

Expected Outcomes: Converting Stand

- After each entry the stand will have new coarse and fine woody material due to the logging slash and unused tree boles
- The first entry will establish a new understory vegetation layer of trees and herbs, and create a two-layered structure within the stand
- By 20–25 years, CWM will have largely decayed
- Additional entries will create new canopy openings (single-tree gaps or patches) that enhance understory light sufficiently to promote additional seedling and herb establishment, stimulate development of the younger age classes, and maintain the vigor of overstory trees
- Periodic cutting will gradually transform the stand into a multi-layered condition with increased vertical structure
- Maintaining a component of the oldest over story trees, coupled with periodic replenishment of understory herbs, ensures continued seed production

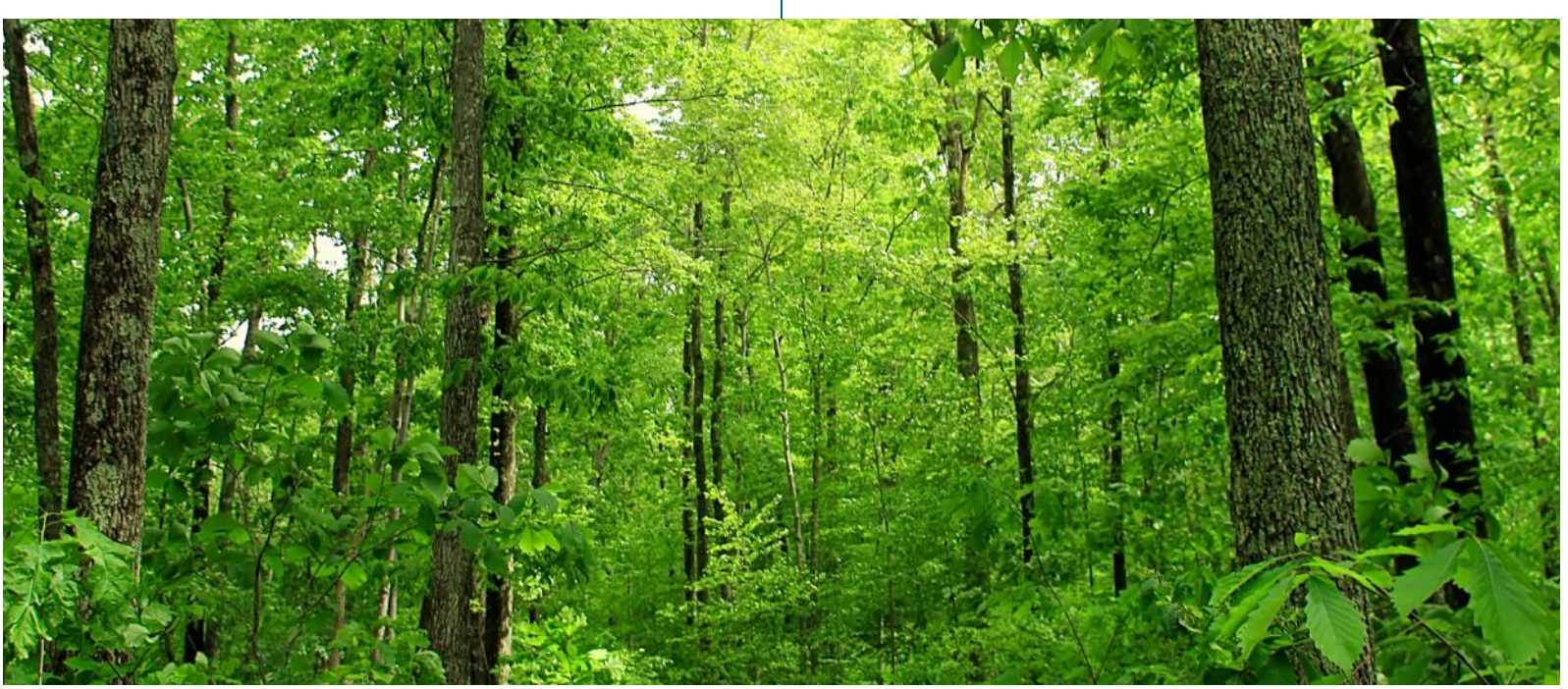


Figure 10. A stand with multiple vertical layers and canopy gaps to promote continued understory development. Photo. Nicholas A. Tonelli/Flickr CC BY 2.0

Silvicultural Options

Mature Forest (Even-aged, >50 years old)

Silvicultural Option #4:
Begin Conversion to a Two-aged Condition

- Control herbivory and interfering plants as necessary
- Use Grade D thinning (cut suppressed, intermediates, and most co-dominates) from below to reduce stocking to 25–35% relative density or lower, regulating spacing between the residual trees
- Due to risks of blowdown and mortality, retain only high-vigor trees of upper-most canopy positions and free of structural defects
- Leave tops of large-diameter felled trees and low-value stems for CWM

Scarlet Tanager. Photo: Randy Streufert/ Audubon Photography Awards

Expected Outcomes:
Converting to a Two-aged Stand

- After cutting, the stand will have abundant coarse and fine wood material due to the logging slash and unused tree boles
- Within 2years, herbaceous plants and some shrubs will become established in abundance, giving the understory a brushy appearance
- By 3–4 years, raspberries will form a dense cover across the site, and shorter herbs will begin to decline
- By 3–4 years most fine woody material will have decayed or become flattened
- By 5–6 years, mid-tolerant and shade-intolerant tree species will have grown through the raspberries, with the raspberries and most other herbs beginning to decline in the partial shade
- By 10–15 years, the new sub-canopy of trees will close and the tallest trees of the young age class will reach 8–10 feet tall
- Thereafter, the stand will have a two-strata structural diversity, but with sparse ground level vegetation
- By 20–25 years, large pieces of coarse wood material will have largely decayed
- Through time (e.g. 50–60 years) the understory tree layer will rise higher and higher above the ground until eventually touching the main crown canopy base
- By that time (50–60 years) the stand will be showing some establishment of tree seedling regeneration and development of an herbaceous layer

Silvicultural Options

Mature Forest (Uneven-aged, Sawtimber)

Stand Description

- Intermixed age classes result in small and short, middle-sized, and large and tall trees throughout the stand
- Layering of foliage at multiple heights gives the stand a high level of vertical structure
- Due to discontinuity within the canopy layers, particularly in managed stands, light filters through to places on the ground
- Resulting environmental conditions support a mixture of advanced tree regeneration, herbs, and shrubs
- Seed production on trees of sawtimber sizes, and by ground-level shrubs and herbs, provides mast from spring through autumn and during most years
- Some large trees have openings on the main stem where ice and snow loading or wind broke off large branches, wood decay fungi became established, and woodpeckers and other animals created cavities in the softened wood
- Managed stands lack snags, but have dispersed CWM

Silvicultural Option #1: Irregular Continuous Canopy Silviculture

- No treatment if existing stand contributes to condition class diversity across the forest or landscape
- If management deemed appropriate, control herbivory and interfering plants as necessary
- Cut trees deemed ready for removal due to size or condition, with no strict attention to tree size or actual age
- Adjust residual tree spacing as needed but without strict control of residual stocking from place to place
- Maintain a continuous multi-layered canopy rather than attempting to regulate the proportions of trees in different size classes
- Leave tops of large-diameter felled trees nad low-value stems for CWM
- Keep cavity trees at dispersed locations, reduce crowding around them, and retain them through multiple entries to the stand

Expected Outcomes: Irregular Continuous Canopy Silviculture

- Periodic cutting creates canopy openings that vary from single-tree gaps to wider ones left by removing groups of trees
- Cutting large trees or groups of smaller trees will promote understory development (advanced tree regeneration and herbs)
- Taking some additional individual trees releases others of preferred condition
- Residual stocking may vary from place to place in the stand, with varying proportions of trees with different heights and ages
- Residual sawtimber-sized trees, coupled with periodic replenishment of understory herbs, ensures continued seed production
- Additional entries will create new canopy openings (single- or multi-tree gaps) that enhance understory light sufficiently to promote additional seedlings and herb establishment at places in the stand, stimulate development of the younger age classes, and maintain the vigor of overstory trees
- After each entry, stands have abundant coarse and fine wood material due to the logging slash and unused tree boles, but with continued management replenishing the supply at irregular intervals

Silvicultural Options

Mature Forest (Uneven-aged, Sawtimber)

Silvicultural Option #2: Selection System*

- No treatment if existing stand contributes to condition class diversity across the forest or landscape
- If management deemed appropriate, control herbivory and interfering plants as necessary
- For the treatment, remove the mature age class to regenerate a replacement cohort with:
  - group selection system to remove clusters of mature trees, likely removing 2–3 groups per 3–4 acres
- Thin the younger age classes, controlling spacing and reducing crowding around selected trees with desirable attributes
- Leave tops of large-diameter felled trees for CWM
- Regulate the proportions of small, medium, and large residual trees to balance the space occupied by different age classes
- Select cavity trees at dispersed locations, reduce crowding around them, and retain through multiple entries to the stand

* Note: "Selection silviculture," which is strategic, should not be confused with unsustainable high grading.

Expected Outcomes Uneven-aged Silviculture

- Periodic cutting under selection system regularly creates canopy openings that vary from single-tree gaps to wider ones left by removing groups of mature trees
- Additional entries will create new canopy openings (single- or multi-tree gaps) that enhance understory light sufficiently to promote additional seedlings and herb establishment, stimulate development of the younger age classes, and maintain the vigor of overstory trees
- Periodic cutting to produce residual stocking levels ($\geq$ 75 ft²/ac) will increase the multi-layered condition and maintain a high level of vertical structure
- Bright conditions at the ground after cutting that leaves a low residual stocking of < 75 ft²/ac and uses extended cutting cycles will initially have understory conditions similar to that following shelterwood seed cutting
- By 10 years, low-density stands will develop a dense sub-canopy tree layer that has characteristics like a young even-aged stand, including a darkened ground surface with few herb or tree seedlings
- Openings created by removing groups of trees will have seedlings and herbs similar to that following clearcutting of small patches, given a circular canopy gap and a width equivalent to at least the height of adjacent trees
- Trees that regenerate in group openings will develop similar to even-aged clusters (islands) in patch clearcuts
- With all these strategies, residual sawtimber-sized trees, coupled with periodic replenishment of understory herbs, ensures continued seed production
- After each entry, stands have abundant coarse and fine wood material due to the logging slash and unused tree boles, with continued management periodically

Management Scenarios

Example Stand 1

Stand Description

- 80–90 year old stand
- Oak (*Quercus spp.*), hickory (*Carya spp.*), some northern hardwoods
- Well stocked, with AGS making up >50% of the stand
- Little to no desirable understory/regeneration because of stressors such as over-browsing by deer

Bird Habitat Objective

The 10% young forest age class goal is met within the surrounding landscape, so improving mature forest habitat may provide the greatest benefit to forest birds. The lack of understory makes this hardwood stand less favorable to forest breeding birds that use mature forest. Creating canopy gaps through periodic group selection will help to stimulate understory regeneration and increase vertical structural.

Landscape Context 1

- 10–20% or more of the landscape surrounding this stand is already in a young forest condition

Silvicultural Prescription #1: Conversion to Uneven-aged Stand using Group Selection

To increase complex habitat structure for birds and other wildlife, convert to an uneven-aged composition using group selection. Create small group cuts 0.25 to 1.5 acre in size, aiming to create canopy gaps. Group cuts should remove all trees from the selected area, including the smaller non-oak trees. Groups should be scattered throughout the stand to mimic openings created by natural disturbances. Thinning can occur in between groups. Over time, additional entries will gradually transform the stand into a mosaic of small even-aged openings. Maintain the uneven-aged character of the stand by periodically cutting new groups and thinning.

Large diameter oaks and hickories (≥ 15–19 inches DBH) should be retained to provide nesting and foraging trees for forest birds. This is particularly important when working within the breeding range of Cerulean Warblers, which favor large diameter hardwood trees for nesting, especially white oak. These large diameter trees can be cavity trees or UGS as well, helping to provide an important habitat feature for multiple species.

Cerulean Warbler.
Photo: DJ McNeil/USDA

Where possible, retain downed woody material (DWM) and control invasive plants. If softwood inclusions are absent, consider planting clusters of conifers, most likely pine in this stand example. Soft mast producing trees and shrubs may also be lacking from this stand, and should be retained where they occur. Additional within-stand habitat features are detailed in Cultivating Structural Diversity in the *Forest Birds and Their Habitats* section.

Management Scenarios

Example Stand 1

Stand Description

- 80–90 year old stand
- Oak, hickory, some northern hardwoods
- Well stocked, with AGS making up >50% of the stand
- Little to no understory/regeneration

Bird Habitat Objective

The young forest age class is needed in this landscape to improve the availability of quality habitat for forest birds.

Landscape Context 2

- Less than 10% of the landscape surrounding this stand is in a young forest condition

Silvicultural Prescription #2: Shelterwood (Irregular)

To create young forest conditions that will benefit some young forest birds and most mature forest birds, and begin the process of regenerating the oak-hickory stand, an irregular shelterwood seed cutting may be a feasible option, dependent upon site conditions and landowner objectives.

Commercial thinning or pre-commercial low shade removal may first be needed as a preparatory treatment to enhance seed production or begin establishing advanced oak regeneration. Once advanced regeneration is observed and the overstory is ready for removal, retain a component of widely and irregularly spaced overstory trees to leave varying amounts of canopy closure. Depending on the size of the stand and the ability to leave large enough gaps between reserve trees, the understory regeneration may be suitable habitat for some young forest-dependent birds.

Where possible, reserve cavity trees and large snags to enhance vertical structure, or create large diameter snags through girdling. Where pine regeneration is observed, retain inclusions to enhance habitat. Leave low-quality logs as DWM, especially those that may be large diameter logs and in some stage of decay. These will provide foraging sites for insectivorous birds, protective cover for reptiles and amphibians, and may serve as drumming logs for Ruffed Grouse.

Where possible, retain DWM and control invasive plants. Additional within-stand habitat features are detailed in Cultivating Structural Diversity. in the *Forest Birds and Their Habitats* section.

Photo: Nicholas A. Tonelli/Flickr CC BY 2.0

Management Scenarios

Example Stand 2

Stand Description

- 30–50 year old stand; even-aged, fully stocked; "mature" forest habitat from a bird perspective
- Over 50% undesirable growing stock (UGS)
- Mixed hardwoods with a high density of interfering vegetation, such as American beech, striped maple (*Acer pensylvanicum*), or hay-scented fern in the understory
- Little to no non-beech understory/regeneration

Bird Habitat Objective

Because there is already enough young forest in the landscape, the "mature forest" conditions of this stand should be retained and improved, focusing on increasing vertical structure by retaining short trees and establishing additional understory vegetation.

Landscape Context 1

- 10–20% or more of the landscape surrounding this stand is already in a young forest condition

Silvicultural Prescription #1: Thinning with Group Selection

Thinning to increase vertical structure and improve habitat for birds and other wildlife should retain trees of suppressed positions, thin the main canopy, and create small canopy openings that will foster establishment of understory regeneration. This will keep the suppressed trees alive, and also help to create new subcanopy layers that increase understory structure. The crown thinning should maintain a relatively closed canopy (≥70%) except for creating small openings scattered throughout the stand to avoid uniform spacing and instead mimic natural disturbances.

Based on timber management goals, identify and retain Acceptable Growing Stock (AGS), and cut the openings by removing poor quality trees adjacent to AGS – similar to a crop-tree release.

Interfering vegetation in understory may need to be controlled to promote regeneration of other species, helping to increase stand diversity. Care should be taken to identify and retain main canopy beech trees that may be resistant to beech bark disease so they reach reproductive maturity and produce beech nuts, an important hard mast crop for birds and other wildlife. Be sure to retain high-value soft and hard mast producing species in understory and midstory, as well as unusual species to promote overall stand diversity.

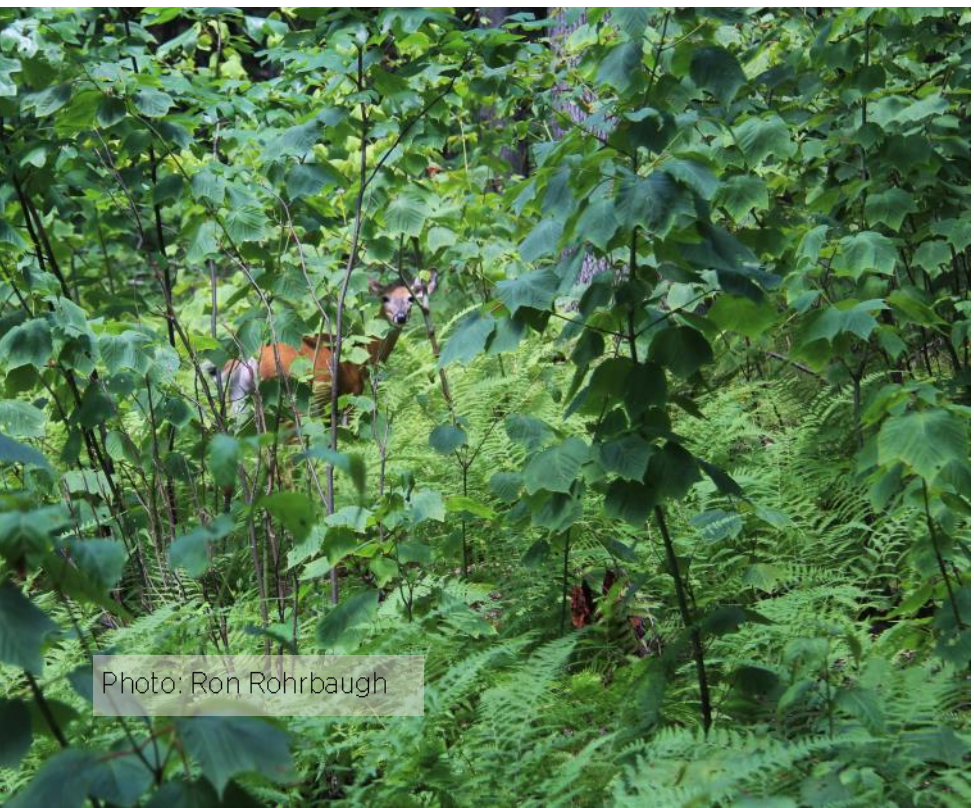


Photo: Ron Rohrbaugh

Where possible, retain DWM, large diameter trees, snags and cavity trees, control invasive plants, and manage for softwood inclusions where they are lacking or limited. See Table 1 for a list of species that will benefit from the "mature forest" habitat created by this management. Additional within-stand habitat features are detailed in Cultivating Structural Diversity in the *Forest Birds and Their Habitats* section.

Management Scenarios

Example Stand 2

Stand Description

- 30–50 year old stand; even-aged, fully stocked; "mature" forest habitat from a bird perspective
- Over 50% undesirable growing stock (UGS)
- Mixed hardwoods with a high density of interfering vegetation, such as American beech, striped maple, or hay-scented fern in the understory
- Little to no non-beech understory/regeneration

Bird Habitat Objective

Because there is a need for more young forest in this landscape, even aged silviculture can be applied to the stand in support of the goal of having up to 20% young forest conditions in the forested landscape.

Landscape Context 2

- Less than 10% of the landscape surrounding this stand is in a young forest condition

Silvicultural Prescription #2: Clearcut with Reserves

A clearcut with reserves (<25 ft²/acre residual basal area or 15–20% canopy closure) may be a viable option to create young forest by regenerating desirable species (including shade intolerant species). It is important to control understory beech either before or after the overstory cutting. Depending on the size of the stand and the timber management goals, the cutting might create several small clearcuts across the stand, although openings should be at least 5 acres in size to accommodate breeding territories and area sensitive young forest species like Prairie Warblers (*Setophaga discolor*).

Avoid creating hard and straight edges where clearcut meets other forest and aim for a more natural disturbance look, with rounded boundaries and feathered edges. Reserve trees or patches should contain desirable seed trees, cavity trees, snags, and softwood inclusions if present. Reserve trees also serve as perch trees, an important habitat feature for some young forest birds. Reserve patches should be at least 0.25–0.5 acre in size for every 10 acres of a clearcut, or approximately 5% of the total area cut. Regeneration of shade-intolerant soft mast producing species, such as cherries (*Prunus spp.*) and *Rubus spp.*, will be beneficial to birds and other wildlife.

Prairie Warbler. Photo: Gary Robinette/ Audubon Photography Awards

Where possible, retain cull or low-grade logs as DWM and control invasive and interfering plants. Additional within-stand habitat features are detailed in Cultivating Structural Diversity in the *Forest Birds and Their Habitats* section.

White-tailed Deer (Odocoileus virginianus): Deer densities are high throughout much of Pennsylvania, and subsequent over-browsing of tree seedlings and saplings can lead to unsuccessful forest regeneration after an even-aged harvest. Monitoring regeneration response is recommended, and additional actions, such as increased hunting or installing deer fence around the harvest site, may be necessary .

Management Scenarios

Example Stand 3

Stand Description

- Mature stand with trees of variable ages, some up to 150 years+; highly variable stocking
- Evidence of past high-grading
- Mixed hardwoods with white pine (*Pinus strobus*) and eastern hemlock, birch (*Betula spp.*), red maple (*Acer rubrum*), beech
- UGS and pulpwood make up >50% of the stand

Bird Habitat Objective

There is an adequate amount of young forest in the landscape, so the stand can be managed to promote a mature forest age class, improve vertical structure, and enhance within-stand habitat features.

Landscape Context 1

- 10–20% or more of the landscape surrounding this stand is already in a young forest condition

Indigo Bunting. Photo: Donald Wuori/ Audubon Photography Awards

Silvicultural Prescription #1: Group Selection/Patch Cuts

To meet timber management goals and improve health and vigor of the stand, use group selection or patch cutting, with the goal of removing UGS and retaining high quality stock. Group or patch openings can vary from less than 0.25 acre to 10 acres, depending on conditions in the stand and the size of the property. Single-tree selection between patches will maintain the vigor of residual trees and further upgrade stand quality. Although group selection openings are commonly too small to accommodate some area-sensitive young forest birds, others like Chestnut-sided Warblers (*Setophaga pensylvanica*) and Indigo Buntings (*Passerina cyanea*) will use these smaller openings. If possible, make group openings or create patches throughout the stand (varying in size, if necessary), to improve access for mature forest birds and their young during the post-fledging period.

Multiple entries are necessary to enhance the uneven-aged stand structure over time. Group openings or patches can be placed next to each other, but avoid simply using a grid system for determining group location, size, and shape; instead center them around groups of overmature or UGS trees. Inclusions of white pine and eastern hemlock should be retained to benefit birds that utilize conifers, such as Magnolia and Pine (*Setophaga pinus*) warblers, and for use as thermal cover.

Where possible, retain DWM, large diameter trees, snags and cavity trees, control American beech brush and invasive plants, and manage for softwood inclusions where they are lacking. Additional within-stand habitat features are detailed in Cultivating Structural Diversity in the *Forest Birds and Their Habitats* section.

Management Scenarios

Example Stand 3

Stand Description

- Mature stand with trees of variable ages, some up to 150+ years; highly variable stocking
- Evidence of past high-grading
- Mixed hardwoods with white pine and eastern hemlock, birch, red maple, beech
- UGS and pulpwood make up >50% of the stand

Bird Habitat Objective

The lack of young forest in the landscape presents an opportunity to implement management to boost regeneration within this stand.

Landscape Context 2

- Less than 10% of the landscape surrounding this stand is in a young forest condition

Silvicultural Prescription #2: Low-density Shelterwood with Reserves (Irregular)

A low-density shelterwood treatment may be an option for creating young forest conditions near the ground, while still leaving 20–40 ft²/acre of residual basal area in mature overstory trees. The resulting formation of a dense understory coupled with mature overstory trees will provide some of the complex vertical structure that many forest birds require. The young forest understory will offer nesting, foraging, and post-fledging habitat for numerous forest birds, and where canopy closure is lowest, some young forest birds may find this habitat suitable.

Reserve trees can include large diameter trees or cavity trees, and can be left in clusters or scattered individually. To further enhance habitat features, retain some snags, as well as soft and hard mast-producing trees, in the overstory. Similar to Prescription 1, retain and promote white pine and eastern hemlock where possible. Shade intolerant soft mast producing species may regenerate in the understory, providing an important food source. Mast-producing trees in the overstory will drop hard and soft mast into the protective cover below, benefiting many wildlife species.

Where possible, retain DWM and control invasive plants. Additional within-stand habitat features are detailed in Cultivating Structural Diversity in the *Forest Birds and Their Habitats* section.

Photo: Ron Rohrbaugh

Black-throated Green Warbler. Photo: Joshua Galicki/ Audubon Photography Awards

Table 1. Overview of forest age classes, associated habitat conditions, and silvicultural practices useful in creating and improving the desired conditions for targeted bird species that respond to silivculture and are in decline. Species in red are Pennsylvania Species of Greatest Conservation Need as defined in the Pennsylvania Wildlife Action Plan.

Forest Age Class	Forest Habitat Structure for the Age Class	Silvicultural Options to Create or Improve Desired Conditions	Species That May Use This Habitat for Nesting
YOUNG Even-aged < 10 years old	0–30% open canopy High stem density of young trees and shrubs Reserve trees from previous stand can be: • Distributed equally • Clustered in patches • Distributed, but concentrated in some areas	Clearcut, seed tree, or shelterwood methods > 5 acres in size (clearcuts)	Acadian Flycatcher* American Goldfinch American Redstart American Woodcock Baltimore Oriole Black-and-white Warbler* Blackburnian Warbler* Black-billed Cuckoo Black-throated Blue Warbler* Black-throated Green Warbler* Blue-winged Warbler Broad-winged Hawk* Brown Thrasher Canada Warbler Cerulean Warbler* Chestnut-sided Warbler Eastern Towhee Eastern Whip-poor-will* Golden-winged Warbler Hooded Warbler* Northern Flicker* Olive-sided Flycatcher Prairie Warbler Purple Finch* Rose-breasted Grosbeak* Ruffed Grouse Scarlet Tanager* Veery Willow Flycatcher Wood Thrush* Worm-eating Warbler Yellow-billed Cuckoo Yellow-throated Vireo* *species that may use the habitat created by a shelterwood for nesting, but are unlikely to use a site where a clearcut or seed tree cut took place

Forest Age Class	Forest Habitat Structure for the Age Class	Silvicultural Options to Create or Improve Desired Conditions	Species That May Use This Habitat for Nesting
Mature – Intermediate 10–50 years old Maturing Even-aged	Commonly 100% closed canopy Few canopy gaps present Midstory and understory vegetation limited or absent Few herbs and shrubs in the understory	Create canopy gaps to promote regeneration Crop tree release Pre-commercial thinning Patch cuts 0..25–10 acres	Few birds will use this forest habitat for breeding due to lack of structural diversity; however, if canopy gaps are created and vertical structure is increased over time, then many of the birds listed below in the mature forest habitat category may use it.
Mature >50 years old)	> 70% canopy cover Small canopy gaps at dispersed locations Vertical structure developing Midstory and understory vegetation developing Herbs and shrubs increasing in the understory	Group selection (uneven-aged), or thinning (even-aged) Create canopy gaps similar to individual tree fall Maintain trees of large diameter Retain a component of snags and cavity trees Maintain or increase downed woody material	Acadian Flycatcher American Redstart Black-and-white Warbler Blackburnian Warbler Blackpoll Warbler Black-throated Blue Warbler Black-throated Green Warbler Broad-winged Hawk Brown Creeper Canada Warbler Cerulean Warbler Cooper's Hawk Downy Woodpecker Eastern Wood-Pewee Hooded Warbler Kentucky Warbler Least Flycatcher Louisiana Waterthrush Northern Flicker Northern Goshawk Northern Saw-whet Owl Prothonotary Warbler Purple Finch Red-bellied Woodpecker Red Crossbill Red-shouldered Hawk Rose-breasted Grosbeak Scarlet Tanager Sharp-shinned Hawk Wood Thrush Worm-eating Warbler Yellow-throated Vireo
Older, even-aged (> 100 years old)	Small canopy gaps at dispersed locations Overstory, midstory and understory vegetation present Herbs, shrubs and advanced tree regeneration in the understory Vertical structure modest in even-aged	Clearcut, seed tree, or shelterwood methods in even aged. > 5 acres in size (clearcuts) Convert to two-aged by thinning or patch cutting (0.25 - 10 acre patch size)	
Mature, uneven-aged	High vertical structure	Group selection Maintain trees of large diameter Retain a component of snags and cavity trees Maintain or increase downed wood material	

Some content contributed by Ralph D.. Nyland, Distinguished Service Professor, Department of Forest and Natural Resources Management, SUNY College of Environmental Science and Forestry.

Selling Silviculture

Tailoring Your Pitch

As an expert in your field, clients rely on your experience, creativity, and thoughtful problem-solving skills to provide them with options and opportunities for managing their forest. Priorities will differ from landowner to landowner, and even from year to year on the same property. Below are a number of management considerations, based on three key landowner priorities—Wildlife Diversity, Timber Harvesting, and Recreation/Hunting—that may be helpful in customizing your recommendations to better meet the expectations of clients. Talking with private landowners about harvesting timber and creating hunting opportunities are often core to the recommendations provided by Pennsylvania foresters. Talking with clients about wildlife diversity, especially non-game birds, is somewhat less common so we provide some resources below to get you started.

Wildlife Diversity

Birds are one of the most conspicuous forms of wildlife on any property—they are easily seen, colorful, and can be heard singing or calling almost any time of year. As such, many landowners are interested in increasing bird diversity, but don't realize they can do it through forest management. Knowing a little about the natural history and identification of birds is a great way to pique a client's interest, which can lead to important habitat management. While it's impossible to cover the details here, we recommend consulting this publication's companion guide (Forest Bird Pocket Guide: 18 Priority Species for Pennsylvania Foresters and Landowners), Audubon phone app (Audubon.org/app), and National Audubon's online Guide to North American Birds (www.audubon.org/bird-guide).

For landowners with an affinity for wildlife and a focus on biodiversity, a combination of prescriptions will likely be needed to encourage healthy habitat for a broad range of species. Young forest favors a spectrum of songbirds, raptors, and game species, as well as small and large mammals.

Providing clients with thoughtful advice on managing healthy edge habitat, such as creating meandering "soft" edges, can significantly enhance the spectrum of bird species likely to be observed on the property. Attention to this portion of the forest shows acute understanding of myriad ways in which habitat can be restored and enhanced.

Two additional considerations for managing forest for wildlife diversity are the maintenance of snags and leaf litter. Snags, or standing dead wood, provide essential habitat for cavity nesting birds such as nuthatches, chickadees, owls, and woodpeckers. For songbirds like the Wood Thrush and Ovenbird, leaf litter accumulations on the forest floor provide ample foraging opportunities. One way to enhance leaf litter access is to control patches of dense fern or Japanese stiltgrass.

Timbering Harvesting

Healthy forest management for birds and other wildlife does not have to conflict with landowner profit. With your guidance, landowners can choose silvicultural practices that both earn money from timber sales and enhance wildlife habitat.

High-grading and diameter-limit cutting typically result in a once and done monetary gain for the client and a disastrous loss of forest health and wildlife diversity. The landowner is unlikely to have any marketable timber after this cut and the forest will have little to no success regenerating without significant intervention and a lengthy rehabilitation period.

When timber production and sale is the primary goal, consider a more profitable **once and again** approach instead. Let your clients benefit from your expertise in crafting a sustainable logging plan that provides immediate income and also allows for forest regeneration that will ensure repeat profitability in the years to come. This thoughtful approach to prescribed maintenance let's your clients know that you not only addressed their current priority, but that you have also considered long-term benefits for them. An added service may include facilitating connections with local mills and assistance in securing market price for their timber.

Recreation/Hunting

Essential to any forest where hunting is a key priority, is the presence of game species. Managing a forest with an eye toward hunting and recreation, simply means evaluating the habitat requirements of the focal species and deploying silviculture prescriptions that align with those needs.

In larger stands (> 100 acres), consider utilizing an early successional approach by converting unhealthy forest to young forest through a clearcut with reserves. In healthy forests, creating canopy gaps that mimic natural disturbance provide habitat for game species and offers targeted hunting locations.

These openings foster new growth and critical habitat for game species such as Ruffed Grouse, American Woodcock, white-tailed deer, and Wild Turkey.

While deer hunting is among the most popular recreational activities for forest landowners, creating deer habitat can hamper management aimed at increasing wildlife diversity. Over-browsing by deer inhibits the establishment of native herbaceous plants and a well-developed understory. In places where deer impact is already high, forest management should focus on creating opportunities to harvest more deer by establishing structure and funnels that narrow deer movement.

Clients can benefit from a keen understanding of game species habitats and are likely to see a wealth of non-game species they may find enjoyable to observe. For example, Prairie Warblers will use young forest and Wood Thrush thrive in the understory that develops beneath canopy gaps. In addition, prescribed timbering in pursuit of healthier habitat for game species may bring unexpected profits to the landowner and opportunities for a longer term relationship with a forester.

Figure 11. Species profile of the Ruffed Grouse from the Forest Bird Pocket Guide.

Resources

Technical Expertise

Educational Support

Financial Assistance

American Forest Foundation

AFF helps family forest owners produce measurable and verifiable conservation impacts consistent with the outcomes in AFF's vision. Financial assistance programs include the Family Forest Carbon Program.

forestfoundation.org

Audubon Pennsylvania

Audubon Pennsylvania's mission is to conserve and restore natural ecosystems, focusing on birds, other wildlife and their habitats for the benefit of humanity and biological diversity in Pennsylvania.

audubon.org

The Center for Private Forests

The Center for Private Forests focuses on applied research, education and outreach to students, forest landowners, the forest-products industry, loggers, conservation districts, agencies, land trusts, nongovernmental organizations and the public.

ecosystems.psu.edu/research/centers/private-forests

The Cornell Lab of Ornithology

The Cornell Lab, Land Trust Bird Conservation Initiative offers a small grants program for forestry professionals working with land trusts and the website includes a wealth of resources on habitat management for birds.

birds.cornell.edu

pennsylvania
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

DCNR's Bureau of Forestry conserves the forests and native wild plants of the commonwealth, provides information on how landowners can manage their forests, especially through the service forester program.

dcnr.pa.gov/about/Pages/Forestry.aspx

NFWF

The National Fish and Wildlife Foundation is a conservation grant-making organization that protects and restores the nation's fish, wildlife, plants and habitats. NFWF's Central Appalachia Habitat Stewardship Program restores and sustains healthy habitat for birds, including priority focal landscapes in Pennsylvania.

nfwf.org

USDA United States Department of Agriculture
Natural Resources Conservation Service

NRCS offers technical and financial assistance to help non-industrial, private forest landowners manage their forest land and address natural resources concerns. NRCS assistance is available through voluntary conservation programs to develop and implement recommendations from Forest Management Plans.

nrcs.usda.gov/wps/portal/nrcs/site/pa

PennState Extension

Penn State Extension's forestry and wildlife experts provide research-based education and assistance on forest and wildlife science and management. The team educates and informs through its fact sheets, publications, workshops, conferences, videos, webinars, and numerous online resources.

extension.psu.edu/forests-and-wildlife

PENNSYLVANIA GAME COMMISSION 1895

The Pennsylvania Game Commission offers technical assistance to private landowners by providing wildlife habitat management plans and financial assistance for implementing habitat improvement projects through various grant programs.

pgc.pa.gov
search "private lands" for more information

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Appendix A: Best Management Practices

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