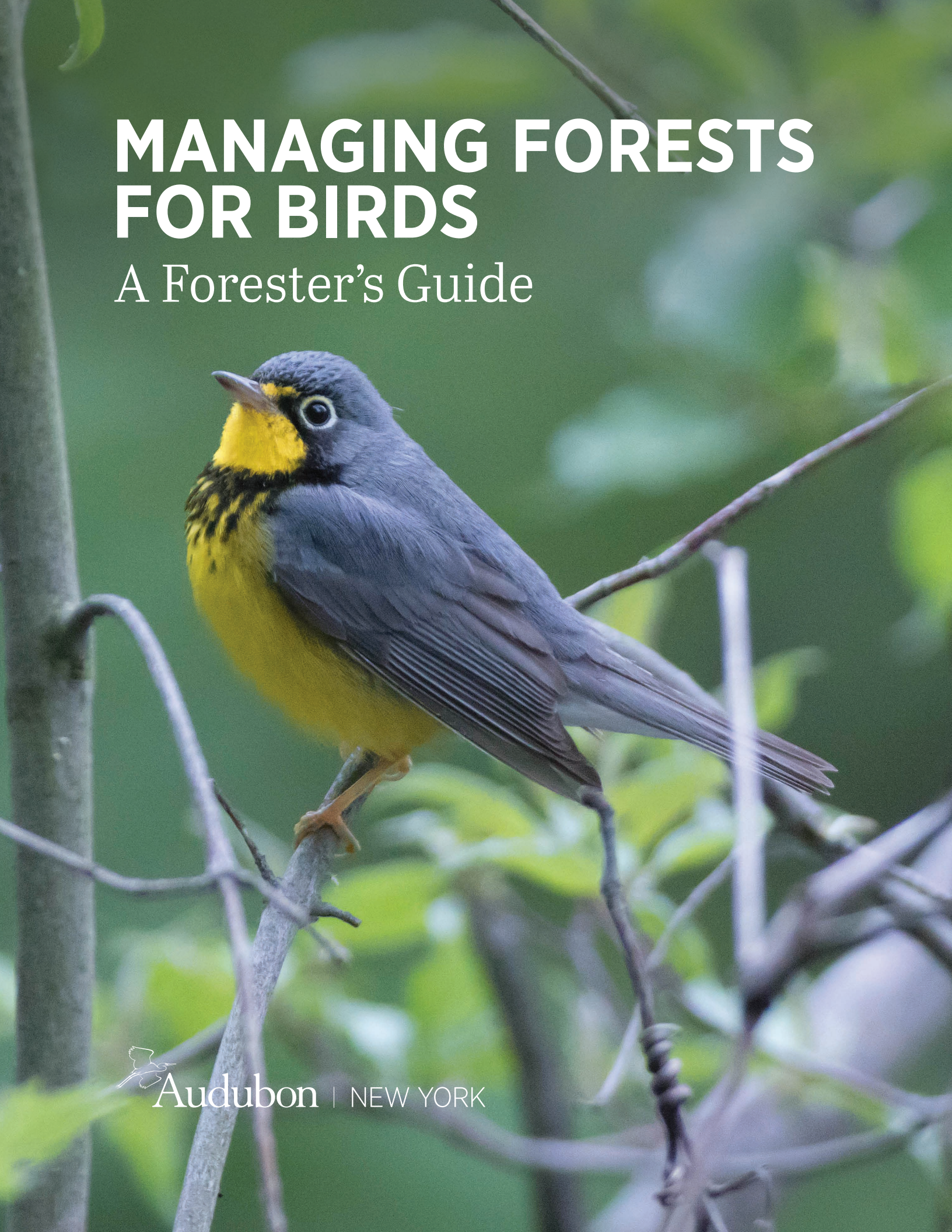
MANAGING FORESTS FOR BIRDS

A Forester's Guide



Audubon | NEW YORK

ACKNOWLEDGEMENTS

We would like to thank the members of our technical review committee (listed below) for their time and expertise in the development of this publication. We are also grateful for the content and comments contributed by Ralph Nyland that greatly improved this guide. In addition, this publication was informed by materials produced by Audubon Vermont's Foresters for the Birds program, which is a partnership between Audubon Vermont and the Vermont Department of Forests, Parks, and Recreation and private consulting foresters, and made possible through a grant from the US Forest Service State and Private Forestry Program. We would also like to thank Justin Potter for reviewing this guide and providing feedback.

Technical Review Committee*

Paul Catanzaro, University of Massachusetts Amherst
Sloane Crawford, New York State Department of Environmental Conservation
John Gibbs, New York State Department of Environmental Conservation
Steven Hagenbuch, Audubon Vermont
Andrew Hinickle, Audubon New York
David King, Ph.D., USDA Forest Service, Northern Research Station
Jerry Michael, New York Forest Owners Association
Ralph Nyland, Ph.D., SUNY College of Environmental Science and Forestry
Glen Roberts, New York State Department of Environmental Conservation
Amanda Rodewald, Ph.D., Cornell Lab of Ornithology and Cornell University
Kenneth Rosenberg, Ph.D., Cornell Lab of Ornithology
Sean Ross, Lyme Timber Company
Linnea Rowse, Audubon New York
Peter Smallidge, Ph.D., Cornell University
Michael Usai, New York City Department of Environmental Protection

*indicates affiliation at the time of review of *Forest Management for New York Birds: a Forester's Guide.*

FUNDING FOR THE PROJECT PROVIDED BY:

The LuEsther T. Mertz Charitable Trust | John and Margot Ernst | Overhills Foundation

Suggested Citation:

Treyger, S.M. 2019. *Managing Forests for Birds: A Forester's Guide.* Audubon New York.

CONTACT US:

audubonny@audubon.org

For more information, visit ny.audubon.org/workinglands

CONTENTS

INTRODUCTION

New York's forests provide important breeding, migratory stop-over, and wintering habitat for more than a hundred species of birds. One of their most important ecological functions is to provide breeding habitat for several dozen bird species, many of which are experiencing population declines due to a number of factors, including habitat fragmentation and the loss of quality habitat. Quality forest habitat for birds and other wildlife means intact, healthy, resilient, regenerating, and diverse forested landscapes. With 63% forest cover in New York State (NYS), the way we manage forestland can significantly influence bird populations.

Evening Grosbeak

Photo: davidehaas383/iStock by Getty Images

The application of sustainable forest management can greatly improve forest bird habitat. Silvicultural prescriptions, under the guidance of a professional forester, can create favorable conditions for birds while achieving timber management objectives and improving the ability of the forest to provide ecosystem services, such as improving water quality and reducing flooding. Audubon New York created ***Forest Management for New York Birds: A Forester's Guide*** as a resource for foresters and other land managers to integrate important habitat components into forest management planning. This technical guide is intended for use by practitioners in the fields of forestry, wildlife management, silviculture, conservation land-use planning, and other natural resources disciplines.

This document is part of Audubon New York'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, where Audubon connects with foresters and forest owners to provide information and assistance to improve forest habitat for birds in need of conservation and to 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 public managed lands nationwide.

New York Priority Forest Areas

Audubon has identified priority forest areas from Maine to Florida composed of large, contiguous tracts of forest that support rich and abundant populations of priority forest bird species (Figure 1). For breeding forest birds, these areas represent the most important habitats in the U.S. portion of the Atlantic Flyway, and they serve as focus areas for Audubon's Healthy Forests initiative. In NYS, there are 25 priority forest areas distributed throughout the state (Figure 2); these also have been identified as Important Bird Areas (IBAs).

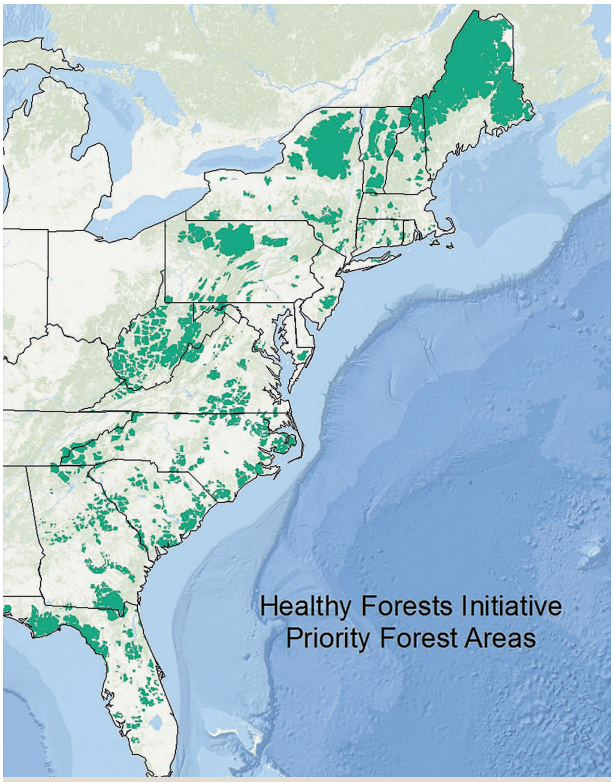


Figure 1. National Audubon Society priority forest areas.

Esri, DeLorme, GEBCO, NOAA, NGDC, and other contributors

Mature forest habitat.

Photo: Nicholas A. Tonelli/Flickr (CC BY 2.0)

Audubon New York concentrates its forest habitat conservation efforts within these priority forest areas, by providing outreach, technical assistance, and habitat management recommendations to foresters, public and private landowners, and other partnering agencies and organizations, to improve forest habitat quality for birds. **For more information about IBAs, visit ny.audubon.org/IBA.**

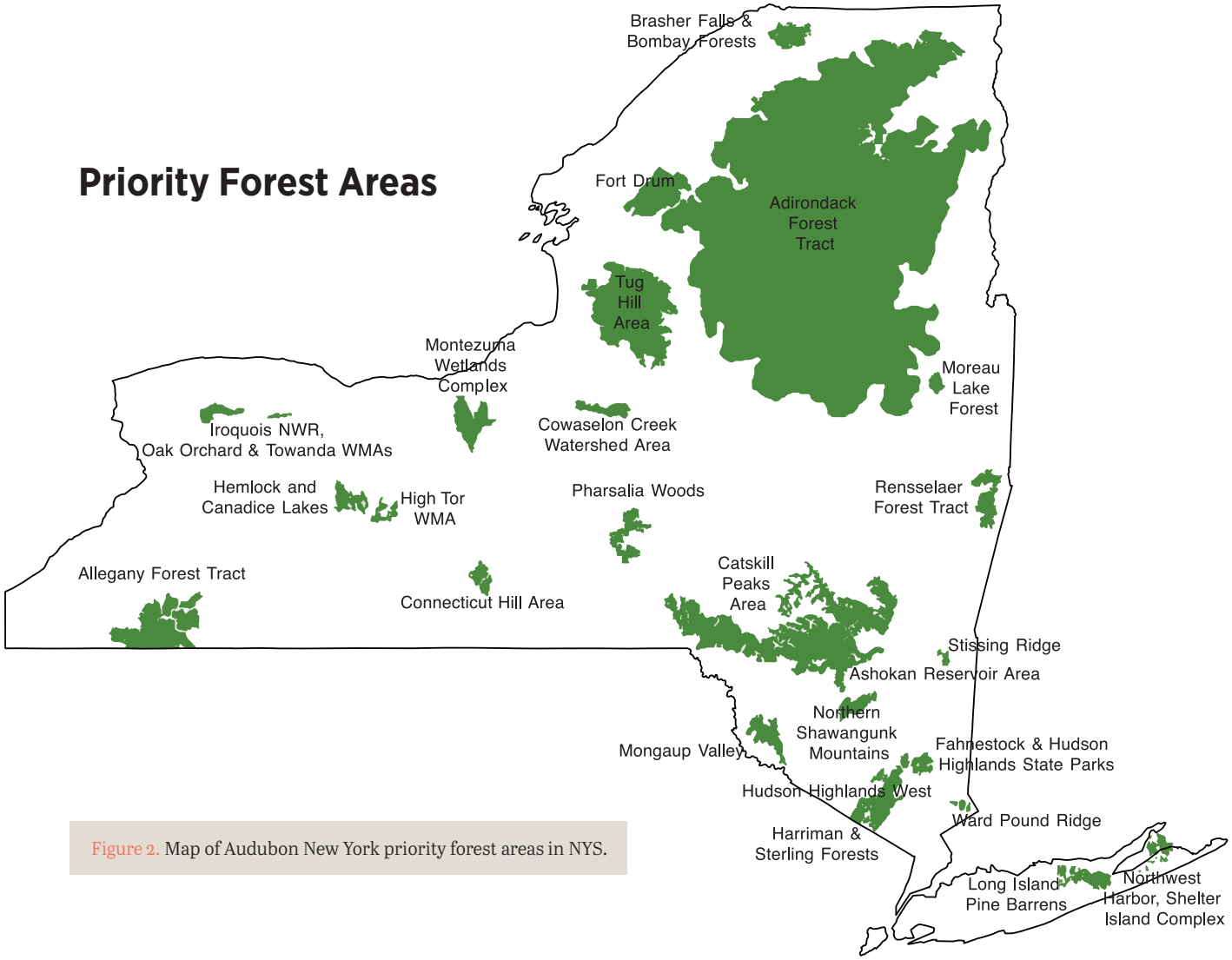
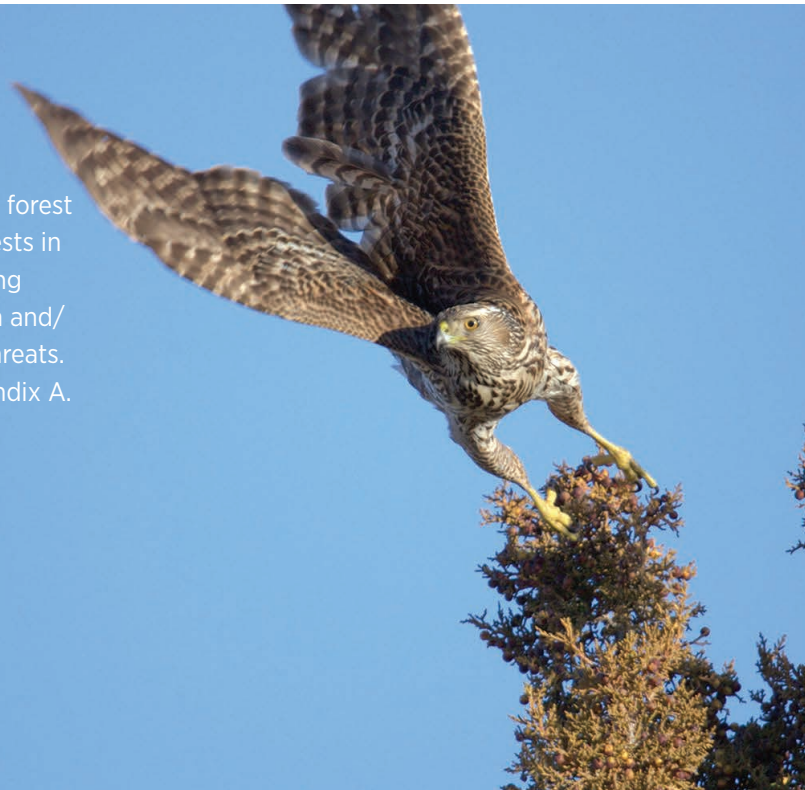


Figure 2. Map of Audubon New York priority forest areas in NYS.

New York Priority Forest Birds

Audubon New York has identified more than 45 priority forest bird species that would benefit from well-managed forests in New York (Table 1). A significant portion of their breeding populations use forests within the Eastern Forest region and/or are experiencing population declines or significant threats. Profiles of several priority species are included in Appendix A.



Cooper's Hawk

Photo: Beth Carpel/Audubon Photography Awards

Habitat for Forest Birds: A Conservation Concern

Suitable habitat for wildlife provides sources of water and food, places to breed and raise young, and cover from weather and predators. Depending on the time of year, habitat needs may change, as is the case with many forest birds that migrate long distances to and from their breeding and wintering grounds. Known as Neotropical migrants, these forest birds typically leave New York in September and spend October through March in warmer climates in Central and South America. In April and May, they return north to forests in New York and beyond to breed. Once here, birds will find a mate, locate suitable nesting habitat and build a nest, produce and incubate eggs, raise nestlings until they fledge, and then continue to rear their young until the fall migration in September.

The quality of forest habitat can greatly impact breeding success of birds. In general, large, contiguous tracts of forests (i.e. landscapes) that include a diversity of tree species and forest types and both young and old forests are needed to conserve the entire forest bird community. For most of New York State, a **young forest age class is a regenerating forest that is 0–10 years in age, but can be upwards of 15–20 years depending on growing and site conditions. Mature forest is typically 50 years or older**, and is the prominent age class found throughout the state, with much of New York's forests falling between 80–90 years of age.

Photo: Linnea Rowse

What is young forest habitat? Young forest habitat includes regenerating forests (seedlings, saplings, etc.), shrub lands, shrub swamps, and old fields with woody encroachment.

For this publication, we have included the **intermediate age class (10–50 years) with mature forest** because during this period fewer young forest birds and more mature forest birds are using these habitats.

Historically, natural disturbances such as beaver impoundments, wind, fire, ice, and flooding events helped to maintain such diverse conditions by creating openings in the forest canopy and initiating new forest growth in the gaps. Changes in land use, most notably the abandonment of farmland throughout the 1900s, coupled with the suppression of many natural disturbance events, have created abundant forest cover in New York, much of which is now relatively mature and similar in age, with little young forest in some parts of the state. There are additional factors that can further compromise the quality of forest habitat, including forest fragmentation, homogeneous structure, over-browsing of tree seedlings and saplings by white-tailed deer, interfering vegetation, and poor timber harvesting in the form of high grading. The purpose of this guide is to explain how forest management can improve forest habitat conditions for birds by restoring a more diversified balance among age classes and creating other desirable habitat characteristics.

What is Quality Forest Habitat?

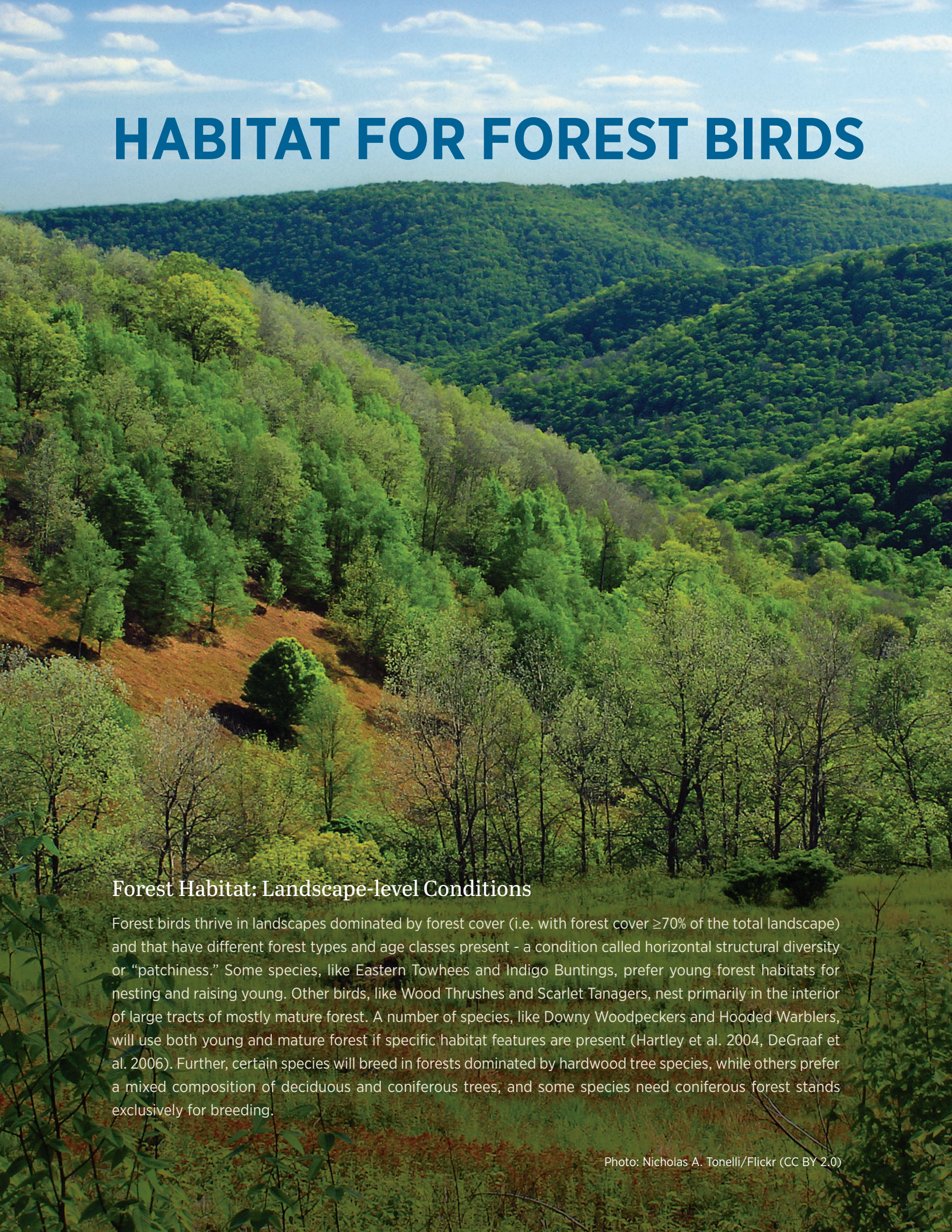
Because each bird species has different habitat requirements, healthy and diverse forested landscapes are critical to meet the habitat needs of an entire suite of forest birds. A healthy forest is intact; diverse; composed of multiple age classes; provides ecosystem services such as carbon sequestration, flood control, and water filtration; and supports forest birds and other wildlife. 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-size trees with high stem density, thick foliage cover, and few overstory trees. In addition, there are forest birds that will use both mature and young forest habitats for nesting (Hartley et al. 2004).

Nest building can occur in all vegetation layers, as well as on the forest floor. Tree and shrub species diversity will provide diverse fruits and seeds and support numerous insects that forest birds consume and feed to their young. Some birds have particular forest habitat associations, like Magnolia and Blackburnian Warblers, which tend to breed in forests with a significant conifer component, whereas Wood Thrushes and Cerulean Warblers utilize 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 (Anders et al. 1998, Vega Rivera et al. 1998, DeGraaf et al. 2006, Vitz and Rodewald 2006, Vitz and Rodewald 2007, King et al. 2011, Vitz and Rodewald 2011, Chandler et al. 2012, Stoleson 2013).

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. The following section explains landscape and stand-level forest habitat conditions that benefit birds.

HABITAT FOR FOREST BIRDS



Forest Habitat: Landscape-level Conditions

Forest birds thrive in landscapes dominated by forest cover (i.e. with forest cover ≥70% of the total landscape) and that have different forest types and age classes present - a condition called horizontal structural diversity or "patchiness." Some species, like Eastern Towhees and Indigo Buntings, prefer young forest habitats for nesting and raising young. Other birds, like Wood Thrushes and Scarlet Tanagers, nest primarily in the interior of large tracts of mostly mature forest. A number of species, like Downy Woodpeckers and Hooded Warblers, will use both young and mature forest if specific habitat features are present (Hartley et al. 2004, DeGraaf et al. 2006). 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.

Photo: Nicholas A. Tonelli/Flickr (CC BY 2.0)

For scale, a landscape can be considered to be about 2,500 acres in size (i.e. 3.9 mi^2, 1,012 hectares, 10.1 km^2), based on studies that examined forest bird habitat use in relation to landscape conditions (e.g., Rosenberg et al. 1999). Forested landscapes that are composed of approximately 5–10% young forest (0–10 years in age, on average) and predominantly of mature forest (>50 years in age), provide a suitable mix of habitat for a suite of forest birds (Rosenberg et al. 1999, King et al. 2001, Dettmers 2003, Becker et al. 2011). This would mean that given a 100–200 year rotation for even-aged stands, and with 5–10% in a young forest age class, multiple age classes would be present throughout the forest, maintaining a high degree of horizontal structural diversity. Percentages apply only to forest cover within the landscape, and do not include acreages of non-forest cover such as agricultural areas or urban, suburban, or other developed areas.

Forest Habitat in a Fragmented Landscape

In areas where forest cover is less than 70% of the landscape due to fragmentation by development or agriculture, it is important to maintain existing forest in order to sustain forest-related benefits for forest birds and other wildlife. Land use decisions should discourage converting existing forests to another cover type, and encourage restoration of non-forest areas back to forest to benefit forest birds and other wildlife. 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 *Stand-Level Conditions* for more information.

Photo: Nicholas A. Tonelli/Flickr (CC BY 2.0)

Photo: Kelly Colgan Azar/Flickr (CC BY-ND 2.0)

Wood Thrush adult and nestlings, with Brown-headed Cowbird nestling on left.

Photo: Luke Thompson/Great Backyard Bird Count

Eastern Towhee

Forest Patch Size and Edge

Where the landscape is <70% forested and forest cover is fragmented by other cover types (i.e. agriculture, 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 (Robinson et al. 1995, Rosenberg et al. 1999, Austen et al. 2001, Driscoll et al. 2005). In general, area sensitive forest birds need a minimum of 200 acres of contiguous forest for suitable breeding habitat (Rosenberg et al. 1999).

Forest "edge" occurs when there is an abrupt change from forest to non-forest. Edge effects, such as predation from raccoons, cats, and skunks and nest parasitism from Brown-headed Cowbirds, threaten the survival and reproductive success of forest interior breeding birds and are more pronounced in landscapes where forest fragmentation is high and where remaining forest patches are relatively small and adjacent to agricultural operations or developed areas (Robinson et al. 1995, Donovan et al. 1997, Hartley and Hunter 1998, Driscoll and Donovan 2004). Within more fragmented landscapes, edge effects have been observed more than 300 feet from the forest edge (Brittingham and Temple 1983, Rosenberg et al. 1999, Austen et al. 2001, Dunford and Freemark 2004, Driscoll et al. 2005, Nol et al. 2005, Environment Canada 2013). Which silvicultural treatments that create young forest are appropriate will greatly depend on the size of the forest patch, as even-aged management within smaller forest patches may temporarily increase edge effects and limit the amount of quality interior forest habitat. Softening or feathering "hard" forest edges to reduce an abrupt transition from forest to another cover type can also help reduce negative impacts to forest interior birds (Rosenberg et al. 1999, Rosenberg et al. 2003, DeGraaf et al. 2006). **See *Young Forest Habitat* for more information.**

Forest Habitat: Stand-level Conditions

The following section describes 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 Northern hardwood forests, but much of NYS lacks this forest age class. Depending on landowner goals, forest can be set aside from management to become late-successional forest in approximately 100–200 years, but the complex structure that is characteristic of older forests can be achieved by mimicking natural disturbances, such as wind throw and beaver flooding, through forest management. Foresters can enhance stand-level habitat features to increase forest birds' nesting success and rearing of fledglings.

Foresters and land managers can use the following descriptions of desired habitat features to compare against existing habitat conditions when performing timber cruises and forest inventories. The recommendations below (in bold face) can be integrated into silvicultural prescriptions to create or improve the key habitat features.

See Table 1 for information about forest habitat characteristics that are of particular importance to priority birds.

Vertical Structural Diversity

Vertical structural diversity refers to the layering of vegetation at multiple heights in a stand. Ones with high vertical structural diversity have overstory, midstory, and understory vegetation layers composed of some combination of trees, shrubs, herbaceous plants, and vines. This vertical structural diversity provides different birds with places to nest, perch, forage, seek cover, and raise young.

Structural complexity can be enhanced in mature forest by creating canopy gaps and stimulating the growth of understory vegetation (Newell and Rodewald 2011). Late successional forests (typically uneven-aged) tend to have high vertical structural diversity, 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, and substantial amounts of downed woody debris of larger logs and snags (DeGraaf et al. 2006, D'Amato and Catanzaro 2010). **In general, creating or maintaining vertical structural diversity within a mature forest stand is highly beneficial to many forest breeding birds.**

Forest with high structural diversity.

Photo: Nicholas A. Tonelli/Flickr (CC BY 2.0)

Species Diversity

Native vegetation provides the most habitat value to wildlife, and managing forests to provide a diversity of native trees, shrubs, vines, and herbaceous plants increases the suitable habitat potential for forest birds. However, some native species, such as American beech, can dominate a stand and reduce diversity. 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. In addition, native trees and shrubs produce more nutritious mast (fruits, seeds, and nuts) when compared to non-natives.

Where interfering vegetation is prohibiting the growth of native tree and shrub species, apply control methods to the interfering vegetation to release the native species. Increase species diversity of native trees and shrubs by applying silviculture that allows varying amounts of sunlight throughout the area you are managing, thereby creating conditions that foster the growth of shade intolerant, tolerant, and intermediately tolerant species (e.g., a 5-acre patch cut in one stand and crop-tree release in another stand).

Photo: Jeff Nadler

Blue-winged Warbler.

Controlling Interfering Vegetation: **Interfering vegetation includes both native and non-native invasive plants that prohibit successful forest regeneration by shading seedlings and other plants. Species such as common buckthorn, Japanese barberry, hayscented and New York ferns, and American beech, can dominate the forest understory thereby suppressing forest regeneration, reducing diversity, and decreasing overall habitat value to wildlife. Management should control interfering vegetation so that tree regeneration and native, non-invasive understory plants regenerate.**

Photo: Eli Sagor/Flickr (CC BY-NC 2.0)

Japanese barberry in a forest understory.

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 (DeGraaf et al. 2006).

Large Diameter Trees

Hardwood trees of at least 24 inches diameter at breast height (DBH) and softwood species of at least 20 inches DBH offer nest sites, perches, and places to forage for a number of forest birds, including Red-shouldered and Broad-winged Hawks. Large trees with cavities and large dead branches enhance the habitat for many forest birds **(see *Dead Standing Trees and Cavity Trees*). Where possible, retain a component of large diameter trees** (DeGraaf et al. 2006, Newell and Rodewald 2011). **If none are present, select some smaller ones to leave so they become large diameter wildlife trees in the future** (DeGraaf et al. 2006).

Large diameter trees.

Photo: Nicholas A. Tonelli/Flickr (CC BY 2.0)

Forest with a small group of softwoods.

Photo: Nicholas A. Tonelli/Flickr (CC BY 2.0)

Softwood Inclusions

Conifer, i.e. softwood, trees provide birds with cover and foraging habitat, and some birds preferentially select softwoods for nesting. In particular, there are a number of forest birds that are associated with eastern hemlocks, and some species, such as Blue-headed Vireos, Northern Saw-whet Owls, Hermit Thrushes, and Black-throated Green Warblers, are often found in areas with hemlocks (Yamasaki et al . 2000). To benefit forest birds, **retain and/or promote at least some softwoods where they occur, especially within predominantly hardwood stands** (DeGraaf et al. 2006). **Even a cluster of softwood trees of less than an acre in size has high habitat value to forest birds** (Yamasaki et al. 2000, DeGraaf et al. 2006).

Dead Standing Trees and Cavity Trees

Dead standing trees or "snags" provide locations for nesting, roosting, and foraging for insects. Cavity trees of all sizes provide nesting and roosting sites for birds. Keeping a range of size classes of snags and cavity trees (living or dead) is desirable, but the larger the better (Tubbs 1987, Yamasaki and Leak 2006). For snags, large diameter hardwood species (well over 18 inches DBH) will provide the best long-term habitat value as dead standing wood, and eventually as coarse downed woody material when they fall (Yamasaki and Leak 2006). **Where you can do so safely, retain at least six snags or cavity trees per acre, with one ≥ 18 inches DBH, and three ≥ 12 inches DBH** (Tubbs et al. 1987, Hagan and Grove 1999, DeGraaf et al. 2006, Bryan 2007, Bennett 2010, Hagenbuch et al. 2011). In areas of young forest, keep some cavity trees and snags (Hagan and Grove 1999, Bennett 2010).

Downed Woody Material (DWM)

DWM or coarse woody debris includes logs, stumps, and large branches (Bennett 2010). DWM 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 (Bennett 2010, Hagenbuch et al. 2011). In areas where deer densities are excessively high, leaving slash (tree material left from a harvest) may deter deer browsing and benefit forest regeneration, as it provides an obstacle that prevents deer from reaching seedlings and saplings. P**rotect existing DWM during harvest operations and increase DWM by leaving poor quality logs and cull material, tree tops, or other slash scattered throughout the stand rather than left in a large pile** (Hagan and Grove 1999). Providing DWM of different size classes and stages of decay is ideal (Hagan and Grove 1999, DeGraaf et al. 2006, Bennett 2010, Hagenbuch et al. 2011).

Downed woody material.

Photo: Suzanne Treyger/Audubon

Maple seedling in deciduous leaf litter.

Photo: Nicholas A. Tonelli/Flickr (CC BY 2.0)

Red-bellied Woodpecker in a dead cavity tree.

Photo: Matt MacGillivray/Flickr (CC BY 2.0)

Leaf Litter and Duff

Leaves, needles, and other decomposing vegetative materials offer foraging habitat for macroinvertebrates, such as worms and beetles. Moist leaf litter has high habitat value to Wood Thrushes, Ovenbirds, and other ground foragers and nesters. To protect the leaf litter layer, limit trails to no more than 10% of the total stand area, and confine skidding and vehicle traffic to these carefully located trails (R. Nyland personal communication). **When possible, avoid harvest operations during times with saturated soils, when rutting and soil compaction may compromise soil structure and drainage** (Leak et al. 2014).

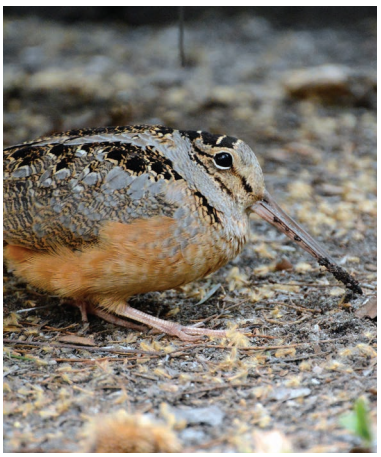
Table 1. **Audubon New York Priority Forest Birds that may benefit from the forest management recommendations included in this guide, their preferred nesting habitat, post-fledging habitats used, and habitat descriptions and special habitat features of significance that foresters can influence through silviculture (see *Forest Habitat: Stand-level Conditions* for detailed information).**

Species in orange are New York State Species of Greatest Conservation Need (for more information, please visit: http://www.dec.ny.gov/animals/9406.html).

SPECIES	NESTING HABITAT	POST-FLEDGING HABITAT	HABITAT DESCRIPTION AND SPECIAL HABITAT FEATURES
Acadian Flycatcher	Multiple age classes	Young forest/ dense understory	Wet deciduous thickets
American Goldfinch	Young forest	Young forest	Open forest, thickets
American Redstart	Young forest	Young forest	Canopy gaps in deciduous forest, thickets and shrubs
American Woodcock	Young forest	Young forest	Wet thickets adjacent to clearings and intermediate aged forest
Baltimore Oriole	Multiple age classes	Young forest	Deciduous and mixed open forest, large diameter trees
Black-and-white Warbler	Multiple age classes	Young forest	Deciduous and mixed forest, downed woody material, leaf litter
Black-billed Cuckoo	Young forest		Deciduous and mixed forest, thickets
Blackburnian Warbler	Mature forest	Young forest/ dense understory	Coniferous and mixed forest, large diameter trees
Blackpoll Warbler	Multiple age classes		Coniferous, spruce-fir forest
Black-throated Blue Warbler	Mature forest	Young forest/ dense understory	Deciduous and mixed forest, dense understory
Black-throated Green Warbler	Mature forest	Young forest/ dense understory	Coniferous and mixed forest, large diameter trees
Blue-winged Warbler	Young forest	Young forest	Deciduous forest
Broad-winged Hawk	Mature forest		Deciduous and mixed forest, large diameter trees, forest openings
Brown Thrasher	Young forest	Young forest	Deciduous and mixed forest, thickets, leaf litter
Canada Warbler	Young forest	Young forest	Moist mixed forest, softwood inclusions, downed woody material, leaf litter, dense understory
Cerulean Warbler	Mature forest		Deciduous forest, large diameter trees, canopy gaps and understory layer present
Chestnut-sided Warbler	Young forest	Young forest	Deciduous forest, thickets
Cooper's Hawk	Mature forest		Deciduous and mixed forest, canopy gaps and other large forest openings
Downy Woodpecker	Multiple age classes	Young forest	Deciduous forest, snags/cavity trees
Eastern Towhee	Young forest	Young forest	Deciduous and mixed forest, leaf litter
Eastern Whip-poor-will	Multiple age classes		Deciduous and mixed forest, canopy gaps and other large forest openings

SPECIES	NESTING HABITAT	POST-FLEDGING HABITAT	HABITAT DESCRIPTION AND SPECIAL HABITAT FEATURES
Eastern Wood-Pewee	Mature forest	Multiple age classes	Deciduous and mixed forest, canopy gaps and other large forest openings
Evening Grosbeak	Multiple age classes		Coniferous and mixed forest, large diameter trees, softwood inclusions
Golden-winged Warbler	Young forest	Multiple age classes	Deciduous forest, clumps of shrubs and perch trees
Hooded Warbler	Multiple age classes	Young forest	Deciduous forest, large diameter trees, dense understory, leaf litter
Least Flycatcher	Mature forest	Young forest	Deciduous and mixed forest, canopy gaps and other large forest openings, large diameter trees
Louisiana Waterthrush	Multiple age classes	Young forest	Deciduous forest, fast-moving streams and brooks, downed woody material, leaf litter
Northern Flicker	Multiple age classes		Deciduous and mixed forest, open forest, cavity trees
Northern Goshawk	Mature forest		Mixed forest, canopy gaps
Northern Saw-whet Owl	Multiple age classes		Coniferous and mixed forest, snags/cavity trees
Olive-sided Flycatcher	Young forest		Coniferous forest, open forest, snags
Prairie Warbler	Young forest	Young forest	Coniferous and mixed forest, softwood inclusions
Prothonotary Warbler	Mature forest		Forested swamps or forests near ponds, lakes, or slow-moving rivers, snags/cavity trees
Purple Finch	Multiple age classes		Coniferous and mixed forest
Red Crossbill	Mature forest		Coniferous forest
Red-shouldered Hawk	Multiple age classes		Deciduous and mixed forest, large diameter trees, open understory
Rose-breasted Grosbeak	Young forest	Young forest	Deciduous or mixed forest
Ruffed Grouse	Young forest	Young forest	Deciduous and mixed forest, downed woody material
Scarlet Tanager	Mature forest	Young forest/dense understory	Deciduous and mixed forest, large diameter trees, canopy gaps, softwood inclusions, dense understory
Sharp-shinned Hawk	Mature forest		Coniferous and mixed forest, softwood inclusions
Veery	Young forest	Young forest	Moist deciduous forest, leaf litter, dense understory
Willow Flycatcher	Young forest		Deciduous thickets
Wood Thrush	Mature forest	Young forest/dense understory	Deciduous and mixed forest, large and small diameter trees, presence of midstory layer, leaf litter
Worm-eating Warbler	Mature forest	Young forest/dense understory	Deciduous forest, dense understory, downed woody material, leaf litter
Yellow-billed Cuckoo	Multiple age classes		Deciduous forest, brushy thickets
Yellow-throated Vireo	Multiple age classes	Young forest	Deciduous forest, large diameter trees

See “Literature Cited” for Table 1 sources.



American Woodcock

Photo: Deborah Rivel

Black-billed Cuckoo

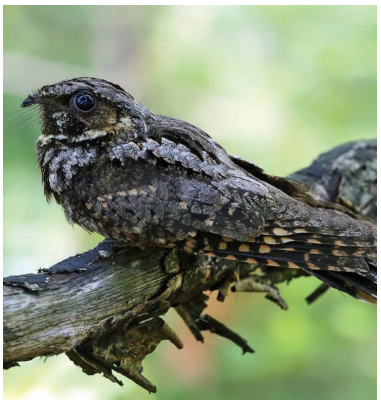
Photo: Shayna Hartley/Audubon Photography Awards

Black-throated Blue Warbler

Photo: Kelly Colgan Azar/Flickr (CC BY-ND 2.0)

Cerulean Warbler

Photo: Gary Robinette/Audubon Photography Awards



Eastern Whip-poor-will

Photo: Tom Murray/Flickr (CC BY-NC 2.0)

Louisiana Waterthrush

Photo: Kelly Colgan Azar/Flickr (CC BY-ND 2.0)

Prothonotary Warbler

Photo: Linda Steele/Audubon Photography Awards

Red-shouldered Hawk

Photo: David Rosenthal/Audubon Photography Awards

Ruffed Grouse

Photo: Francine Ouellette/Audubon Photography Awards

Photo: Tom Murray/Flickr (CC BY-NC 2.0)

Blue-winged Warbler

Photo: Brian Kushner/Audubon Photography Awards

Brown Thrasher

Photo: Dale Bonk/Audubon Photography Awards

Canada Warbler

Photo: KazKuro/Flickr (CC BY-NC-ND 2.0)

Northern Goshawk

Photo: Andy Reago & Chrissy McClarren/Flickr (CC BY 2.0)

Olive-sided Flycatcher

Photo: Will Stuart

Prairie Warbler

Photo: Linda Steele/Audubon Photography Awards

Scarlet Tanager

Photo: Kelly Colgan Azar/Flickr (CC BY-ND 2.0)

Wood Thrush

Photo: Steven Kersting/Flickr (CC BY-NC-ND 2.0)

Worm-eating Warbler

Photo: Nicholas A. Tonelli/Flickr (CC BY 2.0)

LANDSCAPE SCALE FOREST HABITAT MANAGEMENT GUIDE

By selecting from the broad array of silvicultural systems and practices, forest management can meet multiple objectives that include improving habitat for forest birds. However, identifying where to apply specific management prescriptions requires a bit of planning. The following guide can help determine what kind of forest management to use to enhance habitat for forest birds, and in what circumstances to use it. Depending on the surrounding landscape, even-aged or uneven-aged silviculture, or a combination of the two, can be implemented to achieve timber, habitat, and other management goals.

This guide can be used to determine forest habitat components that may be absent from the landscape, and how the parcel you are managing can provide the needed 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. The variety of cover types, land ownership, and potential land uses surrounding the parcel will greatly influence the management you prescribe when managing for forest birds. Across New York, most individual forest ownerships cover a fairly limited acreage, and landscapes have many of these small properties. These small holdings do provide important habitat for forest birds, especially if the property can complement the surrounding forested landscape, by offering a forest age class or habitat feature that is absent or limited (e.g., softwoods in a mostly hardwood dominated landscape). To affect habitat at landscape scales, forest owners with smaller acreages can collaborate with the owners of neighboring properties to plan how and when they will disperse different treatments across the different ownerships.

The guide 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.

Instructions for determining the percent forest cover and amount of young forest in the landscape can be found in Appendix B.

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

1. Diversify forest age classes within the landscape, such that 5–10% of area is in a young forest condition and the majority is in a mature age class. Where young forest is needed, **see** Young Forest Habitat **for management recommendations**.

2. Enhance bird habitat characteristics within mature forest where it is to be retained **(see *Within-stand Habitat Characteristics* for more information)**.

For landscapes less than 70% forested:

1. Proceeding with 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 habitat 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 (Rosenberg et al. 1999).

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 (5–10%), retain mature forest and focus on treatments that improve within-stand structural complexity.
- If there is less than 5% 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 *Forest Management in a Fragmented Landscape* for more information)**.
- If forest fragmentation is very high in the area you are working—landscape is less than 40% forested and the parcel you are managing is large (at least 200 acres), this may be 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 structural diversity 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 *Forest Management in a Fragmented Landscape* for more information).**

Young Forest Habitat (For landscapes with less than 5% young forest cover):

1. New patches cut to create young forest should be at least 5 acres in size to accommodate a full suite of young forest breeding birds (Chandler et al. 2009). Currently, research that examines what maximum clearcut size will benefit the most young forest birds is limited. However, there is evidence that species abundance plateaus with a clearcut size of around 20 acres (Rodewald and Vitz 2005). Reserve trees (individuals or clusters) should be retained within these patches to enhance structure and provide places to perch (Chandler et al. 2009). **See *Forest Stand Management 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). 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 (0.3 to 0.6 miles, when feasible) to aid in habitat connectivity for young forest species (Lehnen and Rodewald 2009, Rodewald 2013). Avoid areas that may be ecologically sensitive and significant, such as vernal pools (Calhoun and deMaynadier 2004).
3. To reduce potential predation and nest parasitism by Brown-headed Cowbirds of young forest breeding birds, avoid creating young forest near forest edges that are near developed areas (urban and suburban areas) or agricultural areas. 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 *Forest Management in a Fragmented Landscape* for more information)**.
4. If there is more than 10% young forest cover in the forested landscape you are working in, retain and enhance mature forest habitat by partial cutting strategies, such as single-tree and group selection system cuttings in uneven aged stands. 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.

In a few relatively small areas of New York, it may be appropriate for young forests to exceed 10% of the forest in a landscape. For example, Audubon NY works with public and private landowners to create young forest within focus areas for the Golden-winged Warbler, a high priority species that nests in young forest habitat.

The largest Golden-winged Warbler focus area in New York is located in the St. Lawrence Valley. Within Golden-winged Warbler focus areas, it is recommended that young forests make up about 20% of the forest in order to increase this species' population size.

Photo: Arni Stinnisson/Audubon Photography Awards

For more information about Audubon NY's Golden-winged Warbler conservation efforts, please visit ny.audubon.org

Photo: Nicholas A. Tonelli/Flickr (CC BY 2.0)

FOREST STAND MANAGEMENT SCENARIOS

The following section provides examples of different forest stand and landscape conditions that are commonly found in New York, as well as examples of potential silvicultural prescriptions that integrate forest bird habitat and timber management objectives.

The example prescriptions should be interpreted with flexibility and utilized as a guide to incorporate habitat considerations in management planning. Most likely there are several plausible silvicultural prescriptions for each stand description we provide. The examples we provide may help to achieve the desired habitat conditions, improve timber quality, and meet other landowner objectives. To devise appropriate prescriptions, foresters will need to assess and take into consideration site-specific conditions, such as the size of the parcel, soil type, landowner objectives, etc.

Each proposed silvicultural prescription is preceded with a "Bird Habitat Objective," to better frame each example from a habitat need perspective. Table 2 provides an overview of forest age class and structure, the silvicultural practices that can be used to achieve those habitat conditions, and a list of forest breeding birds that may benefit from this habitat. For more detailed stand descriptions, silvicultural options, and expected outcomes, please see Appendix C.

Timing the Harvest: To minimize disturbance to forest breeding birds, especially Neotropical migrants, which have a very short time period to nest and rear young, whenever possible harvests should not be conducted during the breeding season, which runs from April through August.

EXAMPLE STAND 1

Stand Description

- 30–50 year old stand; even-aged, fully stocked; "mature" forest habitat from a bird perspective
- Over 50% UGS
- Mixed hardwoods with a high density of American beech in the understory
- Little to no non-beech understory/regeneration

Landscape Context 1

- 5–10% or more of the landscape surrounding this stand is already in a young forest conditio

Silvicultural Prescription 1

- ***Thinning with Group Selection***

  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 structural diversity by retaining short trees and establishing additional understory vegetation.

  Thinning to increase vertical structural diversity and improve habitat for birds and other wildlife should retain trees of overtopped positions, thin the main canopy, and create small canopy openings that will foster establishment of understory regeneration (R. Nyland personal communication). This will keep the short trees alive, and also help to create new subcanopy layers that increase understory structure (R. Nyland personal communication). 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 (Leak et al. 2014, Nyland 2016).

  According to timber management goals, identify and retain Acceptable Growing Stock (AGS), and cut the patches by removing poor quality trees adjacent to AGS – similar to a crop-tree release (Leak et al. 2014).

  Understory American beech may need some control treatment to promote the 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.

Photo: Suzanne Treyger

Keep in mind: Additional within-stand habitat features are detailed in Forest Habitat: Stand-level Conditions. 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 2 for a list of species that will benefit from the "mature forest" habitat created by this management.

Landscape Context 2

- Less than 5% of the landscape surrounding this stand is in a young forest condition

Silvicultural Prescription 2

- ***Clearcut with Reserves***

  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 10% young forest conditions in the forested landscape.

  A clearcut with reserves (<10 ft^2/acre residual basal area or 10–15% canopy closure) may be a viable option to create young forest by regenerating desirable species (including shade intolerant species) (Tubbs et al. 1987, Leak et al. 2014, Smetzer et al. 2014). 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 (Costello et al. 2000, Alterman et al. 2005, DeGraaf et al. 2005, Chandler et al. 2009, Shake et al. 2012, Yamasaki et al. 2014).

  Avoid creating hard and straight edges and aim for a more natural disturbance look, with rounded boundaries and feathered edges (Rodewald 2013, Nyland 2016). Reserve trees or patches should contain desirable seed trees, cavity trees, snags, and softwood inclusions if present (Leak et al. 2014, Nyland 2016). 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 (Bennett 2010). Regeneration of shade-intolerant soft mast producing species, such as cherries and *Rubus* spp., will be beneficial to birds and other wildlife (Yamasaki et al. 2014).

Photo: Suzanne Treyger

Keep in mind: Additional within-stand habitat features are detailed in ***Forest Habitat: Stand-level Conditions.*** Where possible, retain cull or low-grade logs as DWM and control invasive plants.

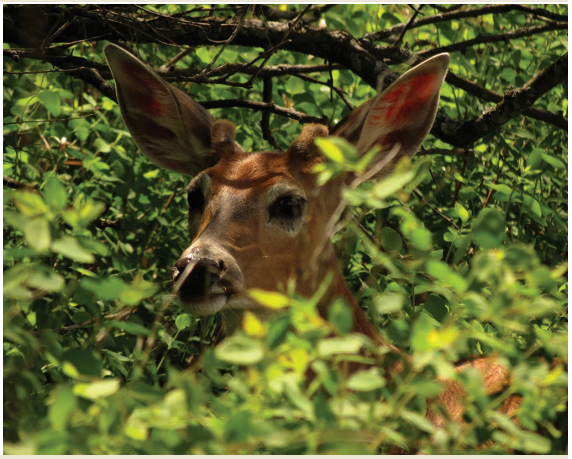


Photo: Alex Galt USFWS Midwest, Flickr/CC

White-tailed Deer: Deer densities are high throughout much of New York, and subsequent overbrowsing of tree seedlings and saplings can lead to unsuccessful forest regeneration after an even-aged harvest. Monitoring regeneration response is recommended, and additional safeguards, such as installing deer fence around the harvest site, may be necessary.

EXAMPLE STAND 2

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

Landscape Context 1

- 5–10% or more of the landscape surrounding this stand is already in a young forest condition

Silvicultural Prescription 1

- ***Group Selection/Patch Cuts***

  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 structural diversity, and enhance within-stand habitat features.

  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 2 acres, depending on conditions in the stand and the size of the property (King et al. 2001, DeGraaf et al. 2006). Single-tree selection between patches will maintain the vigor of residual trees and further upgrade stand quality (Leak et al. 2014, Nyland 2016). Although group selection openings are commonly too small to accommodate some area sensitive young forest birds, others like Chestnut-sided Warblers and Indigo Buntings will use these smaller openings (Costello et al. 2000, Alterman et al. 2005). 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 (Lamson and Leak 2000, Leak et al. 2014).

  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 (Lamson and Leak 2000, Nyland 2016). Inclusions of white pine and eastern hemlock should be retained to benefit birds that utilize conifers, such as Magnolia and Pine Warblers.

Photo: Artem Treyger

Keep in mind: Additional within-stand habitat features are detailed in ***Forest Habitat: Stand-level Conditions***. Where possible, retain DWM, large diameter trees, snags and cavity trees, control American beech and invasive plants, and manage for softwood inclusions where they are lacking.

Landscape Context 2

- Less than 5% of the landscape surrounding this stand is in a young forest condition

Silvicultural Prescription 2

- ***Low-density Shelterwoods with Reserves (Irregular)***

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

  A low-density shelterwood treatment may be an option for creating young forest conditions near the ground, while still leaving 20–40 ft^2/acre of residual basal area in mature overstory trees (Leak et al. 2014, Yamasaki et al. 2014). 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 (King and DeGraaf 2000).

  Reserve trees can include large diameter trees or cavity trees, and can be left in clusters or scattered individually (Leak et al. 2014, Nyland 2016). To further enhance habitat features, retain some snags 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.

Photo: USDA/Flickr (Public Domain Mark 1.0)

Keep in mind: Additional within-stand habitat features are detailed in ***Forest Habitat: Stand-level Conditions.*** Where possible, retain DWM and control invasive plants.

EXAMPLE STAND 3

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

Landscape Context 1

- 5–10% 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***

  Bird Habitat Objective: The 5–10% 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 mature forest breeding birds. Creating canopy gaps through periodic group selection will help to stimulate understory regeneration and increase vertical structural diversity.

  To increase complex habitat structure for birds and other wildlife, convert to an uneven-aged composition using group selection (Nyland 2016). Create small group cuts 0.25 to 0.67 acres in size, aiming to create canopy gaps (DeGraaf et al. 2006, Bakermans et al. 2012). Group cuts should remove all trees from the selected area, including the smaller non-oak trees (R. Nyland personal communication). Similar to Prescription 1 in Stand Description 2, groups should be scattered throughout the stand to mimic openings created by natural disturbances (Lamson and Leak 2000). Thinning can occur in between groups. Over time, additional entries will gradually transform the stand into a mosaic of small even-aged openings (R. Nyland personal communication). Maintain the uneven-aged character of the stand by periodically cutting new groups and thinning (R. Nyland personal communication).

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 **(see Appendix A for Cerulean Warbler breeding range map)** (Wood et al. 2013). These large diameter trees can be cavity trees or UGS as well, helping to provide an important habitat feature for multiple species.

Photo: USDA/Flickr (Public Domain Mark 1.0)

Keep in mind: **Additional within-stand habitat features are detailed in *Forest Habitat: Stand-level Conditions.* Where possible, retain 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.

Landscape Context 2

- Less than 5% of the landscape surrounding this stand is in a young forest condition

Silvicultural Prescription 2

- ***Shelterwood (Irregular)***

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

  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 may first be needed as a preparatory treatment to enhance seed production or begin establishing advanced oak regeneration (R. Nyland personal communication). 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 larger snags to enhance vertical structural diversity, or create large diameter snags through girdling (DeGraaf et al. 2006). Where pine regeneration is observed, retain inclusions to enhance habitat (DeGraaf et al. 2006, Leak et al. 2014). Leave low-quality logs as DWM, especially those that may be large diameter logs and in some stage of decay.

Photo: Eli Sagor/Flickr (CC BY-NC 2.0)

Keep in mind: Additional within-stand habitat features are detailed in ***Forest Habitat: Stand-level Conditions.*** Where possible, retain DWM and control invasive plants.

Table 2. **Overview of forest age classes, associated forest habitat structure, and the silvicultural methods that help to create or improve the desired habitat structure for the birds listed in the last column. Species in red are New York State Species of Greatest Conservation Need.**

FOREST AGE CLASS	FOREST HABITAT STRUCTURE FOR THE AGE CLASS	SILVICULTURAL OPTIONS TO CREATE OR IMPROVE THESE 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 or reserve patches from previous stand	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-whil* Evening Grosbeak* 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
MATURE (includes intermediate and mature age classes)			
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 Patch cuts 0.25–2 acres in size	Few birds will use this forest habitat for breeding due to lack of structural diversity; however, if canopy gaps are created and vertical structural diversity 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 structural diversity developing Midstory and understory vegetation developing Herbs and shrubs increasing in the understory > 70% canopy cover	Single-tree or 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 DWM	Acadian Flycatcher American Redstart Black-and-white Warbler Blackburnian Warbler Blackpoll Warbler Black-throated Blue Warbler Black-throated Green Warbler Broad-winged Hawk Canada Warbler Cerulean Warbler Cooper's Hawk Downy Woodpecker Eastern Wood-Pewee Evening Grosbeak Hooded 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 advance tree regeneration in the understory Vertical structural diversity 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 - 3 acre patch size)	
Mature, uneven-aged	High vertical structural diversity	Single-tree or group selection Maintain trees of large diameter Retain a component of snags and cavity trees Maintain or increase DWM	

*Content contributed by Ralph D. Nyland, Distinguished Service Professor, Department of Forest and Natural Resources Management, SUNY College of Environmental Science and Forestry. See Literature Cited for Table 2 sources.

APPENDICES

Photo: Nicholas A. Tonelli/Flickr (CC BY 2.0)

Appendix A: Audubon New York Priority Species Profiles

American Woodcock (Scolopax minor)

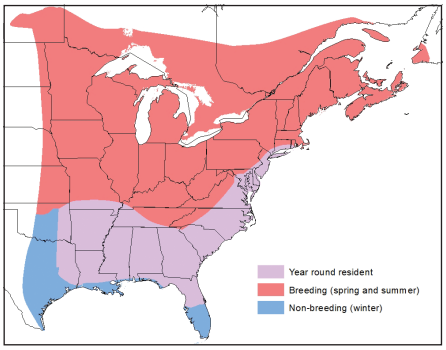
Habitat: Early-successional woodlands or grown-in fields, forest with openings

Trend: Declining in New York and across its range

ID Tips: A plump bird with a long bill, no neck and short legs; mottled cryptic coloration

Song: A nasal beeping peent mostly at dusk; also twittering wing sound when in flight

Management: Retain early-successional habitat; maintain thick alder and aspen stands for cover



Map by Audubon New York. Species distribution data provided by BirdLife International.
Photo: Deborah Rivel

Black-throated Blue Warbler (Setophaga caerulescens)

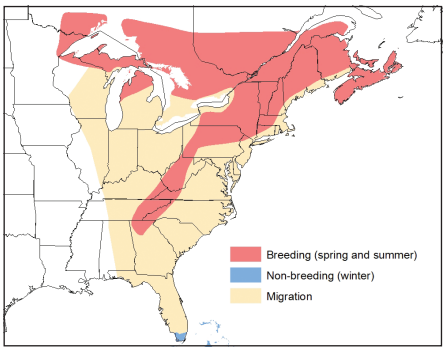
Habitat: Interior hardwood and mixed deciduous-coniferous forests, dense understory

Trend: Stable in New York and increasing across its range

ID Tips: Deep blue on top with black mask and throat; white wing patch "handkerchief"

Song: A thick and buzzy I'm-so-la-zeee with end note rising up to the "blue" sky

Management: Minimize linear openings (roads) and maximize forest interior; needs dense understory for nesting hobble-bush and saplings of striped/sugar maple saplings, hobblebush, and other native trees and shrubs



Map by Audubon New York. Species distribution data provided by BirdLife International.
Photo: Kenneth Cole Schneider, Flickr (CC BY-NC-ND 2.0)

Canada Warbler (Cardellina canadensis)

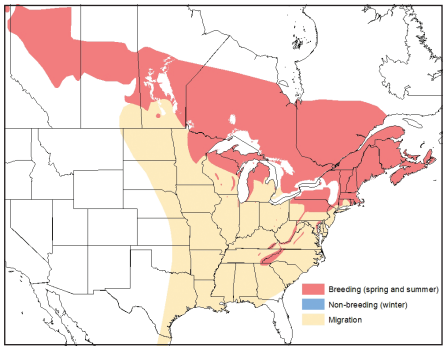
Habitat: Mixed, often young, forests, cedar swamps riparian forests with dense shrubs

Trend: Declining in New York and the Northeastern U.S.

ID Tips: Necklace of black stripes on bright yellow throat and belly, complete white eye-ring

Song: Often has soft introductory chips, then I'm-IN-here, but-you-CAN'T-SEE-ME

Management: Improve riparian buffers, protect cedar swamps and red maple/conifer swamps



Map by Audubon New York. Species distribution data provided by BirdLife International.
Photo: Deborah Rivel

Cerulean Warbler (Setophaga cerulea)

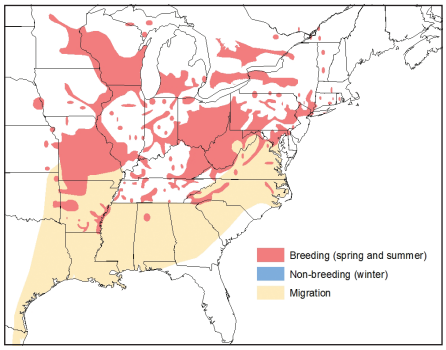
Habitat: Mature, deciduous forests with tall canopy that is partially open, with an open midstory and well-developed understory

Trend: Declining across its range

ID Tips: Sky-blue head and back, white throat and belly, two white wingbars

Song: Series of short buzzy notes, followed by a higher pitched buzz

Management: Retain large diameter trees (> 16 inches DBH), create canopy gaps 400–1000 ft2, improve vertical structure in mid and upper canopy layers, retain native grapevine



Map by Audubon New York. Species distribution data provided by BirdLife International.
Photo: Jeff Nadler

Golden-winged Warbler (Vermivora chrysoptera)

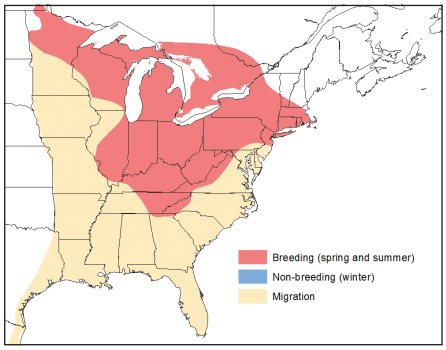
Habitat: Young, deciduous forest with scattered mature perch trees, within a forested landscape

Trend: Declining in New York and across its range

ID Tips: Yellow "cap" and patches on wings, black throat and eye mask

Song: Slow and insect-like seee-bzzz, bzzz

Management: Create young forest patches ≥5 acres within mature forest, retain 5–15 mature trees per acre in young forest patches



Map by Audubon New York. Species distribution data provided by BirdLife International.
Photo: Arni Stinniss/Audubon Photography Awards

Prairie Warbler (Setophaga discolor)

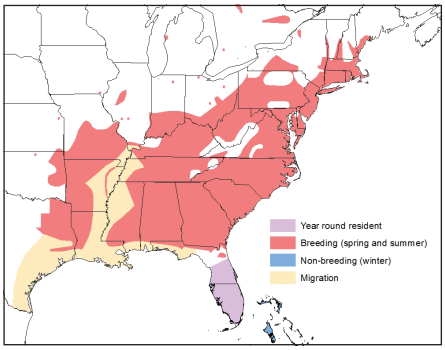
Habitat: Young forest with high densities of shrubs and saplings

Trend: Stable in New York although declining across most of its range

ID Tips: Yellow belly with black streaks on sides, olive green head and back

Song: Series of buzzy, ascending zee zee zee notes

Management: Create young forest habitat composed of a diverse mix of native shrubs and saplings



Map by Audubon New York. Species distribution data provided by BirdLife International.
Photo: Jeff Nadler

Wood Thrush (Hylocichla mustelina)

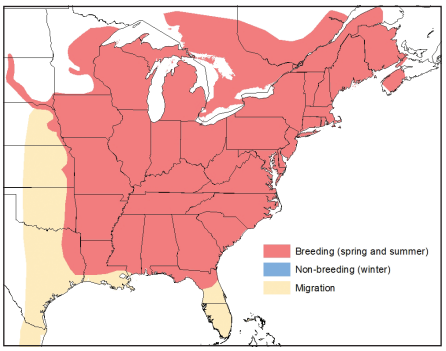
Habitat: Mature, moist deciduous woods with dense understory and heavy layer of leaf litter

Trend: Declining in New York and across its range

ID Tips: Brown back, heavily spotted on white breast; large thrush a little smaller than a robin

Song: A flute-like ee-oh-layy, ending in a sound like shattering glass

Management: Improve vertical structure/understory with small canopy gaps



Map by Audubon New York. Species distribution data provided by BirdLife International.
Photo: Jeff Nadler

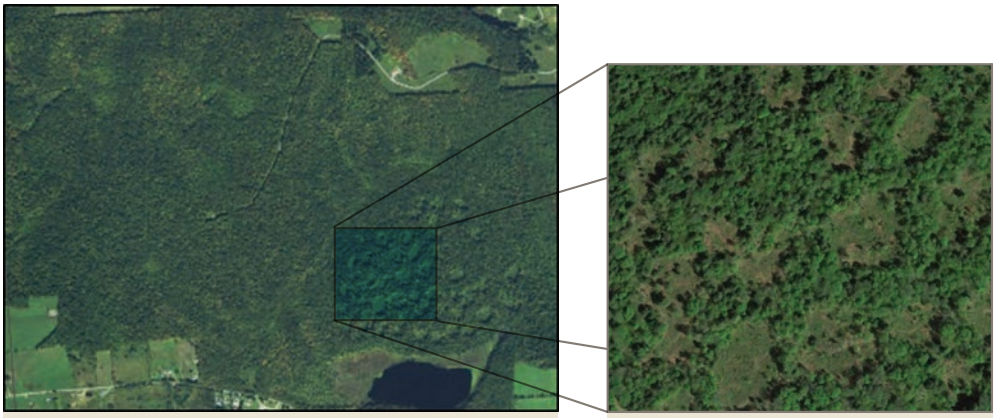
Appendix B.
Assessing Percent of Forest Cover and Amount of Young Forest in the Landscape

Use these steps to determine the percent forest cover within the landscape where you are working, as well as how much of the forested landscape is in a young forest age class. When percent forest cover has been calculated, **see the *Landscape Scale Forest Habitat Management Guide* for forest management recommendations.**

Step 1

Examine the landscape (2,500 acres) containing the property to be managed using satellite imagery from Google Earth or ArcMap, or a similar program. The parcel you are managing should be at the approximate center of the 2,500-acre landscape. Determine the total acreage of forest cover, including young forest, within the landscape containing the parcel you are managing – both Google Earth Pro and ArcMap provide measurement tools that estimate area. Exclude areas developed or used for residential, industrial, or agricultural purposes.

Divide the total amount of forest (including all age classes) by 2,500 to determine what percentage of the landscape is forested.

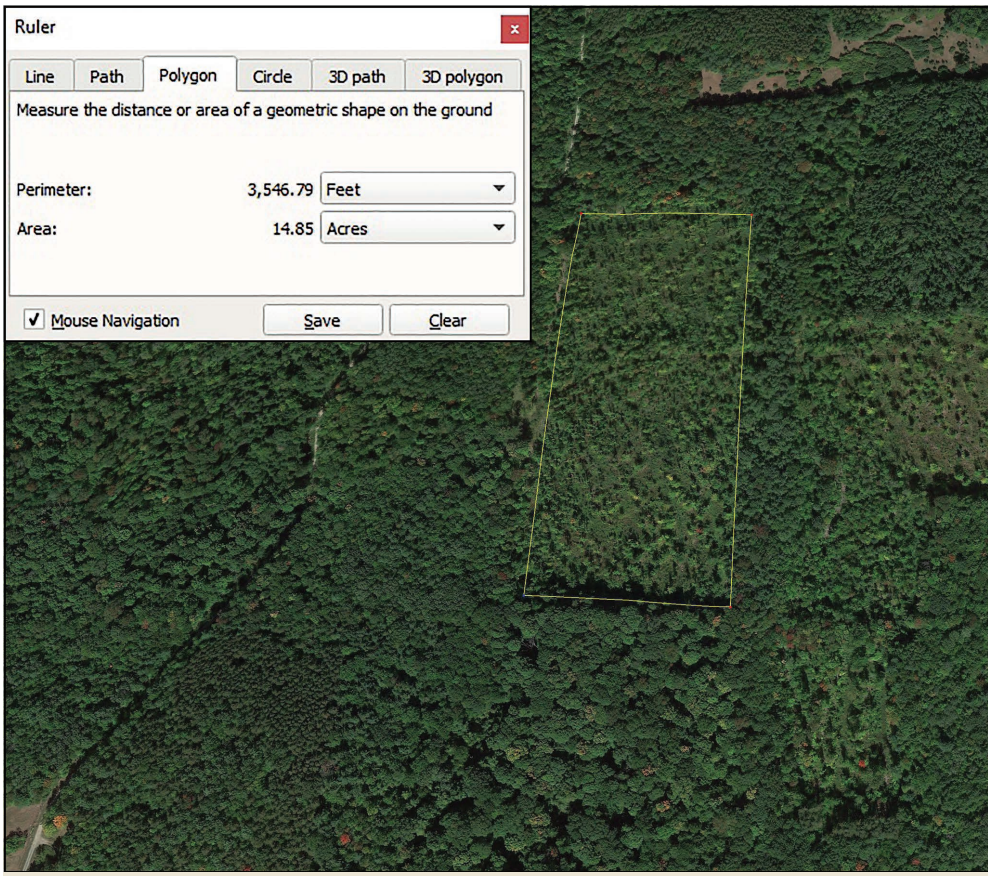


2,500 Acre Landscape View

Zoom in to better see young forest and other cover types.

Step 2

Zoom in to examine areas that may be young forest, and again use the measurement tool to estimate total area of young forest within the 2,500 acre landscape. Divide the amount of young forest by the total amount of forest to determine what percentage of the forest is in a young age class. Note: Some satellite imagery may be dated, making the estimate of young forest inaccurate (in most of New York, young forest conditions persist for about 10–15 years). Look for satellite imagery taken within the last five years, and verify young forest cover estimates with a site visit.



Use a tool that measures area in Google Earth Pro or ArcMap to estimate the amount of young and mature forest in the landscape.

Appendix C.
Additional Example Stand Conditions, Silvicultural Options, and Expected Outcomes, to be used in conjunction with the Forest Stand Management Scenarios section of the guide.

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

The following outline 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, with landscape conditions taken into consideration. **Please remember the bird habitat objective of creating or maintaining a landscape composed of 5–10% young forest and a majority of mature forest when considering the following 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
- Advance 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 condition class diversity across the forest or landscape
- Cleaning to release preferred trees overtopped by others
  - Free selected species of particular 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

Expected Outcomes

- Crowns of released trees will get longer and wider, increasing tree vigor and growth
- Once released, slower developing species will remain part of the developing stand
- Light will filter through gaps created in the canopy and stimulate herbaceous development for at least a short period of years
- Longer tree crowns and enhanced herb cover will improve vertical structural diversity, 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
- Advance tree regeneration absent
- Trees in pole stage, with many 6 to 11 inches DBH
- Often includes a mixture of tree species, but most short-lived trees have likely died
- Seed and soft mast production limited

Silvicultural Options

- No treatment if existing stand contributes to condition class diversity across the forest or landscape
- Pre-commercial thinning
  - Favor trees of upper-canopy positions and with the best growth potential
  - Free selected species of particular 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 timber value
- Retain a component of trees that have cavities, even with small openings
- Girdle selected trees to create snags, particularly trees with the largest diameters

Expected Outcomes

- Crown thinning will free trees of upper-canopy positions and with largest diameters
- Crown thinning will leave overtopped and lower intermediate trees that do not interfere with the crop trees
- Crowns of released trees will get longer and wider, increasing tree vigor and growth
- Tree mortality will decrease, particularly among ones of 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 after death of trees in sub-canopy positions
- Light will filter through the newly created canopy gaps and stimulate herbaceous development
- A shortage of seed will limit establishment of advance tree regeneration
- Longer tree crowns, enhanced herb cover, and retention of short trees will improve vertical structural diversity, and extend it until the crown canopy closes again


Downy Woodpecker

Photo: Margo Burnison/Audubon Photography Awards

MATURE FOREST
(Even-aged, >50 years old)

Stand Description

- Trees in large-pole and sawtimber stage, with ones as big as 12–18 inches DBH
- Closed canopy, with some small gaps where trees of intermediate crown positions died
- Crown canopy elevated, with few short trees remaining
- Little vegetation in the middle and understory canopy layers
- Mortality of main canopy trees increases by about 80 years, opening some canopy gaps
- Until mortality opens upper canopy gaps, herbs and shrubs sparse and consisting of shade-tolerant species
- Advance tree regeneration absent, except beneath the larger canopy gaps
- Often includes a mixture of tree species, but no short-lived ones
- Reproductively mature trees of upper canopy positions and understory herbs produce seed and soft mast
- As a ground layer of herbs and tree seedlings forms and develops, vertical structural diversity increases

Silvicultural Option #1 – Grow for Longer Rotation

- No treatment if existing stand contributes to condition class diversity across the forest or landscape
- Operate commercially by crown thinning to 60% relative density
  - Free selected species of particular wildlife value to 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 the largest diameters
- Leave a component of large-diameter felled trees for CWM

Red Crossbill

Photo: Adam W Ciha/Great Backyard Bird Count

Expected Outcomes

- Crown thinning will free trees of upper-canopy positions and with largest diameters, but leave overtopped and lower intermediate trees that do not interfere with the crop trees
- Crowns of released canopy trees will get longer 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 advance tree regeneration in brightened understory places
- Longer tree crowns, enhanced herb cover, establishment of advance tree regeneration, and retention of short trees will improve vertical structural diversity
- Periodic reentry for subsequent thinning will extend these conditions

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

- If well-developed advance regeneration of desirable species distributed across ≥ 70% of stand
  - Herbivory or interference not likely
  - Clearcut entire stand to promote growth of advance seedlings and establish additional seedlings
  - Alternately use progressive strip or patch clearcutting, covering entire stand in two to three entries
  - Leave tops of large-diameter felled trees for CWM
- If advance tree regeneration missing, small, or sparse
  - Control herbivory when needed
  - Control interfering plants if present, generally after high deer densities are reduced controlled
  - Do shelterwood seed cutting across the stand, reducing relative density to 50% or lower
  - Schedule removal cutting after 3,000 to 5,000 trees have overtopped the raspberries and other herbs, but before new trees exceed 1 inch DBH
  - Leave tops of large-diameter felled trees for CWM

Expected Outcomes – All Even-aged Regeneration Methods

- After cutting, the stand will have abundant CWM and fine woody material (FWM) due to the logging slash and unused tree boles
- Within two 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 FWM 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
- 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
- By 15–20 years, many shorter and overtopped 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 structural diversity
- Through time the tree canopy rises higher and higher above the ground, with vertical structural diversity decreasing in the process
- By 20–25 years, the tree community will have Mature Forest characteristics with respect to forest bird habitat
- By 20–25 years, large pieces of CWM will have largely decayed

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

- Control herbivory and interfering plants as necessary
- Use Grade C thinning from below to reduce stocking to 55–60% relative density, regulating spacing between main canopy trees and removing trees of overtopped 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
- 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 CWM and FWM 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, large pieces of 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 structural diversity
- Maintaining a component of the oldest over story trees, coupled with periodic replenishment of understory herbs, ensures continued seed production
- After each entry, the stand will have abundant CWM and FWM due to the logging slash and unused tree boles, with continuing management periodically replenishing the supply

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

- Control herbivory and interfering plants as necessary
- Use Grade D thinning 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 for CWM

Expected Outcomes – Converting a Two-Aged Stand

- After cutting, the stand will have abundant CWM and FWM due to the logging slash and unused tree boles
- Within two years, 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 FWM 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 CWM 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 has limited structural diversity

MATURE FOREST
(Uneven-aged, of sawtimber status)

Stand Description

- An intermixing of age classes results 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 structural diversity
- Due to discontinuity within the canopy layers, particularly in managed stands, light filters through to places on the ground
- Resulting environmental conditions support an admixture of advance 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 pieces of CWM

Photo: Frances Higgs/Great Backyard Bird Count

Silvicultural Option #1 – 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 single-tree selection system take individual trees here and there from the stand, leaving a uniformly-dispersed residual stand
  - With group selection system remove clusters of mature trees, likely removing 2–3 groups per 3–4 acres
  - Combine single-tree selection with cutting of patches (generally made where inter-mixed mature, undesirable, and/or short-lived trees occur in close proximity)
- 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

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 residual stocking levels (≥ 75 ft2/ac) will increase the multi-layered condition and maintain a high level of vertical structural diversity
- Bright conditions at the ground after cutting that leaves a low residual stocking of < 70 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 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 CWM and FWM due to the logging slash and unused tree boles, with continued management periodically replenishing the supply at regular intervals

Photo: Félix Uribe/Flickr (CC BY-SA 2.0)

(continued) >>>

Silvicultural Option #2 – 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
- Remove dispersed individual trees, cut patches of them, or both
- 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 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 periodically creates canopy openings that vary from single-tree gaps to wider ones left by removing groups of trees
- Cutting large trees or patches will promote understory development (advance 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 CWM and FWM due to the logging slash and unused tree boles, but with continued management replenishing the supply at irregular intervals

Blackpoll Warbler

Photo: Owen Deutsch/Audubon Photography Awards

LITERATURE CITED

Alterman, L.E., Bednarz, J.C., Thill, R. E. 2005. Use of group-selection and seed-tree cuts by three early-succesional migratory species in Arkansas. *Wilson Bulletin*, 117(4), pp. 353-363.

Anders, A.D., Faaborg, J., Thompson, F.R. III. 1998. Postfledging dispersal, habitat use, and home-range size of juvenile wood thrushes. *The Auk*, 115(2), pp. 349-358.

Austen, M.J.W., Francis, C.M., Burke, D.M., Bradstreet, M.S.W. 2001. Landscape context and fragmentation effects on forest birds in Southern Ontario. *The Condor*, 103(4), pp. 701-714.

Bakermans, M.H., Rodewald, A.D., Vitz, A.C. 2012. Influence of forest structure on density and nest success of mature forest birds in managed landscapes. *The Journal of Wildlife Management*, 76(6), pp. 1225-1234.

Becker, D.A., Wood, P.B., Keyser, P.D., Wigley, T.B., Dellinger, R., Weakland, C.A. 2011. Threshold responses of songbirds to long-term timber management on an active industrial forest. *Forest Ecology and Management*, 262, pp. 449-460.

Bennet, K.P. (editor). 2010. *Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire*. 2nd edition, University of NH Cooperative Extension, Durham, NH.

BirdLife International and Handbook of the Birds of the World (2016) Bird species distribution maps of the world. Version 6.0. Available at http://datazone.birdlife.org/species/requestdis.

Brittingham, M.C., Temple, S.A. 1983. Have cowbirds caused forest songbirds to decline? *BioScience*, 33(1), pp. 31-35.

Bryan, R. R. 2007. *Focus Species Forestry: A Guide to Integrating Timber and Biodiversity Management in Maine*. 3rd edition, Maine Audubon.

Calhoun, A. J. K., deMaynadier, P. 2004. *Forestry habitat management guidelines for vernal pool wildlife*. MCA Technical Paper No. 6, Metropolitan Conservation Alliance, Wildlife Conservation Society, Bronx, New York.

Chandler, C.C., King, D.I., Chandler, R.B. 2012. Do mature forest birds prefer early-successional habitat during the post-fledging period? *Forest Ecology and Management*, 264, pp. 1-9.

Chandler, R.B., King, D.I., Chandler, C.C. 2009. Effects of management regime on the abundance and nest survival of shrubland birds in wildlife openings in northern New England, USA. *Forest Ecology and Management*, 258, pp. 1669-1676.

Costello, C.A., Yamasaki, M., Pekins, P.J., Leak, W.B., Neefus, C.D. 2000. Songbird response to group selection harvests and clearcuts in a New Hampshire northern hardwood forest. *Forest Ecology and Management*, 127, pp. 41-54.

D'Amato, A., Catanzaro, P. 2010. *A Forest Manager's Guide to Restoring Late-Successional Forest Structure*. University of Massachusetts Extension.

DeGraaf, R. M., Yamasaki, M., Leak, W. B., Lester, A.M. 2005. *Landowner's Guide to Wildlife Habitat: Forest Management for the New England Region*. Burlington, VT: University of Vermont Press.

DeGraaf, R.M., Yamasaki, M., Leak, W. B., Lester, A.M. 2006. *Technical Guide to Forest Wildlife Habitat Management in New England*. University of Vermont Press.

Dettmers, R. 2003. Status and conservation of shrubland birds in the Northeastern US. *Forest Ecology and Management*, 185, pp. 81–93.

Donovan, T. M., Jones, P.W., Annand, E.M., Thompson, III. F.R. 1997. Variation in local-scale edge effects: mechanisms and landscape context. *Ecology*, 78, pp. 2064–2075.

Driscoll, M.J.L., Donovan, T.M. 2004. Landscape context moderates edge effects: nesting success of wood thrushes in central New York. *Conservation Biology*, 18(5), pp. 1330–1338.

Driscoll, M.J.L., Donovan, T., Mickey, R., Howard, A., Fleming, K.K. 2005. Determinants of wood thrush nest success: a multi-scale, model selection approach. *Journal of Wildlife Management*, 69(2), pp. 699-709.

Dunford, W., Freemark, K. 2004. Matrix matters: effects of surrounding land uses on forest birds near Ottawa, Canada. *Landscape Ecology*, 20, pp. 497-511.

Environment Canada. 2013. *How much habitat is enough?* Third Edition. Environment Canada, Toronto, Ontario.

Hagan, J.M., Grove, S.L. 1999. Coarse woody debris: Humans and nature competing for trees. *Journal of Forestry*, 97(1), pp. 6-11.

Hagenbuch, S., Manaras, K., Shallow, J., Sharpless, K., Snyder, M. 2011. *Silviculture with birds in mind*. Audubon Vermont and Vermont Department of Forests, Parks, and Recreation.

Hartley, M.J., Hunter, M.L. 1998. A meta-analysis of forest cover, edge effects, and artificial nest predation rates. *Conservation Biology*, 12(2), pp. 465-469.

Hartley, M. J., Sullivan, K. L., Burger, M. F. 2004. *Wildlife and Forestry in New York Northern Hardwoods: A Guide for Forest Owners and Managers*. Audubon New York, Albany, New York.

King, D.I., DeGraaf, R.M. 2000. Bird species diversity and nesting success in mature, clearcut and shelterwood forest in northern New Hampshire, USA. *Forest Ecology and Management*, 129, pp. 227-235.

King, D.I., DeGraaf, R.M., Griffin, C.R. 2001. Productivity of early successional shrubland birds in clearcuts and groupcuts in an eastern deciduous forest. *The Journal of Wildlife Management*, 65(2), pp. 345-350.

King, D. I., Yamasaki, M., DeGraaf, R.M., Costello, C.A. 2011. Three decades of avian research on the Bartlett Experimental Forest, New Hampshire, U.S.A. *Forest Ecology and Management*, 262, pp. 3-11.

Lamson, N. I., Leak, W.B. 2000. *Guidelines for applying group selection harvesting*. NA-TP-02-00, USDA Forest Service.

Leak, W.B., Yamasaki, M., Holleran, R. 2014. *Silvicultural guide for northern hardwoods in the northeast*. Gen. Tech. Rep. NRS-132. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.

Lehnen, S.E., Rodewald, A.D. 2009. Dispersal, interpatch movements, and survival in a shrubland breeding bird community. *Journal of Field Ornithology*, 80(3), pp. 242-252.

Newell, F.L., Rodewald, A.D. 2011. Role of topography, canopy structure, and floristics in nest-site selection and nesting success of canopy songbirds. *Forest Ecology and Management*, 262, pp. 739-749.

Nol, E., Francis, C.M., Burke, D.M. 2005. Using distance from putative source woodlots to predict occurrence of forest birds in putative sinks. *Conservation Biology*, 19(3), pp. 836-844.

Nyland, R.D. 2016. *Silviculture: Concepts and Applications*. McGraw-Hill Co., NY. 3rd edition.

Robinson, S.K., Thompson, III F.R., Donovan, T.M., Whitehead, D.R., Faaborg, J. 1995. Regional forest fragmentation and the nesting success of migratory birds. *Science*, 267, pp. 1987-1990.

Rodewald, A. D. 2013. *Managing forest birds in southeast Ohio*: A guide for land managers. Ohio Bird Conservation Initiative.

Rodewald, A.D., Vitz, A.C. 2005. Edge and area sensitivity of shrubland birds. *Journal of Wildlife Management*, 69(2), pp. 681-688.

Rosenberg, K.V., Hames, R.S., Rohrbaugh, Jr., R.W., Barker Swarthout, S., Lowe, J.D., Dhondt, A.A. 2003. *A Land Manager's Guide to Improving Habitat for Forest Thrushes*. The Cornell Lab of Ornithology, Ithaca, NY.

Rosenberg, K. V., Rohrbaugh, Jr., R.W., Barker, S.E., Lowe, J.D., Hames, R.S., Dhondt, A.A. 1999. *A Land Managers Guide to Improving Habitat for Scarlet Tanagers and Other Forest-interior Birds*. The Cornell Lab of Ornithology, Ithaca, NY.

Shake, C.S., Moorman, C.E., Riddle, J.D., Burchell, M.R., II. 2012. Influence of patch size and shape on occupancy by shrubland birds. *The Condor* 114(2), pp. 268-278.

Smetzer, J.R. 2014. Science-based management of shrubland birds in Vermont's Green Mountain National Forest. M.S. Thesis. University of Massachusetts Amherst.

Stoleson, S.H. 2013. Condition varies with habitat choice in postbreeding forest birds. *The Auk*, 130(3), pp. 417-428.

Tubbs, C.H., DeGraaf, R.M., Yamasaki, M., Healy, W.M. 1987. *Guide to Wildlife Tree Management in New England Northern Hardwoods*. Gen. Tech. Rep. NE-118. Broomail, PA: U.S. Department of Agriculture, Forest Service, Northern Forest Experiment Station.

Vega Rivera, J.H., Rappole, J.H., McShea, W.J., Haas, C.A. 1998. Wood thrush postfledging movements and habitat use in northern Virginia. *The Condor*, 100(1), pp. 69-78.

Vitz, A.C., Rodewald, A.D. 2006. Can regenerating clearcuts benefit mature-forest songbirds? An examination of post-breeding ecology. *Biological Conservation*, 127, pp. 477-486.

Vitz, A.C., Rodewald, A.D. 2007. Vegetative and fruit resources as determinants of habitat use by mature-forest birds during the postbreeding period. *The Auk*, 124(2), pp. 494-507.

Vitz, A.C., Rodewald, A.D. 2011. Influence of condition and habitat use on survival of post-fledging songbirds. *The Condor*, 113(2), 400-411.

Wood, P.B., Sheehan, J., Keyser, P., Buehler, D., Larkin, J., Rodewald, A., Stoleson, S., Wigley, T.B., Mizel, J., Boves, T., George, G., Bakermans, M., Beachy, T., Evans, A., McDermott, M., Newell, F., Perkins, K., White, M. 2013. *Management Guidelines for Enhancing Cerulean Warbler Breeding Habitat in Appalachian Hardwood Forests*. American Bird Conservancy. The Plains, Virginia.

Yamasaki, M., DeGraaf, R.M., Lanier, J.W. 2000. *Wildlife habitat associations in eastern hemlock — birds, smaller mammals and forest carnivores*. Proceedings: symposium on sustainable management of hemlock ecosystems in eastern North America (editors K.A. McManus, K.S. Shields and D.R. Souto), pp. 135–143. USDA General Technical Report 267. Newtown Square, PA.

Yamasaki, M., Leak, W.B. 2006. Snag longevity in managed northern hardwoods. *Northern Journal of Applied Forestry* 23(3), pp. 215-217..

Yamasaki, M., Costello, C.A., Leak, W.B. 2014. *Effects of clearcutting, patch cutting, and low-density shelterwoods on breeding birds and tree regeneration in New Hampshire northern hardwoods*. Res. Pap. NRS- 26. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.

TABLE 1 SOURCES

Anders, A.D., Faaborg, J., Thompson, F.R. III. 1998. Postfledging dispersal, habitat use, and home-range size of juvenile wood thrushes. *The Auk*, 115(2), pp. 349-358.

Annand, E.M., Thompson, F.R., III. 1997. Forest bird response to regeneration practices in central hardwood forests. *Journal of Wildlife Management*, 61(1), pp. 159-171.

Burger, M.F. "Birds of Conservation Concern in New York." Audubon New York. https://ny.audubon.org/sites/g/files/amh406/f/birds_of_conservation_concern_in_ny_-_march_2017.pdf. Accessed June 27, 2017.

Chandler, C.C., King, D.I., Chandler, R.B. 2012. Do mature forest birds prefer early-successional habitat during the post-fledging period? *Forest Ecology and Management*, 264, pp. 1-9

DeGraaf, R.M., Yamasaki, M., Leak, W. B., Lester, A.M. 2006. *Technical Guide to Forest Wildlife Habitat Management in New England*. University of Vermont Press.

Hartley, M.J., Beyea, J., M.F. Burger. 2003. Use of meta-analysis to assign bird species to assemblages indicative of responsiveness to logging intensity in northeastern, hardwood forests. *Unpublished research*.

King, D.I., Labbe, M.A., Collins, J. 2007. *Habitat use of wildlife openings and clearcuts by birds during the post-fledging period*. A Preliminary Report to MassWildlife.

Marshall, M.R., DeCecco, J.A., Williams, A.B., Gale, G.A., Cooper, R.J. 2003. Use of regenerating clearcuts by late-successional bird species and their young during the post-fledging period. *Forest Ecology and Management*, 183, pp. 127-135.

National Audubon Society. "Guide to North American Birds." http://www.audubon.org/bird-guide. Accessed January 20, 2017.

Porneluzi, P.A., Brito-Aguilar, R., Clawson, R.L., Faaborg, J. 2014. Long-term dynamics of bird use of clearcuts in post-fledging period. *The Wilson Journal of Ornithology*, 126(4), pp. 623-634.

Streby, H.M., Peterson, S.M., Kramer, G.R., Andersen, D.E. 2015. Post-independence fledgling ecology in a migratory songbird: implications for breeding-grounds conservation. *Animal Conservation*, 18(3), pp. 228-235.

Vitz, A.C., Rodewald, A.D. 2006. Can regenerating clearcuts benefit mature-forest songbirds? An examination of post-breeding ecology. *Biological Conservation*, 127, pp. 477-486.

TABLE 2 SOURCES

DeGraaf, R.M., Yamasaki, M., Leak, W. B., Lester, A.M. 2006. *Technical Guide to Forest Wildlife Habitat Management in New England*. University of Vermont Press.

Goodale, E., Lalbhai, P., Goodale, U.M., Ashton, P.M.S. 2009. The relationship between shelterwood cuts and crown thinnings and the abundance and distribution of birds in a southern New England forest. *Forest Ecology and Management*, 258, pp. 314-322.

King, D.I., DeGraaf, R.M. 2000. Bird species diversity and nesting success in mature, clearcut and shelterwood forest in northern New Hampshire, USA. *Forest Ecology and Management*, 129, pp. 227-235.

Rodewald, A. D. 2013. *Managing forest birds in southeast Ohio: A guide for land managers*. Ohio Bird Conservation Initiative.

Yamasaki, M., Costello, C.A., Leak, W.B. 2014. *Effects of clearcutting, patch cutting, and low-density shelterwoods on breeding birds and tree regeneration in New Hampshire northern hardwoods*. Res. Pap. NRS- 26. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.

Audubon | NEW YORK

Audubon New York, a state program of the National Audubon Society, protects birds and the places they need, today and tomorrow. Our network of 70,000 members, seven sanctuaries and nature centers, and 27 local chapters works throughout the state using science, advocacy, education, and on-the-ground conservation. A nonprofit conservation organization since 1905, Audubon believes in a world in which people and wildlife thrive.

INTERNATIONAL PAPER

SUSTAINABLE FORESTRY INITIATIVE

MANUFACTURED WITH 100% RENEWABLE ENERGY

FSC www.fsc.org MIX Paper from responsible sources FSC® C103525

Printed on Accent Opaque paper proudly produced at and donated by International Paper's Ticonderoga mill from working Adirondack forests, managed responsibly in accordance with the principles of the Sustainable Forestry Initiative®.

Papers used in this booklet are 80# Accent Opaque Smooth Cover and 80# Accent Opaque Smooth Text.

Printed by Fort Orange Press, Albany, NY. Manufactured with 100% renewable energy and meeting the principles and criteria for the environmental, economic and social standards of the Forest Stewardship Council®.

CONTACT US: audubonny@audubon.org

ny.audubon.org/workinglands

Indigo Bunting
Photo: Jeff Nadler

Northern Saw-whet Owl

Photo: Kameron Perensovich/Flickr (CC BY-SA 2.0)