Managing Forest Birds in Southeast Ohio:

A Guide for Land Managers

Ohio Department of Natural Resources Division of Wildlife

The Ohio State University

The Nature Conservancy
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Ohio Bird Conservation Initiative

Ohio Department of Natural Resources

OBCP

Terrestrial Wildlife Ecology Laboratory

About This Guide

This guide is written for land managers seeking to improve habitat conditions for forest birds. Recommendations are based on research conducted in the forested landscapes of southeast Ohio by The Ohio State University and Ohio Division of Wildlife. Although many of the patterns and general strategies may apply elsewhere, birds are known to show regional variation in habitat associations and responses to disturbance. Additional detail about study site locations, methodology, and results as well as site-specific data can be found in theses and dissertations of graduate students and published articles (see appendix for a list of these sources).

Photo credits for cover: Ohio Division of Wildlife and Andrew Vitz

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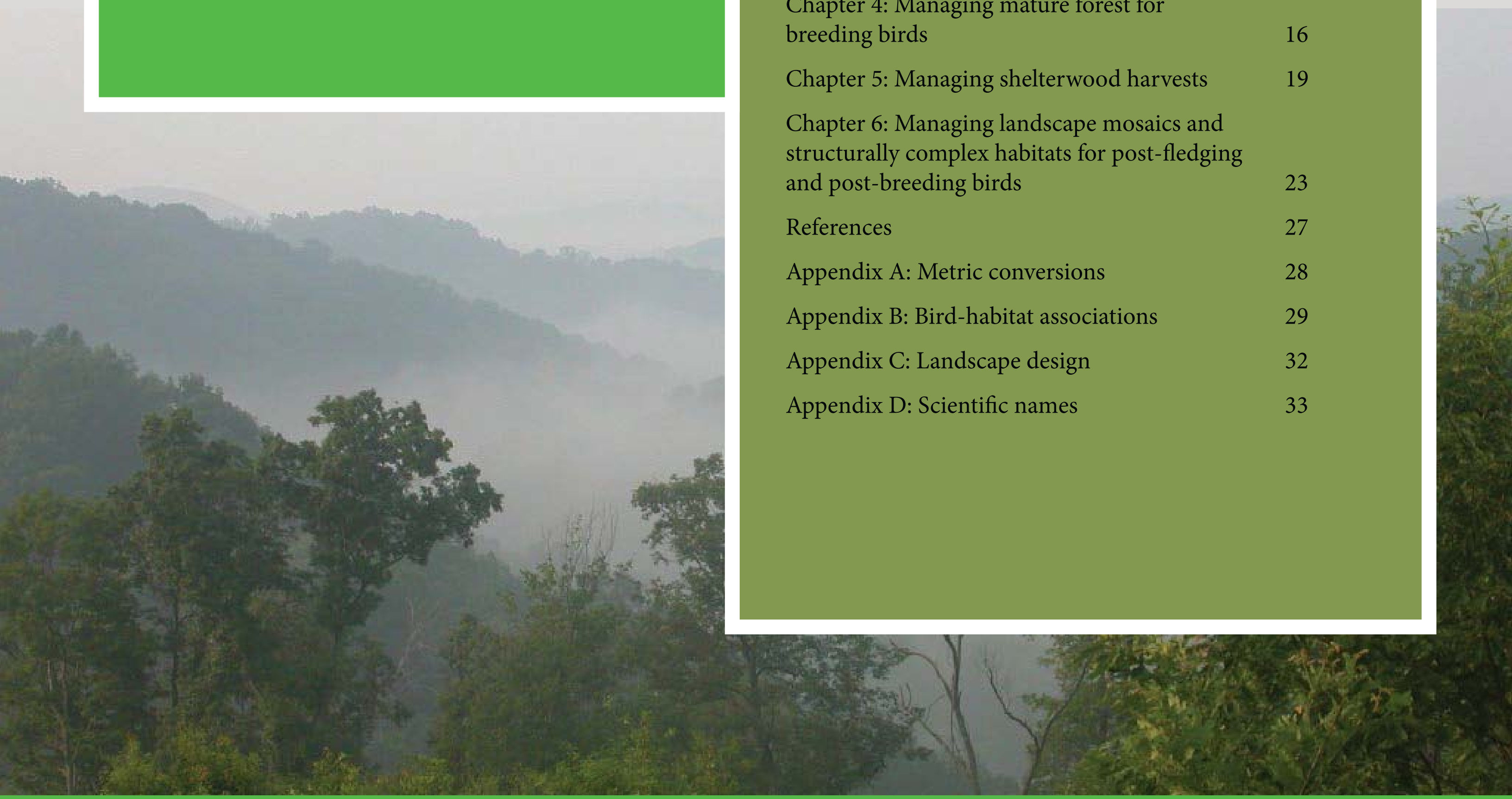

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Summary of Management Recommendations

Early-successional habitats for shrubland birds

Indigo bunting. Photo by Ohio Division of Wildlife.

- In harvests that are regenerating, encourage growth of native hardwood vegetation rather than planting conifers. Allow dense woody vegetation to regenerate in some areas, as density of shrubland birds increases with woody stems during the first several years of regeneration Although native and non-native plants both contribute to vegetative structure, native plants offer better food resources to birds and their insect prey. Because exotic plants can quickly invade following disturbance, managers should use species-specific recommended techniques to remove exotic plants both before and after harvest.
- For sites permanently managed as successional habitats, introduce disturbance at 6-8 year intervals. Abundance of shrubland specialists declines sharply after 6 years post-harvest.
- When possible, avoid creating small (<12 acres; 5 ha), narrow (<300 ft wide; 100 m), or irregularly-shaped shrubland patches. A better strategy is to manage for patches large enough to provide habitat >250 ft (75 m) from edges. Smooth or straight edges of harvests also will allow greater numbers of territories to be accommodated. Favoring square or circular patches rather than rectangular or irregular ones will increase the interior habitat of clearcuts without necessarily increasing harvest area.
- When possible, cluster harvests and shrubland patches within particular management areas or zones. Providing multiple patches within 0.3-0.6 miles (0.5-1.0 km) may promote landscape connectivity for shrubland birds.
- Recognize that these recommended strategies (i.e., creating larger and more regularly shaped shrubland patches or clustering of patches) also have the potential to benefit mature forest dependent species in managed forest landscapes by reducing the amount of edge and fragmentation.
- Engage in landscape-scale and long-term planning to ensure that the needs of early- and late successional wildlife are met. See Appendix C for an example.

Mature Forests for Late-Successional Birds

- Efforts to manage local habitat features, such as forest structure, are an important piece of sustaining mature-forest breeders. In the forested landscapes (>70% forest cover) of southeast Ohio, structural attributes of forest (i.e., canopy structure, tree size, vertical complexity) had strong relationships with density and nest survival of sensitive species.
- Features generally associated with older forests may be important habitat components for mature forest breeders, such as cerulean warbler. These old-forest characteristics include a heterogeneous canopy, diverse understory vegetation, grapevines, and emergent large trees. Thus, using longer rotation ages (>100 years), as well as specific harvest prescriptions (e.g., single tree and group selection) and timber stand improvement practices (e.g., thinning and crop tree release) are likely to encourage the development of these features.
- As described in the section on "managing shelterwood harvests", white oak should be emphasized in management because it is a favored nesting tree for cerulean warblers and other canopy-nesting birds. (see Chapters 4 snd 5 for additional details about floristic composition of stands).
- Several sensitive species breeding in mature forest would benefit from creating canopy gaps (>430 ft^2, 40 m^2) through single-tree or group selection cuts.

Scarlet tanager. Photo by T. K. Tolford.

- Based on results from the Cooperative Cerulean Warbler Forest Management Project (Boves 2011), recommendations for Appalachian forested landscapes specify that forests supporting > 2 territories per 10 acres (>5 territories/10 ha) of Cerulean Warbler should be managed without harvesting and in ways that minimize disturbance. On forest stands with fewer territories, management should reduce basal area to 56-78 ft^2 / acre (13-18 m^2/ha) while retaining large overstory trees (>16 inches dbh; >40cm dbh), especially of white oak. Because identifying the best management course depends upon bird densities, coordination and cooperation with wildlife biologists may be necessary.

Shelterwood Harvests for Early and Late-Successional Birds

Eastern towhee. Photo by Ohio Division of Wildlife.

- Partial harvesting (~50% stocking level), such as the shelterwood technique, can be used to provide habitat to both early-successional birds (e.g., prairie warbler, Eastern towhee) and canopy-nesting species usually associated with mature forest (e.g., yellow-throated vireo, scarlet tanager). In southern Ohio, reducing basal area from 100-143 ft^2/ acre to 39-70 ft^2/ acre (23-33 m^2/ ha to 9-16 m^2 / ha) supported greater numbers of both shrubland and canopy-nesting species than unharvested mature forest.

- Recognizing that overstory is typically removed for oak regeneration within 5-10 years, shelterwood prescriptions need to ensure that nesting habitat is maintained across space and through time within the landscape.

- Favor white oaks rather than red oaks in shelterwood harvests, as white oaks (white and chestnut oaks) were strongly favored for nesting and foraging by most canopy nesting species. Red oaks (Northern red, Eastern black, and scarlet oaks) also may depress nesting success of canopy nesting birds.

- When possible, retain large diameter trees (>15 inches dbh; >38 cm dbh), which are most heavily used for nesting by canopy birds, including cerulean warbler.

- In cases where there is wide latitude in choice of harvest location, avoid older forests with canopy gaps and/or those on northeast-facing slope, because these tend to be most heavily used by the declining cerulean warbler. Instead, shelterwood harvests are better implemented in areas that lack steep slopes (> approximately 15%) and/or have few canopy gaps, where they are more likely to create or improve habitat for species requiring heterogeneous canopies.

Landscape Mosiacs and Structurally Complex Habitats for Post-Fledging and Post-Breeding Birds

- Manage mature forests in ways that promote structural complexity, which encourages microhabitats that provide dense understory vegetation. Examples include treefall gaps, riparian thickets, and natural patches of shrubs. Because some of these features are typical components in old, uneven-aged forests, consider allowing stands to reach ages greater than 100 years.

- Allow roadsides and other human-associated edges to develop the thick vegetation that is heavily used by post-breeding birds. There appear to be no strong size requirements for use by birds.

- When consistent with other management goals (e.g., oak regeneration), consider using silvicultural techniques to create areas with dense vegetation. Group-selection harvests and shelterwood harvests may be good examples of this. Although use of these harvest types has not been specifically studied during this stage in the annual cycle, changes in habitat structure associated with those silvicultural techniques are consistent with features preferred by post-breeding and post-fledging birds.

- Regarding harvest size, be attentive to needs of other species and during other stages of the annual cycle. Post-fledging birds do not seem to require large patches of successional habitat and can use dense vegetation within mature forests. Consequently shrubland habitats are probably best managed according to recommendations for early-successional breeders.

- Engage in landscape-scale planning to ensure that sufficient forest is retained to permit movement through the landscape (see Appendix C). Not only are independent juveniles known to make extensive movements, but numbers of post-breeding birds using harvests was positively related to forest cover within 0.62 miles (1 km).

Ovenbird fledgling. Photo by Andrew Vitz.

Chapter 1: The state of forest birds in Ohio

Ohio's forests have seen remarkable change over the last two centuries. After widespread clearing in the 1800s, forest cover plummeted to approximately 10% of the state. However, forest regeneration over the last 80-100 years has resulted in roughly one-third of Ohio being classified as forested. While speaking generally about trends in forest cover is easy, generalizing population trends and conservation threats across bird species is decidedly more difficult.

Although forest birds remain a legitimate conservation concern, data from the Breeding Bird Survey in Ohio show that woodland-breeding species in Ohio fared reasonably well as a group, with only 14% showing significant negative population trends and 51% with significant positive trends between 1966-2009 (Sauer et al. 2011; Figs 1 and 2). Species that use shrublands and other successional habitats fared worse with 32% declining and 26% increasing since 1966 (Boxes 1 and 2). Those trends contrast with the 83% of grassland bird species that significantly declined in abundance in Ohio. Among the most severely declining birds are species that occupy reclaimed strip mines and other grassland habitat in southeast Ohio: grasshopper sparrow, bobolink, Eastern meadowlark, savannah sparrow, and Henslow's sparrow. Though southeast Ohio is not thought to have historically supported large numbers of grassland species, their global population declines may warrant management where local populations exist, such as on reclaimed strip mines. Recent initiatives to reforest strip mines (e.g., Appalachian Reforestation Initiative; website) are now stimulating dialogues about conservation priorities and long-term and landscape-scale planning efforts.

Box 1. Forest birds showing significant population declines in Ohio, 1966-2009.

Mature or late-successional

Whip-poor-will
Cerulean Warbler
Least Flycatcher
Eastern Wood-Pewee
Great Crested Flycatcher
Tufted Titmouse

Shrubland or early- successional

Northern Bobwhite
Field Sparrow
Prairie Warbler
Yellow-breasted Chat
Brown Thrasher
Song Sparrow

Box 2. Forest birds showing significant population increases in Ohio, 1966-2009.

Mature or late-successional

Wood Thrush
Red-eyed Vireo
Scarlet Tanager
Yellow-throated Vireo
Downy Woodpecker
Carolina Chickadee
Rose-breasted Grosbeak
Red-bellied Woodpecker
Ruby-thr. Hummingbird
Black-capped Chickadee
Black-and-white Warbler
Pileated Woodpecker
Ovenbird
White-breasted Nuthatch
Broad-winged Hawk
Yellow-throated Warbler
Worm-eating Warbler
Red-shouldered Hawk
Cooper's Hawk
Hooded Warbler
Northern Parula
Wild Turkey

Shrubland or early- successional

Northern Cardinal
House Wren
Gray Catbird
White-eyed Vireo
Carolina Wren

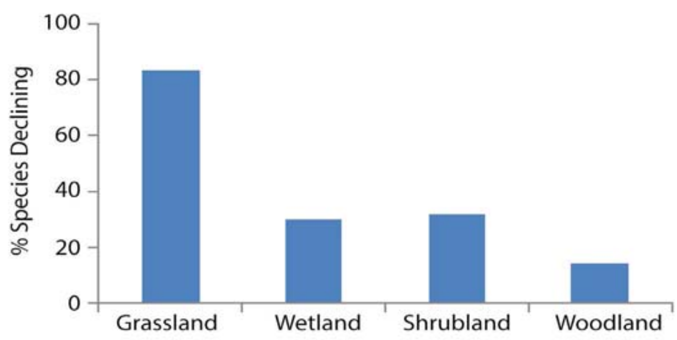
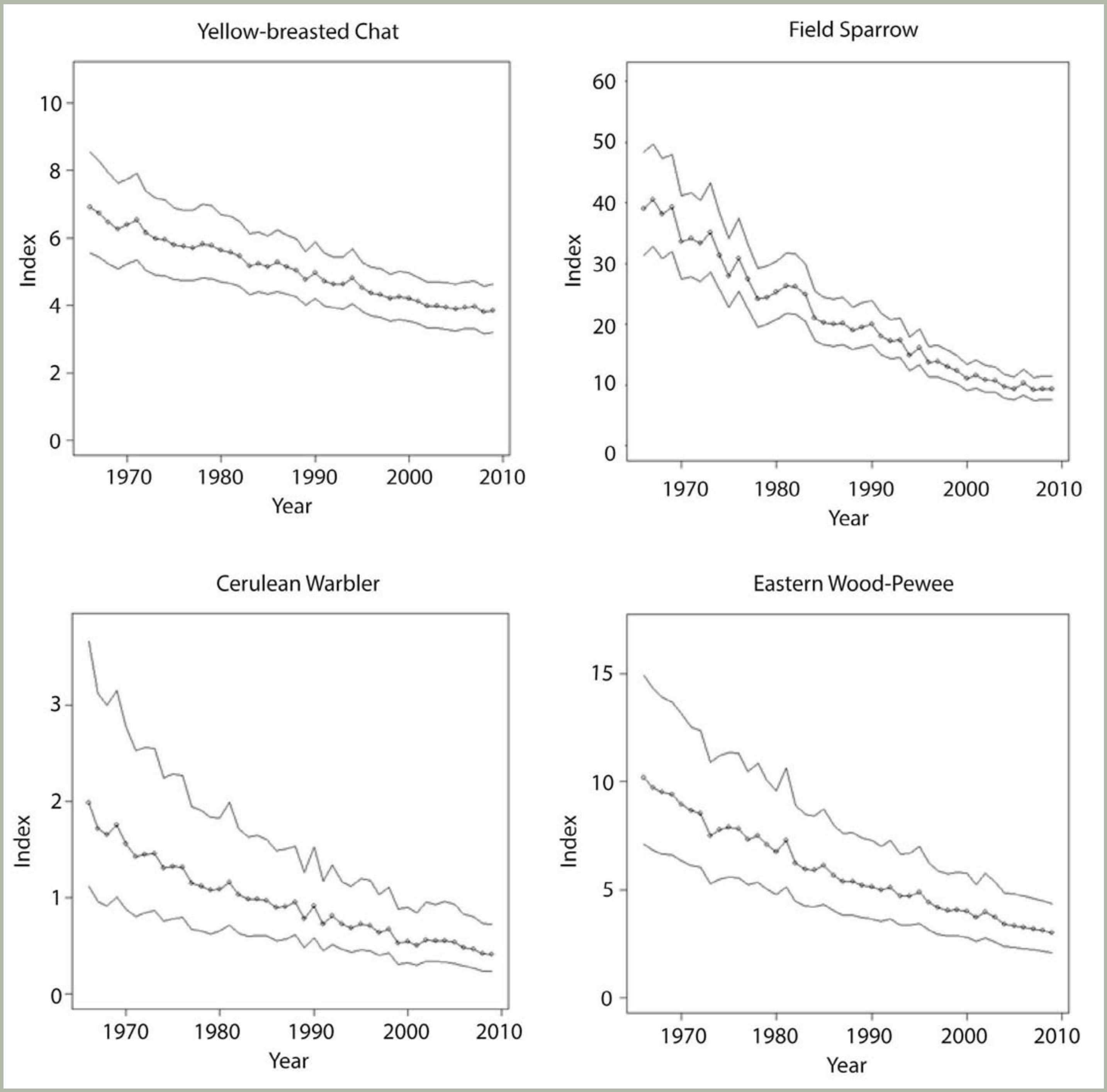


Figure 1. Percentage of Ohio species among habitat guilds that have significantly declined since 1966. Data based on Breeding Bird Survey (1966-2009). Sauer et al. 2011.

Figure 2. Population trends from Breeding Bird Survey (BBS) data for two early-successional (yellow-breasted chat and field sparrow) and two late-successional (Eastern wood-pewee and cerulean warbler) species, 1966-2009 (Sauer et al. 2011). BBS abundance indices are shown on the y-axes.



How does Ohio contribute to regional conservation initiatives for forest birds?

Because most woodland in Ohio is privately owned, the southeastern region of the state stands out in its relatively high proportion of publicly managed forest, forested landscapes, and, consequently importance for forest birds. Public ownership facilitates landscape-scale and long-term planning and management, as well as provides one of the state's best opportunities to retain large blocks of contiguous forest. Indeed, some of the region's most sensitive species reach their highest densities in this part of the state. Not surprisingly then, southeast Ohio features prominently in regional conservation initiatives.

Kentucky warbler. Photo by T. K. Tolford.

Partners-in-Flight: Plan for Ohio Hills

Southeastern Ohio falls within the Ohio Hills Physiographic Province or Ecoregion for the national planning efforts of Partners-In-Flight, which is a public-private partnership for bird conservation in the Western Hemisphere. The Ohio Hills plan identifies priority species and habitats that occur in southeastern Ohio. In mature deciduous forest, the following species are considered to be management priorities: cerulean warbler, Louisiana waterthrush, worm-eating warbler, Acadian flycatcher, Kentucky warbler, and wood thrush. In early successional shrub, golden-winged warbler (not currently documented as breeding in southeastern Ohio), prairie warbler, and field sparrow are the priorities. In addition, Henslow's sparrow is listed as a priority for grassland habitats, which primarily occur on reclaimed mines in southeast Ohio landscapes. The Ohio Hills plan further identifies both the level of continental concern (i.e., large-scale population declines) and regional responsibility (i.e., high proportion of the global population residing in a particular ecoregion; Box 3).

Box 3. Priority species in Partners-in-Flight plan for Ohio Hills based on continental concern and regional responsibility.

High Continental Concern + High Regional Responsibility (only those for OH)	***High Continental Concern***	***High Regional Responsibility***
Cerulean Warbler	Louisiana Waterthrush	Scarlet Tanager
Henslow's Sparrow	Acadian Flycatcher	Yellow-throated Vireo
Prairie Warbler	Field Sparrow	Hooded Warbler
Kentucky Warbler	Yellow-breasted Chat	Yellow-throated Warbler
Worm-eating Warbler	Black-billed Cuckoo	Chimney Swift
Blue-winged Warbler	Eastern Towhee	
American Woodcock	Indigo Bunting	
Wood Thrush		

Appalachian Mountains Joint Venture: Plan For The Appalachian Mountains Bird Conservation Region

Southeastern Ohio falls within the boundaries of the Appalachian Mountains Joint Venture (AMJV), which is one of 18 habitat Joint Venture partnerships in the US. The AMJV represents a public-private partnership of agencies, organizations, and industries that work together to support the long-term viability of native birds that breed in the Appalachian Mountains.

The following landbirds are those that regularly breed in southeastern Ohio and are listed as priority species for AMJV and in the Ohio Division of Wildlife's Ohio's Wildlife Action Plan (species marked with * are only in AMJV plan).

Acadian Flycatcher
Black-and-white Warbler
Black-billed Cuckoo
Blue-winged Warbler
Broad-winged Hawk*
Brown Thrasher*
Canada Warbler
Cerulean Warbler
Chimney Swift
Chuck-will's-widow
Eastern Meadowlark
Eastern Towhee
Eastern Wood-Pewee
Field Sparrow
Grasshopper Sparrow
Henslow's Sparrow
Hooded Warbler
Indigo Bunting
Kentucky Warbler
Lark Sparrow
Loggerhead Shrike
Louisiana Waterthrush
Marsh Wren
Northern Bobwhite
Northern Flicker
Northern Harrier
Northern Parula*
Northern Saw-whet Owl
Peregrine Falcon
Prairie Warbler
Prothonotary Warbler
Purple Martin
Red-headed Woodpecker
Ruffed Grouse
Scarlet Tanager
Sedge Wren
Sharp-shinned Hawk*
Short-eared Owl
Summer Tanager*
Whip-poor-will
Willow Flycatcher
Wood Thrush
Worm-eating Warbler
Yellow-breasted Chat
Yellow-throated Vireo
Yellow-throated Warbler*

Ohio Bird Conservation Initiative: All-Bird Conservation Plan for Ohio

The Ohio Bird Conservation Initiative (OBCI) is a coalition of over 90 member organizations that support bird conservation, bird recreation, education and outreach. As part of its planning efforts, OBCI developed a statewide bird conservation plan that identifies priority species and habitats as well as target population objectives. In the OBCI plan, the highest priority deciduous or mixed forest birds are wood thrush, worm-eating warbler, and cerulean warbler, whereas the highest priority species associated with early-successional habitats are American woodcock and blue-winged warbler. Other species are listed according to high and moderate priority levels (Table 1).

Table 1. Ohio's Priority birds associated with Deciduous, Mixed, or Successional Forest.

Highest Priority	High Priority	Moderate Priority	
Wood Thrush	Whip-poor-will	Ruffed Grouse	Veery
Worm-eating Warbler	Black-billed Cuckoo	Yellow-billed Cuckoo	Canada Warbler
Cerulean Warbler	Hooded Warbler	Northern Saw-whet Owl	American Redstart
American Woodcock	Kentucky Warbler	Eastern Screech-Owl	Black-and-white Warbler
Blue-winged Warbler	Red-headed Woodpecker	Chuck-will's-widow	Scarlet Tanager
	Northern Bobwhite	Northern Flicker	Willow Flycatcher
	Loggerhead Shrike	Eastern Wood-Pewee	Brown Thrasher
	Bell's Vireo	Great Crested Flycatcher	Yellow-breasted Chat
	Prairie Warbler	Yellow-throated Vireo	Eastern Towhee
	Field Sparrow	Golden-crowned Kinglet	Indigo Bunting
		Blue-gray Gnatcatcher	Orchard Oriole

Both from statewide and regional perspectives, the forests of southeastern Ohio are important focal areas for bird conservation and management if we are to achieve population goals. Not only did a decision-support tool developed by Joint Ventures identify the region as the highest conservation value in the state (Fig. 3), but there also are specific focal areas identified by OBCI (Fig. 4).

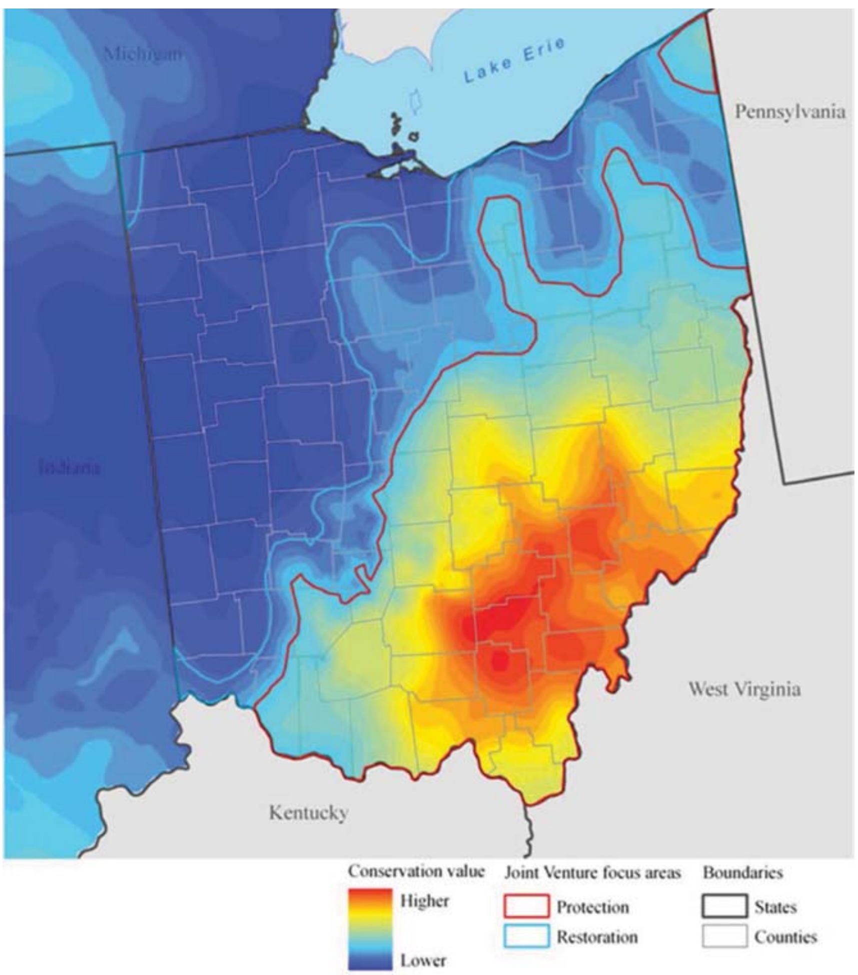
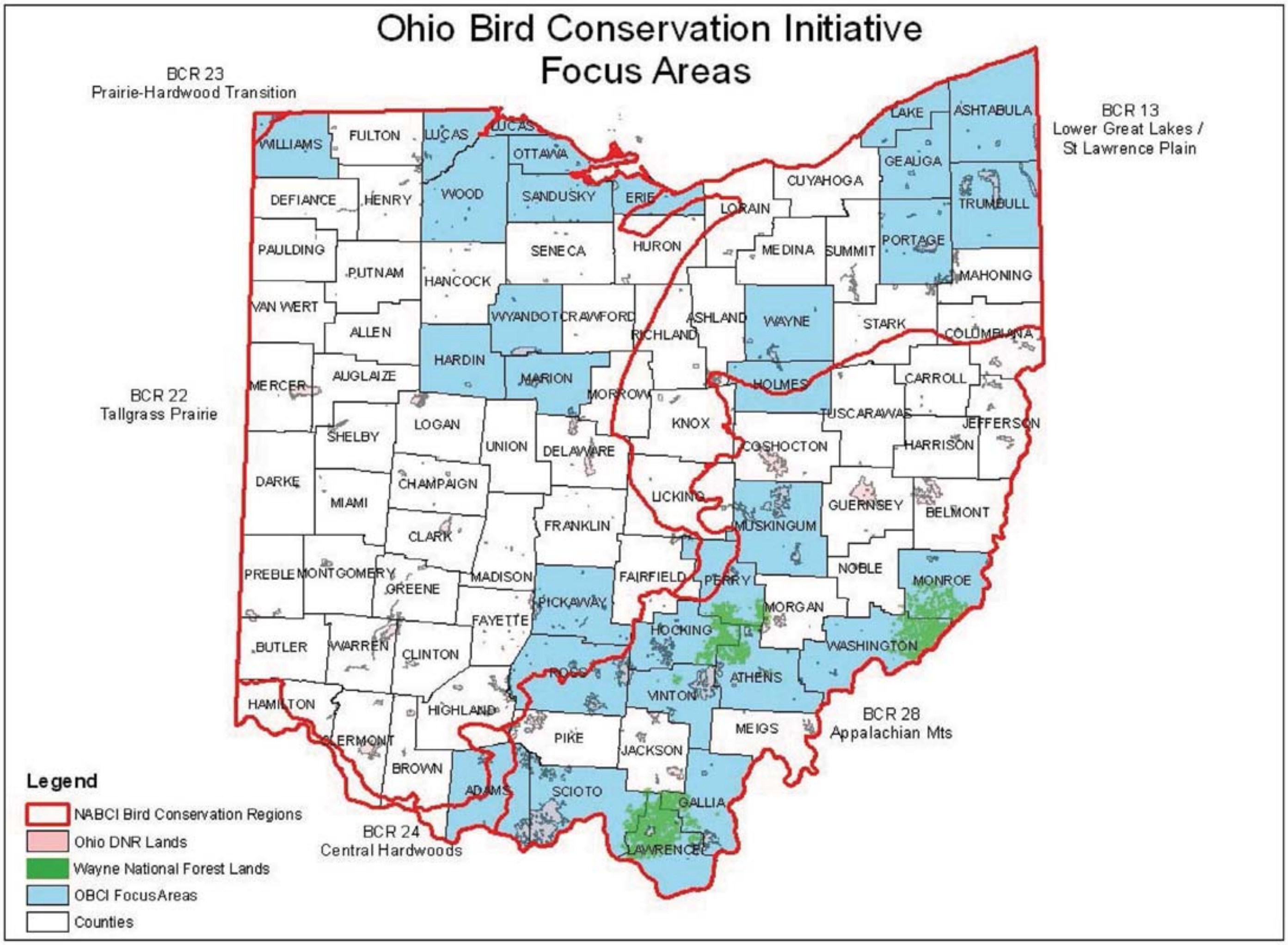


Figure 3. Areas of high priority for woodland breeding bird conservation in Ohio. From: Ohio Bird Conservation Initiative. 2010. Ohio All-bird Conservation Plan. Unpublished report to the Ohio Department of Natural Resources-Division of Wildlife. 106 pp.

Figure 4. Map showing Ohio Bird Conservation Initiative Focus Areas (blue counties) in relation to Ohio DNR lands (pink areas), Wayne National Forest lands (green), and Bird Conservation Regions. From Ohio Bird Conservation Initiative Plan. 2010.



Forest Plan for Wayne National Forest

As part of the National Forest Management Act, the Wayne National Forest is mandated to maintain viable populations of all wildlife on National Forest lands. To help achieve this goal, biologists, managers, and other experts identified several "Management Indicator Species" in the recently revised Wayne National Forest Plan (2006). Abundances of the following species are used to indicate the suitability of the forest for other species within the same habitat guilds:

Yellow-breasted chat. Photo by Sarah Lehnen.

- Pine warbler – mature pine and pine hardwood communities
- Pileated woodpecker – mature hardwood forest with snags and coarse woody debris
- Cerulean warbler – mature interior hardwood forests with a heterogeneous canopy
- Worm-eating warbler – mature interior hardwood or pine-hardwood forest on hillsides with a dense understory and coarse woody debris
- Louisiana waterthrush – mature riparian forest corridors along headwater streams
- Ruffed grouse – mosaic of successional forest stages
- Yellow-breasted chat – early successional forest
- Henslow's sparrow – extensive grasslands

Chapter 2
Forest birds and succession

Forest succession is the change in the structure and composition of forests over time. Understanding how succession influences avian communities is essential to effectively manage forests for birds and other wildlife. Because many bird species require specific habitat attributes, forests at different successional stages favor different bird species by virtue of the resources they provide (Box 4). For example, certain birds, such as prairie warbler and yellow-breasted chat, specialize on the dense and shrubby habitat provided by early-successional stands. Others, like the cerulean warbler, favor late-successional forests with large trees and diverse canopy for breeding. Thus, no matter how a forest is managed, whether actively or passively, certain species will be favored and others discouraged. The best strategy depends upon the management goal.

Although many members of the general public might judge conservation value by forest age, biologists recognize that all successional stages have the ability to support birds of high conservation value. There is a growing recognition that throughout much of eastern North America, availability of early-successional habitats has declined since the 1950s with changing disturbance regimes (e.g., fire suppression) and human activities (e.g., changing agricultural practices and farmland abandonment). Concomitantly, numbers of shrub-successional birds have declined so severely in some cases that early-successional birds are now included as priority species in many regional conservation plans. Estimates of the amount of early-successional habitat in pre-settlement North American landscapes varies among studies, but they are consistent in the view that there were a variety of natural (e.g., fire, storms, beaver activity) and anthropogenic disturbances (e.g., burning was used a management tool by Native Americans) that made successional habitat more common on the landscape than it is now. Even mature forests were likely different from today's second growth due to their older and uneven age structure that resulted in larger trees and more numerous canopy gaps.

Box 4. Abundant breeding bird species detected in different forest stands in Athens, Vinton, Gallia, and Jackson counties. Birds are listed in order of declining abundance.

Regenerating clearcuts (4-7 years post-harvest)

1. Blue-winged warbler
2. Yellow-breasted chat
3. White-eyed vireo
4. Gray catbird
5. Prairie warbler
6. Indigo bunting
7. Eastern towhee
8. Common yellowthroat
9. Baltimore oriole
10. Field sparrow

Shelterwood harvests (50% stocking, 2-5 years post harvest)

1. Red-eyed vireo
2. Hooded warbler
3. Brown-headed cowbird
4. Scarlet tanager
5. Black-and-white warbler
6. Ovenbird
7. Indigo bunting
8. Eastern towhee
9. Prairie warbler
10. Wood thrush

Mature, unharvested oak-hickory forest:

1. Ovenbird
2. Red-eyed vireo
3. Hooded warbler
4. Wood thrush
5. Scarlet tanager
6. Black-and-white warbler
7. Worm-eating warbler
8. Brown-headed cowbird
9. Eastern wood-pewee
10. Blue jay

Scarlet tanager. Photo by Marja Bakermans.

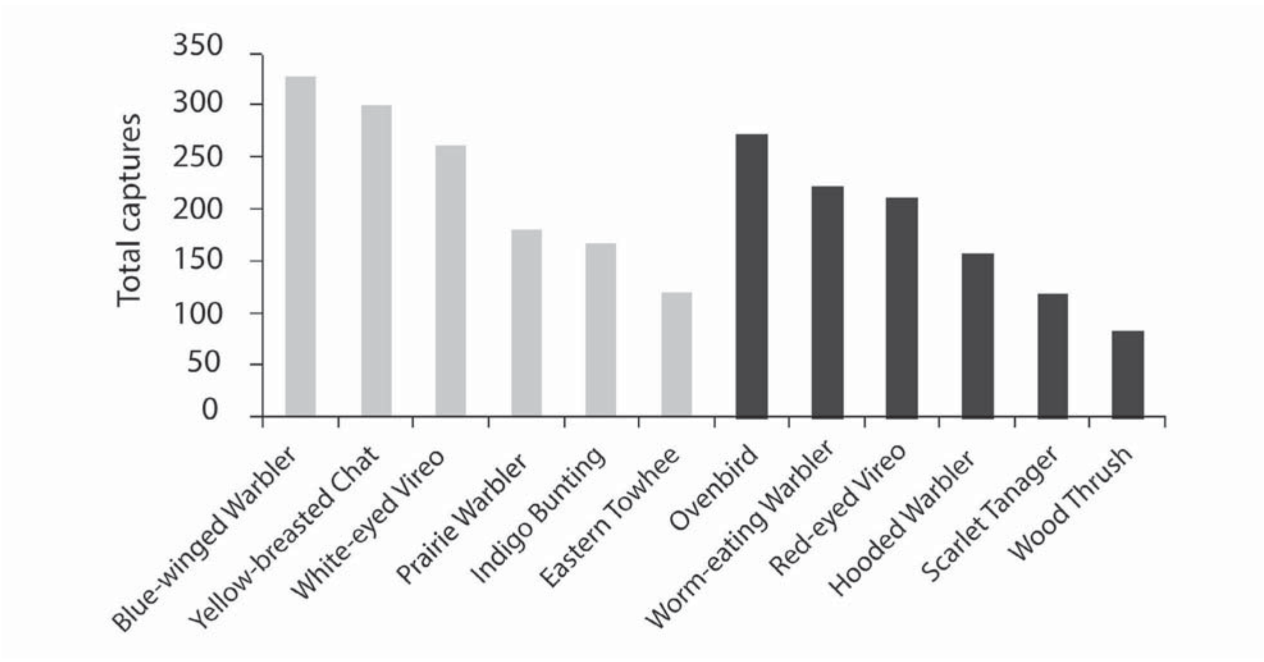
Another issue that adds to the complexity of understanding relationships between birds and forest succession is that birds can differ in their needs across the annual cycle. We often categorize species according to their breeding habitats, but patterns of habitat use shift across life stages. The post-breeding stage, which extends from the end of nesting to the start of migration, provides one excellent illustration of such shifts in habitat use. During this period, adult birds are molting feathers and gaining mass as they prepare for migration, while juvenile birds continue to learn how to forage effectively and evade predators. One especially critical time during the post-breeding window is the post-fledging stage, which represents the first few weeks after a young bird has left the nest. During the post-fledging period, birds may face the greatest risk of mortality, often due to predation. Studies conducted in Ohio and elsewhere in the US indicate that many birds that breed in mature forest actively seek dense vegetation, including but not exclusive to successional habitat, during this period of the annual cycle. For example, in regenerating clearcuts (4-7 years post-harvest) in southeast Ohio, Vitz and Rodewald (2006) captured 32 species, which represents nearly all mature-forest breeding species. Moreover, mature-forest birds rivaled successional breeders in abundance (Box 5, Fig. 4).

Box 5. Mature-forest breeding species using regenerating clearcuts in post-breeding season (in order of decreasing abundance)

1. Ovenbird
2. Worm-eating warbler
3. Red-eyed vireo
4. Hooded warbler
5. Scarlet tanager
6. Wood thrush
7. Ruby-throated hummingbird
8. Black-and-white warbler
9. Carolina chickadee
10. Tufted titmouse

Hooded warbler. Photo by T.K. Tolford.

Figure 4. Numbers of captures for early-successional (light bars) and late-successional (dark bars) forest breeding birds in regenerating clearcuts (4-7 years post-harvest) in southeast Ohio, 2002-2003 (Vitz and Rodewald 2006).



Chapter 3
Managing early-successional habitats for shrubland birds

Shrub-successional breeders

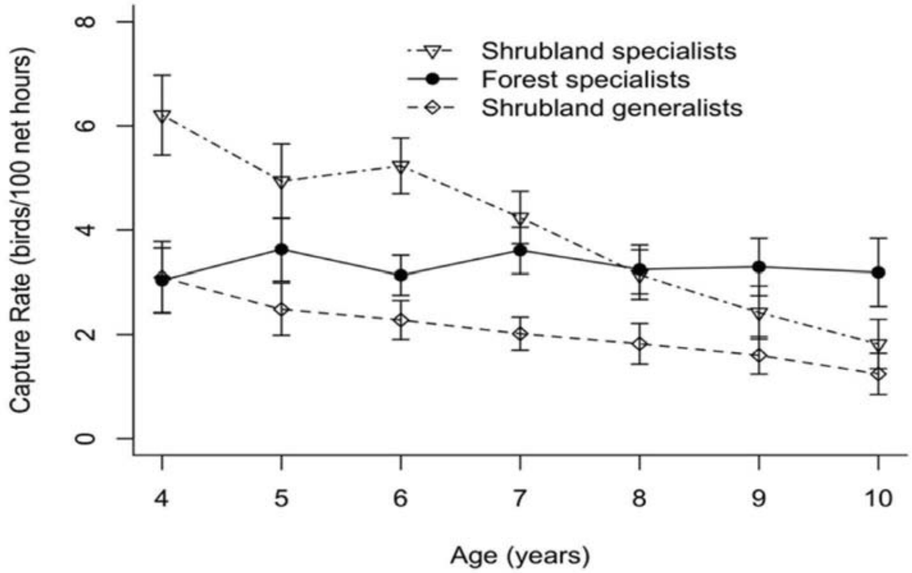
Successional habitats can support an impressive diversity of birds, some of which are habitat specialists and of high conservation importance. As with other habitat guilds, shrubland birds are sensitive to habitat attributes across multiple spatial scales, from local to landscape.

Indigo bunting. Photo by Marja Bakermans.

Local habitat and successional stage

A wide range of natural and anthropogenic disturbances create and maintain shrub-successional habitats. The process of forest succession eventually changes local attributes to the point where they no longer are attractive to many shrubland specialists. Though shrubland birds become more abundant with increasing density of woody stems, this occurs only up to a point. Research at regenerating clearcuts aged 4 to 10 years post-harvest indicated that abundance of shrubland generalists (i.e., species that use multiple types of habitat) and specialists (i.e., species restricted to only one type of habitat or require special features) were greatest at the earliest successional stages studied (Fig. 5, Lehnen 2008). Numbers of shrubland specialists declined strongly after 6 years post-harvest. Likewise, when weighting abundances by priority ranks assigned to each species by Partners-in-Flight, the conservation value of stands also was greatest four-to-five years after harvest. These findings suggest a short harvest rotation schedule applied to certain sites or concentrated in specific regions might most benefit shrubland birds.

Figure 5. Capture rates by harvest age for songbird species in 13 shrubland patches in Ohio during the late- and post-breeding period (15 June to 17 August). Songbirds classified into for three categories: shrubland specialists, forest specialists, and shrubland generalists. Bars show +1 standard error. From Lehnen (2008).



Edge and area sensitivity

Research in southeastern Ohio has consistently shown that many shrubland birds occupy edges of harvests in lower densities than interiors. In one study, birds were captured and banded at distances of 60, 150, and 240 ft (20, 50, and 80 m) from mature-forest edges at 6 small (1-15 acres; 4–8 ha) and 6 large (32-40 acres; 13–16 ha) regenerating clearcuts. Results suggested that many shrubland specialist birds avoided the edges where the shrubby habitat abutted the mature forest (Fig. 6, Rodewald and Vitz 2005). Seven of 8 shrubland specialists, particularly blue-winged warbler, prairie warbler, yellow-breasted chat, indigo bunting, and field sparrow, avoided mature-forest edges (Table 2). The reasons that birds avoided edges remain unclear because we found no relationship between distance to edge and vegetation, insect biomass, or fruit abundance. Likewise, nest survival and placement did not change with distance to edge (Lehnen 2008).

In their initial work, Rodewald and Vitz (2005) found no strong evidence that shrub-successional birds prefer larger than smaller harvests (Fig. 6, Table 3). Subsequently, Lehnen and Rodewald (2009) also examined density, annual survival, and productivity by examining capture rates, apparent annual survival estimates, and juvenile-to-adult-female ratios in small and large harvests. Capture rates for six focal shrubland birds increased with patch area and were up to 44% higher in largest than smallest patch. However, this area effect was only significant for the yellow-breasted chat and the common yellowthroat and was less pronounced after data were adjusted for probability of capture based on bird movements. Patch area was not a good predictor of apparent annual survival or juvenile-to-adult-female ratios for any species, suggesting that area did not affect reproductive rates (Lehnen and Rodewald 2009a). Thus, there was no evidence that annual survival or productivity differed by patch area in regenerating clearcuts in southeastern Ohio.

Subsequent research to understand the pattern of apparent edge avoidance focused on Yellow-breasted chats, as they showed the most consistent relationships with both edge and area. Based on 37 male chats that were radio-tracked, estimated home range size was 8 acres (3.3 ha) with birds most heavily using areas of 1.7 acres (0.68 ha) within that home range (Lehnen 2008). Detailed study of the movement, home range size, and nest success of chats suggested that birds did not actively avoid edges of regenerating harvests. Instead, we suspect that the shape and size of smaller or edge-dominated harvests limit the number of territories (Fig. 7).

Figure 6. Capture rates of shrubland specialist birds of hatch-year (juveniles) and after-hatch-year (>1 year old) ages at varying distances from edges of regenerating harvests and different stand sizes.

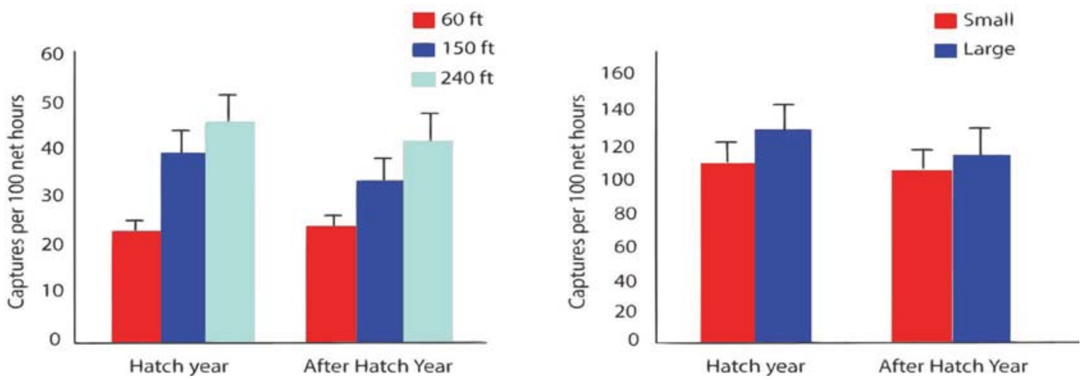


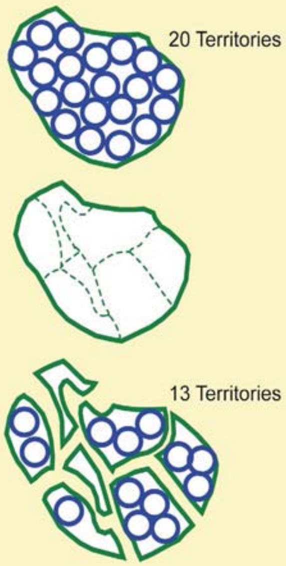
Table 2. Mean capture rates for every 100 hours of netting (+SE) of juvenile (hatch-year) and adult (after-hatch-year) birds at varying distances from edge in 12 regenerating clearcuts in southern Ohio that were 4-6 years post-harvest from June-August 2002 and 2003.

	Juveniles			Adults		
Species	60 ft	150ft	240 ft	60 ft	150ft	240 ft
White-eyed vireo	1.1 (0.21)	1.7 (0.27)	1.3 (0.22)	1.3 (0.26)	1.5 (0.26)	1.2 (0.23)
Blue-winged warbler	1.0 (0.19)	1.7 (0.35)	1.4 (0.24)	1.0 (0.19)	1.3 (0.31)	2.3 (0.44)
Prairie warbler	0.7 (0.20)	1.3 (0.22)	1.9 (0.38)	0.5 (0.13)	0.8 (0.13)	1.1 (0.22)
Yellow-breasted chat	1.5 (0.14)	2.1 (0.28)	2.7 (0.32)	1.0 (0.16)	1.2 (0.25)	1.8 (0.30)
Common yellowthroat	0.4 (0.08)	0.7 (0.26)	0.7 (0.21)	0.5 (0.12)	0.7 (0.30)	0.7 (0.26)
Eastern towhee	0.3 (0.11)	0.3 (0.14)	0.4 (0.09)	0.6 (0.23)	0.7 (0.17)	0.8 (0.18)
Field sparrow	0.2 (0.08)	0.5 (0.14)	1.0 (0.24)	0.1 (0.04)	0.3 (0.11)	0.7 (0.23)
Indigo bunting	0.8 (0.18)	1.4 (0.27)	1.3 (0.28)	0.4 (0.13)	0.8 (0.14)	1.1 (0.20)

Table 3. Mean capture rates for every 100 hours of netting (+SE) of juvenile (hatch-year) and adult (after-hatch-year) birds 6 small (1—15 acres; 4–8 ha) and 6 large (32-40 acres; 13–16 ha) regenerating clearcuts that were 4-6 years post-harvest from June-August 2002 and 2003.

	Juveniles		Adults	
Species	Small	Large	Small	Large
White-eyed vireo	3.3 (0.67)	4.7 (0.63)	3.1 (0.72)	4.7 (0.78)
Blue-winged warbler	3.9 (0.88)	4.3 (1.12)	3.8 (0.96)	5.5 (1.01)
Prairie warbler	3.5 (1.25)	4.2 (0.57)	2.1 (0.56)	2.7 (0.31)
Yellow-breasted chat	5.0 (0.61)	7.4 (0.77)	2.6 (0.73)	5.2 (0.67)
Common yellowthroat	0.9 (0.34)	2.4 (0.77)	1.2 (0.49)	2.4 (1.12)
Eastern towhee	1.0 (0.57)	0.9 (0.43)	2.8 (0.63)	1.5 (0.41)
Field sparrow	1.3 (0.59)	2.0 (0.16)	0.8 (0.43)	1.3 (0.48)
Indigo bunting	2.8 (0.64)	4.3 (0.79)	2.2 (0.37)	2.5 (0.56)

Figure 7. Shape of a harvest can limit the number of territories that can be accommodated even in the absence of true edge avoidance. In this example, a greater number of fixed-size territories can be accommodated in one contiguous harvest patch versus several smaller patches of equal total area.



The finding that chats did not actively avoid edges because they offered suboptimal habitat provides an important cautionary tale to managers. Based on spatial patterns alone, one might quickly conclude that edges provided low-quality habitat. However, it seems more likely that birds were displaced near edges simply due to geometry. Although the outcome of reduced densities near edges is the same, the most recent work suggests that small or irregularly shaped patches are no less "preferred" and are not detrimental to bird nesting success or survival. Despite having an identical pattern, the alternate mechanisms lead to different management implications. Thus, managers should reduce edges in order accommodate greater densities of shrubland birds (i.e., due to geometry), but they have less reason to worry that edge-dominated harvests will be actively avoided or will function as population sinks.

Landscape-scale sensitivity

As with birds dependent upon large blocks of contiguous mature forest, shrubland birds also may be sensitive to landscape context. Lehnen and Rodewald evaluated the importance of landscape composition to shrubland birds by comparing the relative importance of plot, patch, and landscape characteristics to explain capture rates of shrubland birds in regenerating clearcuts (Lehnen 2008). Numbers of shrubland birds within a regenerating harvest increased with the amount of shrubland habitat within 0.62 miles (1 km; Lehnen and Rodewald 2009b). Overall, the work suggests that amount of shrubland habitat in the landscape is more important than the size of harvest. Thus, clustering patches may be an effective strategy for managing successional habitats. Clustering patches also has the additional benefit of concentrating disturbance and edge, which has the potential to negatively affect species using late successional habitats.

Data on dispersal and movements also are consistent with the possibility that having multiple patches of early-successional habitat within the same landscape is important for some shrubland birds. After accounting for probability of detection, 21% of birds banded as juveniles and recaptured as adults returned to the patches where they were hatched and 78% of adult birds returned to the same patch to breed in successive years (Lehnen and Rodewald 2009b). The tendency of birds to return to previously used patches, coupled with the fact that the patches are short-lived successional stages, suggests that shrubland birds may colonize new breeding areas that are relatively close to previously occupied sites. Indeed, data on dispersing individuals showed that young birds moved approximately 1 mile and adults only one-tenth of a mile to new patches. Movement among patches was common, with 35% of our radio-marked male yellow-breasted chats moving among nearby patches within the breeding season. Our study provides evidence that shrubland birds, especially chats, move among patches during the breeding season, averaging movements of 0.3 mile. Based on our results, birds seemed to frequently move among patches separated by 0.3 miles or less with occasional visits to patches located more than a half-mile away. Here again, clustering patches of shrubland habitat may reduce risks posed by movement among patches and minimize disturbance to mature forest habitat.

Management Recommendations

1. In harvests that are regenerating, encourage growth of native hardwood vegetation rather than planting conifers. Allow dense woody vegetation to regenerate in some areas, as density of shrubland birds increases with woody stems during the first several years of regeneration. Although native and non-native plants both contribute to vegetative structure, native plants offer better food resources to birds and their insect prey. For this reason, managers should also be prepared to control exotic plants that can quickly invade following disturbance.

2. For sites permanently managed as successional habitats, introduce disturbance at 6-8 year intervals. Abundance of shrubland specialists declines sharply after 6 years post-harvest.

3. When possible, avoid creating small (<12 acres; 5 ha), narrow (<300 ft wide; 100m), or irregularly-shaped shrubland patches. A better strategy is to manage for patches large enough to provide habitat >250 ft (75 m) from edges. Smooth or straight edges of harvests also will allow greater numbers of territories to be accommodated. Favoring square or circular patches rather than rectangular or irregular ones will increase the interior habitat of clearcuts without necessarily increasing harvest area.

4. When possible, cluster harvests and shrubland patches within particular management areas or zones. Providing multiple patches within 0.3-0.6 miles (0.5-1.0 km) may promote landscape connectivity for shrubland birds.

5. Recognize that these recommended strategies (i.e., creating larger and more regularly shaped shrubland patches or clustering of patches) also have the potential to benefit mature forest dependent species in managed forest landscapes by reducing the amount of edge and fragmentation.

6. Engage in landscape-scale and long-term planning to ensure that the needs of early- and late successional wildlife are met. See Appendix C for an example.

Chapter 4
Managing mature forest for breeding birds

As iconic symbols of forest conservation, many birds that breed in mature forest are area-sensitive and need large patches of forest in order to meet habitat requirements. As such, conservation efforts have emphasized the amount of forest within landscapes and been less sensitive to local forest conditions. Over recent decades, we have learned that management for this suite of birds is more nuanced than originally thought. Not only can sensitivity to area and edges vary across landscapes, but studies have shown that many mature-forest birds are also disturbance-dependent and may be highly sensitive to subtle features of the forest. Within this context, effective management requires attention to attributes within (i.e., local) and surrounding (i.e., landscape) forest tracts used for breeding.

Local habitat management

Ecologists have learned that the mature forests of today are very different from presettlement forests, which generally were older and with greater structural diversity. For example, old forests are influenced by canopy gap formation processes that create treefall gaps, high structural complexity, standing and downed dead trees, widely-spaced large trees, and a thick but patchy herbaceous layer. Thus, even within late-successional forests, specific habitat attributes can vary remarkably depending upon forest age, topography, floristics, disturbance history, previous management activities, and pressure from herbivores and pests. Such differences likely contribute to the wide variation in densities of forest birds breeding among mature forest stands in southeast Ohio (Bakermans et al., 2012. Table 4).

Table 4. Mean densities/10 ha and range of densities of common breeding birds across all 12 mature forest study sites in southeast Ohio, USA, 2004 – 2006. (Bakermans et al. 2012.)

Species	Mean density (SE)	Range (mix – max)
Wood thrush	7.25 (0.57)	4.50 – 10.50
Ovenbird	8.75 (0.35)	7.00 – 11.30
Worm-eating warbler	3.46 (0.44)	0.00 – 5.33
Kentucky warbler	0.63 (0.24)	0.00 – 2.25
Hooded warbler	3.19 (0.57)	1.00 – 7.25
Cerulean warbler	1.97 (0.69)	0.00 – 7.47
Scarlet tanager	4.46 (0.18)	3.50 – 5.50

In mature forest stands (80-120 years old) in southeast Ohio, densities of breeding birds were related to forest structure, especially canopy gaps (Bakermans et al. 2012). Density of cerulean warbler was positively related to canopy openness, density of vegetation in the understory, and slope but negatively related to the number of small and large trees. Density of scarlet tanager was increased with height of the forest canopy, density of vegetation in the understory, slope, and canopy openness. Density of ovenbirds was positively associated with canopy openness and slope but was negatively related to canopy height. Wood thrush densities were positively associated with numbers of small and large trees but negatively associated with slope, canopy openness, and understory density. Worm-eating, hooded, and Kentucky warbler densities were positively related to canopy height and understory density. Recent work also suggests that canopy openness might influence nest survival as well as density (Bakermans et al. 2012).

Special Focus on Cerulean Warbler

Perhaps more so than most other mature-forest breeding birds, cerulean warblers seem particularly sensitive to forest structure. Cerulean warbler, a Neotropical migratory species, is receiving tremendous attention from conservation and management groups because it shows one of the fastest and steepest declines among North American breeding birds. From 1966-2003, populations declined at 3.2% per year, increasing to -4.6%/year between 2003-2008 (Ziolkowski et al. 2010). As such, cerulean warblers are listed as “vulnerable to extinction” by Birdlife International, a species of conservation concern by the U. S. Fish and Wildlife Service, and a priority species in Ohio and other regional bird conservation plans. The Ohio Hills is an important focal area because it supports among the highest breeding densities for the species.

Cerulean warbler. Photo by Marja Bakermans.

Over the last several years, a number of research projects have examined how forest management may affect breeding populations of cerulean warblers in southeast Ohio. Although the species only breeds in relatively forested landscapes (often >60% forest cover), the presence of scattered regenerating clearcuts and interior edges (e.g., edges within larger expanses of mature forest) does not appear to affect either density or nesting success. To the contrary, there is some evidence that cerulean warblers preferentially locate territories near small-scale disturbances. Moreover, studies indicate that density and nesting success may be best explained by local habitat features and tend to be positively associated with stands having relatively open structure, in terms of tree density and canopy (Bakermans and Rodewald 2009, Bakermans et al. 2012). These structural features correspond well to stocking levels between 60-70% compared to stands with stocking levels ranging from 70-85%. Numbers of cerulean warblers have indeed been shown to decline with increasing basal area (Bakermans and Rodewald 2009, Newell and Rodewald 2011, Bakermans et al. 2012). Likewise, in a recent multi-state cooperative experiment of canopy manipulation, densities increased with reductions in canopy cover that were consistent with heavy thinning (Boves 2011). Thus, improved management for cerulean warblers may require creating features that mimic old-growth forests.

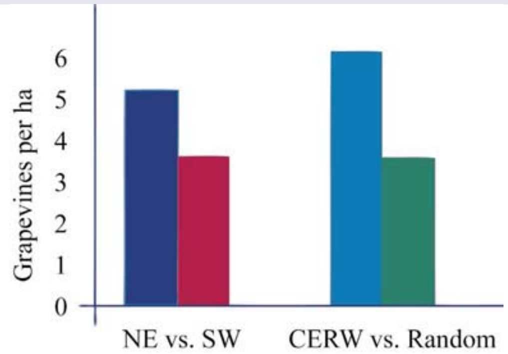


Fig. 8. Cerulean warblers nested in areas with greater numbers of grapevines than randomly-located plots. In addition, Cerulean warblers are known to prefer northeast-facing slopes, which also have higher numbers of grapevines than southwest-facing slopes (Bakermans and Rodewald 2009).

Patterns of nest survival for cerulean warblers present a more complicated picture. While nest survival rates are low overall compared to other canopy-nesting species, there is evidence of reduced survival on harvested stands, despite higher densities (Boves 2011). Within mature forests, structural attributes were related to nest survival. Grapevines seem to be important for nest-site selection (Fig. 8) and nest survival. For example, number of grapevines was positively associated with nest survival of cerulean warblers, perhaps because being close to grapevines, which are used in nest construction, reduced the conspicuousness of female movements or conceals nests (Bakermans and Rodewald 2009). Cerulean nests that were surrounded by large amounts of grapevine (i.e., up to 23 vines >5 cm dbh within 11.3 m of the nest) were more likely to fledge young than those nests with few grapevines. Even in situations where grapevines must be removed prior to harvest, managers might try to preserve grapevines in small (>40 ft radius) patches where overstory trees are retained, though the effectiveness of that approach has not been explicitly tested.

Floristic composition also may be important. In southeast Ohio, cerulean warblers showed a preference for white oaks and an avoidance of red oaks for nesting (Bakermans 2008, Newell and Rodewald 2011). Similar patterns were reported throughout the Appalachians as part of the cooperative experiment, with white oaks being the most preferred nest trees, and red oaks and red maples being avoided (Boves 2011).

Landscape sensitivity (edge, adjacency to harvests)

Mature forest breeders are widely recognized as being sensitive to the composition and configuration of the landscape. Probably the most common management recommendation for mature-forest birds is to retain large habitat patches to reduce edge effects and accommodate area-sensitive species. Although this is a good general strategy, research shows that edge and area effects are strongly linked to the landscape context. Increasing fragmentation in the landscape will tend to magnify the effects of edge, area, and isolation, whereas their effects may not be detected at all in forested landscapes. Indeed, minimum patch sizes can range from 25-2500 acres for some species, with area requirements increasing with declining forest cover. One explanation for the absence of area and edge effects in forested landscapes is that populations of generalist predators often associated with increased predation near edges do not substantially increase until the landscape has become quite fragmented. Thus, a patch of disturbance, such as a clearcut, within heavily forested landscapes seems not to be as detrimental to birds using mature forests as the same disturbance in a fragmented landscape. This means that managers concerned with edge effects must be keenly aware of landscape context.

To date, research in southeast Ohio has been consistent with this idea of landscape-dependent edge effects. For example, neither adjacency nor distance to harvest was significant related to density of several focal species, including cerulean warbler, ovenbird, and worm-eating warbler (Table 5; Bakermans et al. 2012). Likewise, there was no apparent relationship with nest survival (Bakermans et al. 2012). The key point to remember here is that during the period of research, forest cover within the study area counties exceeded 70%. With land use change, loss of forest cover, or changes in forest patch age and size, there may be increased presence of edge and area effects.

Table 5. Mean densities/25 acres (10 ha) at different distances from the edge of regenerating clearcuts, and densities by harvest context of common breeding birds across all 12 mature forest study sites in southeast Ohio, USA, 2004 – 2006. (Bakermans et al. 2012)

Species	<600 ft from edge	>600 ft from edge	Bordering harvest	Surrounded by forest
Wood thrush	6.67	7.75	7.21	7.29
Ovenbird	8.61	9.53	9.07	8.35
Worm-eating warbler	3.33	4.11	3.72	3.19
Kentucky warbler	1.00	0.75	0.88	0.38
Hooded warbler	3.92	3.17	3.54	2.83
Cerulean warbler	1.03	1.72	1.31	2.62
Scarlet tanager	4.00	4.42	4.21	4.71

Management recommendations

1. Efforts to manage local habitat features, such as forest structure, are an important piece of sustaining mature-forest breeders. In the forested landscapes (>70% forest cover) of southeast Ohio, structural attributes of forest (i.e., canopy structure, tree size, vertical complexity) had strong relationships with density and nest survival of sensitive species.

2. Features generally associated with older forests may be important habitat components for mature forest breeders, such as cerulean warbler. These old-forest characteristics include a heterogeneous canopy, diverse understory vegetation, grapevines, and emergent large trees. Thus, using longer rotation ages (>100 years), as well as specific harvest prescriptions (e.g., single tree and group selection) and timber stand improvement practices (e.g., thinning and crop tree release) are likely to encourage the development of these features.

Grapevines. Photo by Marja Bakermans.

3. As described in the section on "managing shelterwood harvests", white oak should be emphasized in management because it is a favored nesting tree for cerulean warblers and other canopy-nesting birds. (see next chapter for additional details about floristic composition of stands).

4. Several sensitive species breeding in mature forest would benefit from creating canopy gaps (>430 ft^2, 40 m^2) through single-tree or group selection cuts.

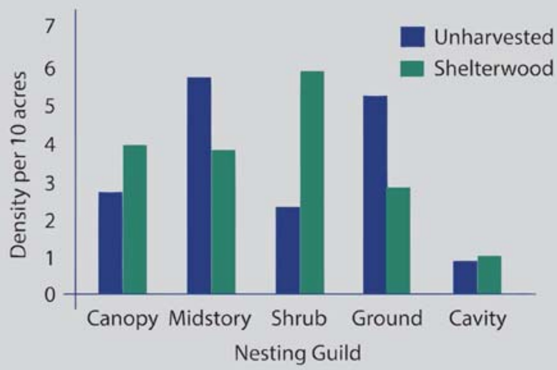
5. Based on results from the Cooperative Cerulean Warbler Forest Management Project (Boves 2011), recommendations for Appalachian forested landscapes specify that forests supporting > 2 territories per 10 acres (>5 territories/10 ha) of Cerulean Warbler should be managed without harvesting and in ways that minimize disturbance. On forest stands with fewer territories, management should reduce basal area to 56-78 ft^2 / acre (13-18 m^2/ha) while retaining large overstory trees (>16 inches dbh; >40cm dbh), especially of white oak. Because identifying the best management course depends upon bird densities, coordination and cooperation with wildlife biologists may be necessary.

Oak leaves. Photo by Amanda Rodewald.

Chapter 5: Managing shelterwood harvests

Oaks (*Quercus* spp.) have dominated many eastern forests for at least 10,000 years, resulting from climatic conditions, periodic fires, land practices of Native Americans (including burning), and repeated cutting followed by fire and grazing after European settlement. However, changes in disturbance regimes have made it difficult for oaks to regenerate. Now shade tolerant species, such as, red maple (*Acer rubrum*), sugar maple (*A. saccharum*), and blackgum (*Nyssa sylvatica*) dominate the understory and midstory layers of many oak forests.

Figure 9. Densities per 10 acres for avian nesting guilds in shelterwood and unharvested stands in southern Ohio (Newell & Rodewald 2012).



Fire played an important role in the historic dominance of oak-hickory in eastern deciduous forests for the last 10,000 years. Because oaks are tolerant to fire, periodic fires favor oaks to other species, like maple and tulip. For this reason, prescribed burning is an increasingly common management tool used to improve oak regeneration. In the same study area as the other research highlighted in this guide, Artman et al. (2001) investigated the short-term consequences of prescribed burning (62-146°C temperature fires) on birds. Of 30 bird species monitored, densities of only six changed in response to burning. Four species, ovenbirds, worm-eating warbler, hooded warbler, and northern cardinal declined in number, whereas American robin and Eastern wood-pewee increased in response to burning. As a whole, ground- and low-shrub nesting birds experienced the most adverse effects, but there were no overall changes in the bird community.

Changing forest composition impacts bird communities by affecting food and nesting resources. Consequently, agencies are now implementing forest management specifically intended to improve oak regeneration. One example is that oak regeneration is a major component of the revised Forest Plan for Wayne National Forest (in the "Historic Old Forest" management units). Silvicultural techniques, such as shelterwood harvests, also are used to increase oak regeneration and recruitment. Due to their open canopy structure, abundant understory vegetation, and mature trees, stands managed for oak regeneration can have the unique ability to support a diverse assemblage of early- and late-successional forest birds for the first 5-10 years until retained trees are removed.

What is a Shelterwood Harvest?

A shelterwood harvest is a cut that retains an overstory of maturing trees. This technique allows new stems to grow under the cover of the remaining trees. In traditional shelterwood harvests, residual overstory trees are typically removed within 10-30 years.

Shelterwood harvest. Photo by Amanda Rodewald.

Canopy nesters. For example, in 18 stands across 4 state forests in southeastern Ohio, Newell and Rodewald (2012) found that densities of canopy-nesting species that are typically associated with mature forest (i.e., cerulean warbler, yellow-throated vireo, scarlet tanager, blue-gray gnatcatcher) were 31-98% higher in shelterwood than unharvested reference stands (Fig. 9, Table 6). Density of cerulean warblers was highly variable among forests. At Zaleski State Forest, density of ceruleans was >200% higher in shelterwood than references stands, whereas few territories were present at Richland Furnace State Forest. The variation in response to shelterwood harvesting might be due to differences among forests in slope and aspect, given that ceruleans were positively associated with northeast-facing slopes.

Midstory and ground nesters. In contrast to canopy nesters, late-successional midstory and ground-nesting species were negatively associated with shelterwood harvesting, and occupied shelterwoods at 33% and 46% lower densities, respectively for these groups. At the level of individual species, red-eyed vireos, wood thrush, and worm-eating warblers were 26–38% less abundant while Acadian flycatchers and ovenbirds were 67% less abundant in shelterwoods than reference stands (Table 6).

Understory-nesters. Because shelterwood harvesting stimulates understory growth, shrub-nesting species were positively associated with shelterwood stands, with densities reaching 155% higher than in reference stands. Density of Eastern towhees was 300% higher in shelterwoods three years post-harvesting. Kentucky warblers, indigo buntings, and prairie warblers all began breeding in shelterwood stands within two or three years of harvesting.

Table 6. Mean density per 10 acres in recent shelterwood harvests and unharvested forest in southeastern Ohio, USA, 2007–2008. Adapted from Newell and Rodewald (2012).

Species	Unharvested	Shelterwood
Canopy-nesting guild	2.7	3.9
Eastern wood-pewee	0.5	0.8
Yellow-throated vireo	0.2	0.4
Blue-gray gnatcatcher	0.2	0.4
Cerulean warbler	0.4	0.6
Scarlet tanager	1.0	1.3
Midstory-nesting guild	5.7	3.8
Acadian flycatcher	0.4	0.1
Red-eyed vireo	3.0	2.3
Wood thrush	1.3	0.9
American redstart	0.4	0.5
Shrub-nesting guild	2.3	5.8
Carolina wren	0.2	0.4
Prairie warbler	0.0	0.9
Kentucky warbler	0.0	0.6
Hooded warbler	1.8	2.2
Eastern towhee	0.4	0.9
Indigo bunting	0.0	1.0
Ground-nesting guild	5.2	2.8
Black-and-white warbler	0.9	1.1
Worm-eating warbler	0.9	0.6
Ovenbird	3.3	1.1
Cavity-nesting guild	0.8	0.9
Red-bellied woodpecker	0.1	0.2
Eastern tufted titmouse	0.3	0.3
White-breasted nuthatch	0.2	0.2
Avian predators and brood parasite	0.7	0.7
Blue jay	0.5	0.6
American crow	0.1	0.2
Brown-headed cowbird	0.6	1.3

Habitat use versus suitability

Although shelterwood stands were used heavily by many birds within the first few years of harvest, managers must be cautious about the possibility of creating an ecological trap. An ecological trap occurs when a cue that once could be reliably used to indicate quality of a habitat, resource, or mate no longer conveys the correct information and organisms using the cue have lower performance, reproduction, or survival. Animals are therefore attracted to or prefer a habitat feature that results in lower survival or reproductive success. In these cases, abundance does not indicate habitat quality and may even be greatest at the worst sites. Other metrics may serve as better indicators of quality, including age distribution, reproductive success, and site fidelity.

In the southeast Ohio study, Newell and Rodewald found that shelterwood stands had over twice as many young first-time breeders of canopy nesters, including both cerulean warblers and scarlet tanagers, than reference stands. Although this might suggest a lower preference for harvested stands, the pattern also might be a consequence of young birds colonizing newly created or improved habitat. Site fidelity (i.e., returning to breed at the same site across years) was similar at ~50% in unharvested and shelterwood stands.

Based on over 700 nests, nest survival did not differ between shelterwood and unharvested stands, possibly because numbers of avian predators did not change with harvesting. Despite increased numbers of brown-headed cowbirds in shelterwoods, only 2% of canopy nests in which young could be identified were parasitized. No differences in brood size were found between stand types either. One worrisome pattern was that, despite the lack of a harvest effect, nesting success was low, ranging from 15–19% for yellow-throated vireos and cerulean warblers, to 27–36% for scarlet tanagers, blue-gray gnatcatchers and Eastern wood-pewees, which is lower than reported for other Appalachian forests.

Brown-headed cowbird. Photo by Ohio Division of Wildlife.

As a whole, the research suggests that shelterwood harvests containing abundant overstory trees (~32 overstory trees/acre or 80 trees/ha) can provide short-term breeding habitat for canopy songbirds. However, recognizing that overstory is typically removed for oak regeneration within 5-10 years, shelterwood prescriptions need to ensure that nesting habitat is maintained in space and through time within the landscape.

Long-term responses of birds to partial harvesting may differ given that management for oak regeneration will typically remove all overstory trees later in the cutting cycle, which should initially eliminate breeding habitat for canopy songbirds.

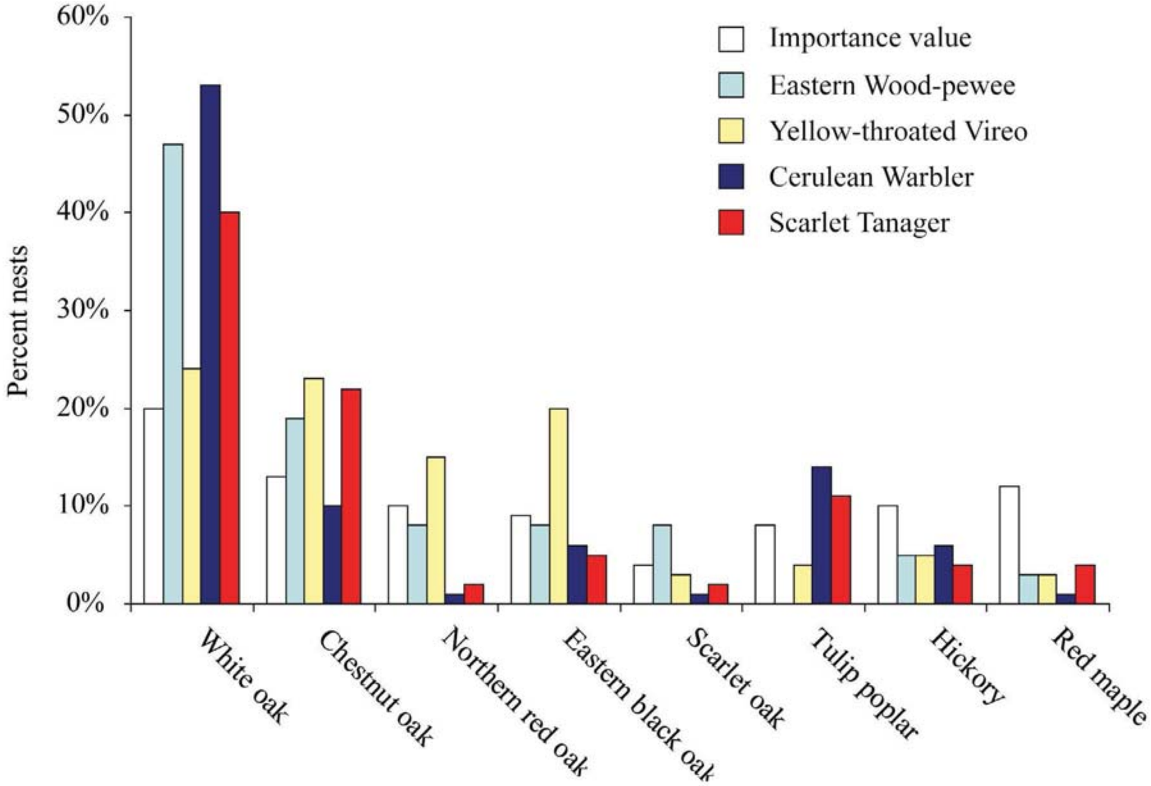
The importance of tree species, tree size, and microhabitats.

Newell and Rodewald (2011) found that factors such as topography, canopy structure, and floristics may be important in habitat selection and nesting success for canopy songbirds. Canopy-nesting birds selected large trees in higher proportion than available (i.e., 66–75% of nests in large trees compared to importance values of 47%) and selected areas with fewer medium-sized trees (9-15 inches dbh; 23–38 cm dbh). The Eastern wood-pewee favored placing nests along ridges and open canopies created by partial harvesting, whereas cerulean warblers favored productive northeast-facing slopes with abundant grapevines.

Southeast Ohio forest. Photo by Andrew Vitz.

Although importance of oaks to birds is often generalized across oaks, Newell and Rodewald (2011) found strong differences among oak groups (i.e., white [white and chestnut oaks] and red [Northern red, Eastern black, and scarlet oaks]). Almost all canopy species favored white oak as a nest substrate, which is similar to work by Bakermans and Rodewald (2008). Red oak was avoided for nesting by blue-gray gnatcatchers, cerulean warblers and scarlet tanagers, and Eastern wood-pewees avoided tulip poplar (Fig. 10). Most species also avoided red maple. For the canopy-nesting guild and several individual species, nesting success was negatively associated with red oaks around the nest.

Figure 10. Tree species preferences for nesting for canopy-nesting species in southern Ohio. Importance values indicate the relative availability of each tree species. Adapted from Newell and Rodewald 2011.



Management recommendations

1. Partial harvesting (~50% stocking level), such as the shelterwood technique, can be used to provide habitat to both early-successional birds (e.g., prairie warbler, Eastern towhee) and canopy-nesting species usually associated with mature forest (e.g., yellow-throated vireo, scarlet tanager). In southern Ohio, reducing basal area from 100-143 ft^2/ acre to 39-70 ft^2/ acre (23-33 m^2/ ha to 9-16 m^2 / ha) supported greater numbers of both shrubland and canopy-nesting species than unharvested mature forest.

2. Recognizing that overstory is typically removed for oak regeneration within 5-10 years, shelterwood prescriptions need to ensure that nesting habitat is maintained across space and through time within the landscape.

3. Favor white oaks rather than red oaks in shelterwood harvests, as white oaks (white and chestnut oaks) were strongly favored for nesting and foraging by most canopy nesting species. Red oaks (Northern red, Eastern black, and scarlet oaks) also may depress nesting success of canopy nesting birds.

Prairie warbler. Photo by T. K. Tolford.

4. When possible, retain large diameter trees (>15 inches dbh; >38 cm dbh), which are most heavily used for nesting by canopy birds, including cerulean warbler.

5. In cases where there is wide latitude in choice of harvest location, avoid older forests with canopy gaps and/or those on northeast-facing slope, because these tend to be most heavily used by the declining cerulean warbler. Instead, shelterwood harvests are better implemented in areas that lack steep slopes and/or have few canopy gaps, where they are more likely to create or improve habitat for species requiring heterogeneous canopies.

Chapter 6:

Managing landscape mosaics and structurally complex habitats for post-fledging and post-breeding birds

One of the most surprising findings to emerge from studies of forest wildlife over the last decade is that many species widely considered to be obligate late-successional species are, in fact, disturbance dependent in one or more periods of their annual or life cycles. During these periods, species may use habitats that differ widely from those used for reproduction. Such is the case with many birds that breed in mature forest as they move into post-breeding and post-fledging periods that extend from the completion of breeding activities (or leaving the nest) until the onset of migration. For example, mature-forest breeders, such as ovenbirds and worm-eating warblers, are detected in large numbers in habitats with dense understory vegetation, early-successional forests, and even regenerating clearcuts. Because post-breeding birds tend to be less maneuverable due to molting or inexperience and have high energetic demands, they have a high risk of mortality. Differences in habitat use between birds during breeding and post-breeding seasons are thought to reflect an attraction of post-breeding birds to (1) dense cover to reduce risk of predation, and (2) abundant fruit resources to facilitate foraging. Although the reasons driving habitat selection remain unclear for many species, providing quality habitat to post-breeding and post-fledging birds is now recognized as an important component of any comprehensive approach to managing forest birds.

Local habitat features

Habitat Use. As a complementary study to their research on shrubland birds, Vitz and Rodewald (2007) examined post-breeding use of regenerating hardwood clearcuts (3-7 years old) in southeast Ohio. Vegetation structure was the most important factor associated with post-breeding bird use of regenerating clearcuts in southeastern Ohio. The greatest number of birds was captured in the most heterogeneous areas within clearcuts and specifically areas with open structure close to the ground (Vitz and Rodewald 2007). Extremely dense patches of vegetation near the ground may make it difficult for birds to forage and provide areas where predators, such as snakes, can hide.

At the same time, numbers of post-breeding birds were positively related to vegetation height and density within the clearcuts (Vitz and Rodewald 2007). For instance, nearly twice as many ovenbirds and 6x as many wood thrush were captured when the canopy was >12 ft than < 8 ft tall. Tall canopies (shrub-sapling canopy) not only provide additional structural resources, but also may protect birds from aerial predators such as Cooper's or broad-winged hawks, common raptors at sites. Abundance of most mature-forest juveniles and post-breeding adults was best explained by vegetation structure. However, fruit was the most important variable when explaining captures of scarlet tanager, which are known to consume large amounts of fruit outside the breeding period (Vitz and Rodewald 2007).

The finding that vegetation plays the most important role in habitat selection during the post-breeding period is consistent with work done by Vitz and Rodewald (2012) that examined stable isotope composition ($\delta 15N$ and $\delta 13C$) in retrices and basic plumage body feathers of juvenile Scarlet Tanagers, Wood Thrush, and Ovenbirds captured in regenerating clearcuts in southeastern Ohio, 2005-2006. Stable isotopes can be used to identify the diet of individuals. Isotopic ratios suggested that independent juveniles did not heavily consume fruits and rather primarily consumed both lepidopteran and predatory arthropods rather than primarily lepidopteran larvae. Thus, mature forest birds during the post-fledging period did not seem to specifically use regenerating clearcuts for fruit resources.

Ovenbird. Photo by Marja Bakermans.

Habitat selection and survival

Even though their initial work showed high use of early-successional habitat, the relationship between habitat selection and survival had not been studied. Two subsequent studies used radio-telemetry to identify patterns of habitat selection, not only use, and test associations between selection and survival (Vitz 2008, Vitz and Rodewald 2010, Vitz and Rodewald 2011).

From a management perspective, this information is critical because the idea that mature-forest breeders might require large patches of successional habitat during the post-breeding period could conceivably give rise to a scenario where one has to ask, "Do we harvest part of the remaining small patch of forest to improve post-fledging habitat, or do we keep the forest in a mature state to improve nesting habitat?" Consequently, managers need to know which features and habitats promote high survival of birds soon after they leave the nest.

From 2004-2007, Vitz and Rodewald radio-tagged and recorded daily locations of 51 ovenbirds and 60 worm-eating warbler fledglings in southeast Ohio. Survival rates were similar for the two species and estimated to be 65% for ovenbirds and 67% for worm-eating warblers, which are higher rates than reported for other species and regions. Overall, fledglings of both species actively selected densely vegetated habitats that contained 40-60% more woody stems in the understory than random locations (Fig 11).

Use of dense vegetation promoted survival. Surviving individuals of both species used areas with approximately 20% more woody stems than non-surviving individuals (Fig. 12). Importantly, survival was not linked specifically to use of large patches of early-successional habitat. Birds that fledged nests near clearcuts and those far from clearcuts survived at similar rates.

Figure 11. Mean number (+ SE bars) of woody stems (left) and canopy cover (right) at fledgling, random, and nest locations for worm-eating warblers and ovenbirds in southern Ohio. From Vitz and Rodewald 2011.

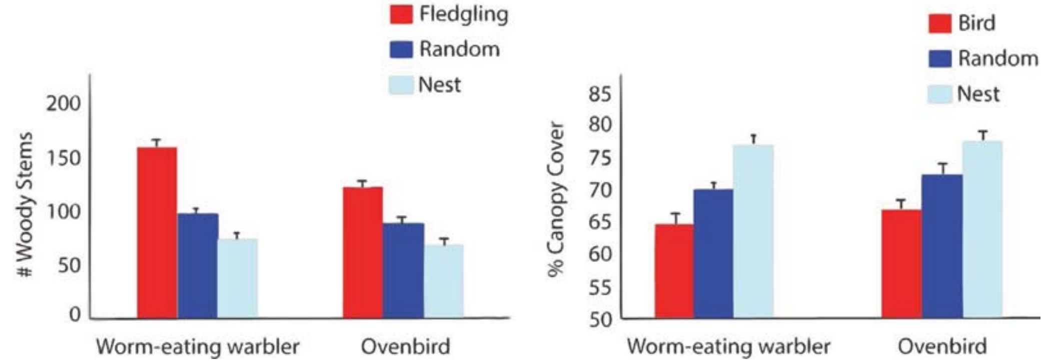
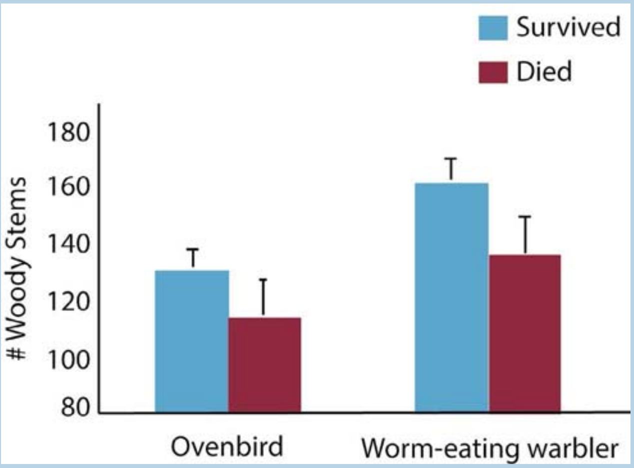


Figure 12. Mean number (+ SE bars) of woody stems at ovenbird and worm-eating warbler locations of individuals that survived and died during the post-fledging period in southern Ohio. From Vitz and Rodewald 2011. Photo by Andrew Vitz.



Worm-eating warbler nest.

Moreover, nearly all birds used dense vegetation within the forest or along edges (e.g., riparian habitats, road edges, treefall gaps) and few used clearcuts. These findings suggest that specific habitat features (i.e., dense woody vegetation) rather than habitat types (i.e., shrubland habitat) are key to providing quality post-fledging habitat. Given that dense understory vegetation promotes survival of fledging birds, providing such vegetatively dense habitat within a forested landscape may improve juvenile survivorship and increase recruitment into the population.

Two findings of Vitz and Rodewald also suggest that the quality of nesting habitat might influence survival of juveniles during the post-fledging period. First, body condition of nestlings was positively related to survival during the post-fledging period. Thus, individuals fledged from nests in the highest quality breeding habitats are likely to have the greatest survival rates due to their presumably greater access to food resources. Second, ovenbirds fledging earlier in the season survived at a higher rate than those leaving the nest later in the season, potentially due to changes in food resources across the season. Declining survival of fledglings across the breeding season demonstrates an additional cost of high rates of nest predation. If early nesting attempts fail, even a successful renesting attempt may incur substantial fitness consequences from higher post-fledging mortality. Here again, providing the highest quality nesting habitat may positively affect post-fledging survival.

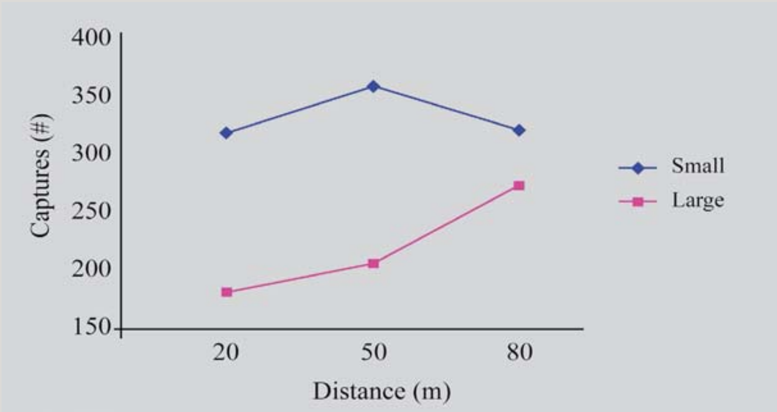
Because observational studies have important limitations, Vitz and Rodewald also experimentally tested how access to and use of large patches of successional habitat (i.e., regenerating clearcuts) influenced survival and behavior of juvenile Ovenbirds that were independent (i.e., ~3 weeks of age). Between 2004 and 2006 they captured and radio-tagged 85 Ovenbirds and randomly assigned individuals to one of three experimental groups that were released in 1) the original clearcut of capture, 2) a different clearcut of similar age, and 3) a mature forest. Across a 52-day period, survival of independent juveniles was 83% and was similar across the three experimental treatments. Juvenile survival was best explained by and positively related to both vegetation density and individual energetic condition. As with the younger fledglings, juveniles selected dense understory vegetation that promoted survival. These results are important from a management perspective because they show that while dense vegetation is selected by and promotes juvenile survival, birds apparently do not apparently require large patches of successional habitat. Rather, juveniles seem able to use a wide range of successional habitats and patches of dense vegetation (e.g., treefall gaps, road edges) that occur within mature forests.

Collectively, these findings show that during the post-breeding and post-fledging periods, birds actively select areas with dense understory vegetation, which may occur either within mature forest, along edges, or in different habitats (e.g., riparian or successional habitats). They also provide strong evidence that shifts in microhabitats promote survival.

Edge, area, and landscape sensitivity

The sensitivity of mature-forest birds to edge and area during the breeding season is well established in many studies and a variety of regions. However, research on post-breeding birds suggests that they may actually favor edge habitats due to preferences for thick vegetation. Vitz and Rodewald (2006) tested for attraction or aversion to edges of regenerating clearcuts and for sensitivity to harvest size. Surprisingly, they found that most post-breeding individuals avoided areas closest to the mature-forest edge of clearcuts, and instead heavily used the clearcut interiors.

Figure 13. Total number of captures of mature-forest birds during the post-breeding period with respect to distance and stand size in regenerating clearcuts in southeast Ohio, 2002 and 2003. From Vitz and Rodewald 2006.



Paradoxically, juveniles and post-breeding adults also avoided large clearcuts (which should have more "interior"), and capture rates were up to 4 times greater in small than large regenerating clearcuts (Fig 13). Capture rates for five of the six species of mature-forest birds were 10-380% greater in small than large cuts; an interesting paradox with the pattern of edge avoidance. They detected no difference in habitat structure or food resources to explain this pattern, but several possible explanations exist, including avoidance of predators along edges, reducing competitive interactions with individuals still breeding in mature forest, or differences in food availability. Post-breeding birds may discriminate among regenerating clearcuts based on size, shape, or edge. For some species, higher capture rates in small stands also may be a result of a concentration effect. As a function of clearcut size, small clearcuts within a forested landscape generally have more mature forest habitat (and presumably more mature-forest birds) in the immediate landscape compared to large cuts. Consequently, if mature-forest birds select regenerating clearcuts during the post-breeding period one would expect greater numbers of them being concentrated in the small regenerating clearcuts.

Other work conducted by Vitz and Rodewald (2010) on movements also provides insights into potential area requirements of post-fledging birds. Natal home range sizes for ovenbird and worm-eating warbler far exceeded the size of breeding territories, with natal home range size of worm-eating warblers (25 acres; 10 ha) being twice as large as that for ovenbirds (12 acres; 5 ha). Fledglings also made surprisingly long dispersal movements from natal areas - oftentimes more than 600 ft within only two weeks of leaving the nest. Birds in better condition made longer movements. Use of large areas after fledging may contribute to patterns of area sensitivity, at least in fragments smaller than the natal home range size. Once a patch exceeds this size, these effects would likely be reduced because family groups may have overlapping natal home ranges. If area sensitivity is partially explained by natal home range size, then species exhibiting large natal home ranges should demonstrate a higher degree of area sensitivity. Indeed, worm-eating warblers, which utilized natal home ranges that were nearly twice the area as those for ovenbirds, are more sensitive to fragmentation than ovenbirds.

Another interesting connection between movement and area requirements comes from the experimental study with independent juveniles described previously (Vitz 2008). Ovenbirds released into mature forest habitat traveled farther from their release location after both 7 and 14 days compared to birds released into both clearcut treatments. The higher movement rates of individuals relocated in mature forest habitats might indicate that if birds are to rely upon mature forest to provide post-breeding and post-fledging habitat, that they must move over larger areas to locate suitable microhabitats (Figs. 14, 15). Thus, maintaining large patches may be important in landscapes dominated by late-successional forest.

Lehnen (2008) found that captures of post-breeding forest specialists were best explained by the combination of both local habitat variables and amount of mature forest within 0.62 mile (1 km). Thus, maintaining forested landscapes that have abundant late-successional forest is an important component of providing habitat to post-breeding and post-fledging birds.

Figure 14. The mean distance moved from the release location for independent juvenile Ovenbirds for each of the three treatment groups (mf = mature forest, cc-diff = released in a different clearcut, cc-same = released in original clearcut of capture). From Vitz 2008, Vitz and Rodewald 2013.

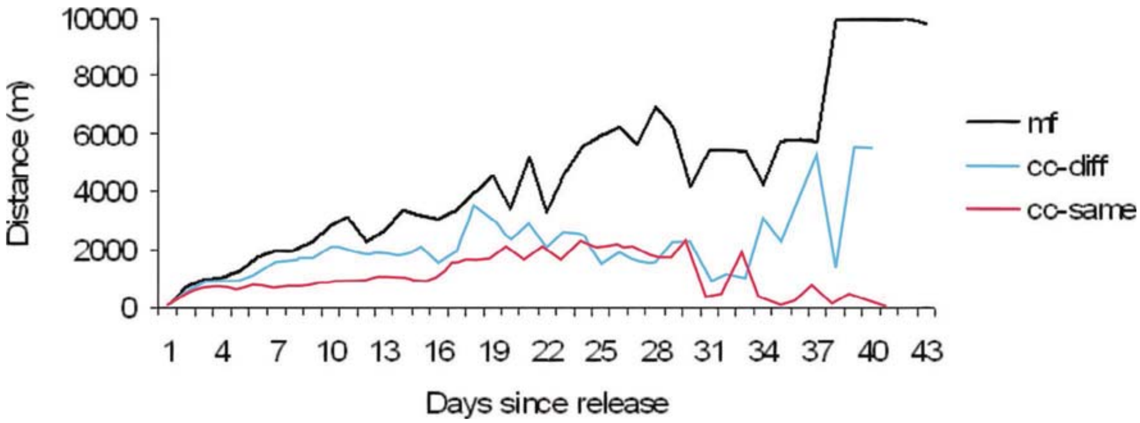
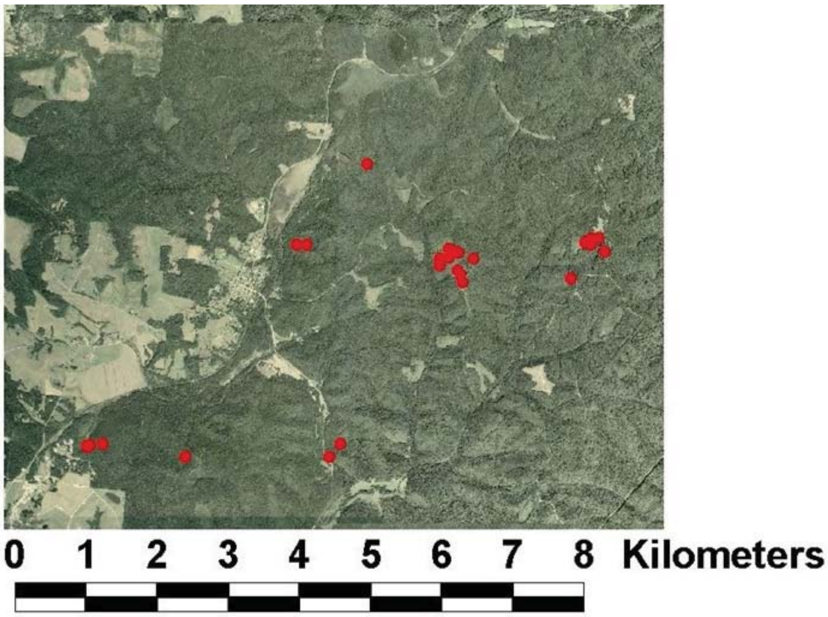


Figure 15. Daily locations of an independent juvenile ovenbird in southeastern Ohio (Vitz 2008).



Management recommendations

1. Manage mature forests in ways that promote structural complexity, which encourages microhabitats that provide dense understory vegetation. Examples include treefall gaps, riparian thickets, and natural patches of shrubs. Because some of these features are typical components in old, uneven-aged forests, consider allowing stands to reach ages greater than 100 years.

2. Allow roadsides and other human-associated edges to develop the thick vegetation that is heavily used by post-breeding birds. There appear to be no strong size requirements for use by birds.

3. When consistent with other management goals (e.g., oak regeneration), consider using silvicultural techniques to create areas with dense vegetation. Group-selection harvests and shelterwood harvests may be good examples of this. Although use of these harvest types has not been specifically studied during this stage in the annual cycle, changes in habitat structure associated with those silvicultural techniques are consistent with features preferred by post-breeding and post-fledging birds.

4. Regarding harvest size, be attentive to needs of other species and during other stages of the annual cycle. Post-fledging birds do not seem to require large patches of successional habitat and can use dense vegetation within mature forests. Consequently shrubland habitats are probably best managed according to recommendations for early-successional breeders.

5. Engage in landscape-scale planning to ensure that sufficient forest is retained to permit movement through the landscape (see Appendix C). Not only are independent juveniles known to make extensive movements, but numbers of post-breeding birds using harvests was positively related to forest cover within 0.62 mile (1 km).

References

Artman, V.L., E.K. Sutherland, and J.F. Downhower. 2001. Prescribed burning to restore mixed-oak communities in southern Ohio: effects on breeding bird populations. Conservation Biology 15:1423-1434.

Bakermans, M.H., A.D. Rodewald, and A.C. Vitz. 2012. Influence of forest structure on density and nesting success of mature forest birds in managed landscapes. Journal of Wildlife Management 76:1225-1234.

Bakermans, M. H. and A. D Rodewald. 2009. Think globally, manage locally: the importance of steady state forest features for a declining songbird. Forest Ecology and Management 258:224-232.

Bakermans, M.H. 2008. Demography and habitat use of Cerulean Warblers on breeding and wintering grounds. Ph.D. dissertation, The Ohio State University, Columbus, OH.

Boves, T.J. 2011. Multiple responses of Cerulean Warblers to experimental forest disturbance in the Appalachian Mountains. PhD Dissertation. College of Natural Resources. University of Tennessee, Knoxville, TN.

Lehnen, S. E. and A. D. Rodewald. 2009a. Investigating area-sensitivity in shrubland birds: responses to a patchy landscape. Forest Ecology and Management 257:2308-2316.

Lehnen, S. E. and A. D. Rodewald. 2009b. Dispersal, inter-patch movements, and survival in a shrubland breeding bird community. Journal of Field Ornithology 80:242-252.

Lehnen, S. E. 2008. An evaluation of survivorship and habitat use of early-successional birds during the breeding season: implications for conservation. Ph.D. dissertation, The Ohio State University.

Newell, F. L. and A. D. Rodewald. 2012. Management for oak regeneration: Short-term effects on the bird community and suitability of shelterwood harvests for canopy songbirds. Journal of Wildlife Management 76:.683-693.

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

Rodewald, A. D. and A. C. Vitz. 2005. Edge and area-sensitivity of shrubland birds. Journal of Wildlife Management 69:681-688.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2011. The North American Breeding Bird Survey, Results and Analysis 1966 - 2009. Version 3.23.2011 USGS Patuxent Wildlife Research Center, Laurel, MD

Vitz, A. C. and A. D. Rodewald. 2013. Behavioral and demographic consequences of access to early-successional habitat by juvenile ovenbirds: an experimental approach. Auk 130: 21-29.

Vitz, A. C. and A. D. Rodewald. 2012. Using stable isotopes to investigate the dietary trophic level of fledgling songbirds. Journal of Field Ornithology 83:73-84.

Vitz, A. C. and A. D. Rodewald. 2011. Survival in the thicket: Dense vegetation promotes survival of post-fledging songbirds. Condor 113:400-411.

Vitz, A. C. and A. D. Rodewald. 2010. Fledgling songbird movements within and beyond the natal home range. The Auk 127:364-371.

Vitz, A. C. and A. D. Rodewald. 2007. Vegetative and fruit resources as determinants of habitat use by mature-forest birds during the post-breeding period. Auk 124:494-507.

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

Vitz, A. C. 2008. Survivorship, habitat use, and movements for two species of mature forest birds during the post-fledging period. Ph.D. dissertation, The Ohio State University.

Ziolkowski, D. J., Jr. K. L. Pardieck, and J. R. Sauer. 2010. The S2003-2008 summary of the North American breeding bird survey. Bird Populations 10:90-109.

Appendix A. Common metric conversions.

Metric	**English conversion**
1 meter	x 3.28 = ft
1 cm	x 0.394 = inches
1 m^2	x 10.76 = ft^2
1 hectare	x 2.471 = acres
Trees per hectare	x 0.4047 = trees per acre
m^2 per hectare	x 4.356 = ft^2 per acre
cm dbh	X 0.3939 = inches dbh

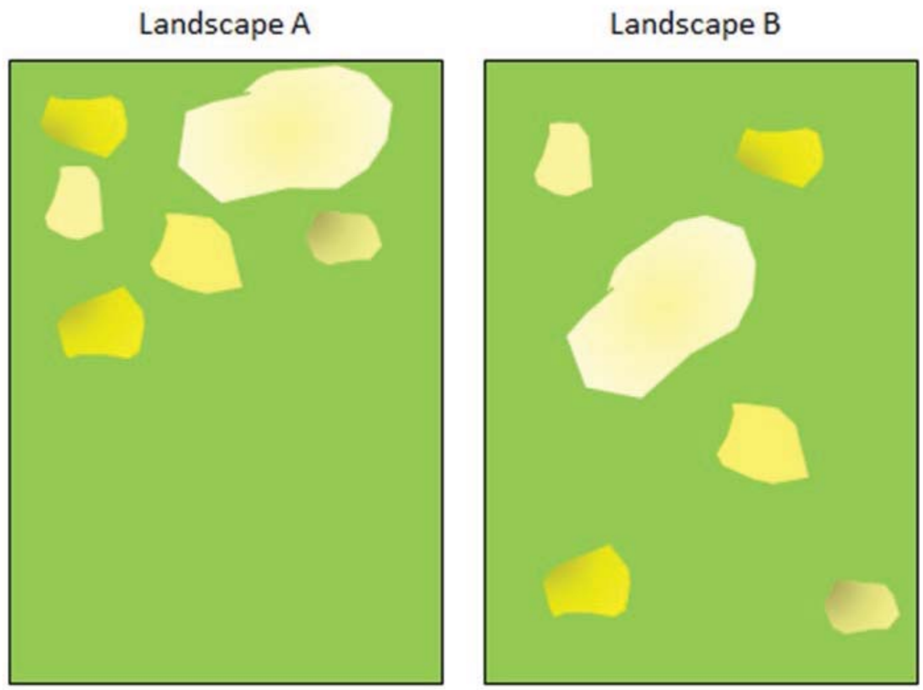
Appendix B: Habitat associations, nest location (gr = ground, us = understory and midstory, can = canopy, cv= cavity) , expected responses to management (- lower densities, + higher densities, √ no change or limited use of habitat), and special features required for priority breeding birds in southeastern Ohio.

	General HabitatType	Nest	Management prescription: Clear-cut	Seedtree	Shelterwood	Single tree	Group Select	Light Thin	Heavy Thin	Mature	Special features
Highest Priority											
Wood Thrush	forest	us	–	–	–	√	√	√	–	+	multi-layered forest with understory
Worm-eating Warbler	forest	gr	–	–	–	√	√	√	–	+	forested slopes
Cerulean Warbler	forest	can	–	–	+	√	√	√	+	+	large trees, canopy gaps
American Woodcock	forest/shrub	gr	+	√	√	–	–	–	–	–	wet shrub-scrub and early successional
Blue-winged Warbler	shrub	gr	+	+	+	–	–	–	+	–	
High Priority											
Whip-poor-will	forest	gr	+	+	+	√	√	√	√	+	
Black-billed Cuckoo	forest	can	√	√	√	√	√	√	√	+	
Hooded Warbler	forest/shrub	us	–	–	+	+	+	+	+	+	multi-layered forest with understory
Kentucky Warbler	forest	gr	–	–	+	+	+	+	+	√	
Red-headed Woodpecker	open woodland	cv	–	+	+	–	–	–	+	√	savannah-like oak forest
Prairie Warbler	shrub	gr	+	+	+	–	–	–	–	–	
Field Sparrow	shrub	gr	+	+	+	–	–	–	–	–	

	General Habitat Type	Nest	Management prescription								Special features
			Clear-cut	Seed tree	Shelterwood	Single tree	Group Select	Light Thin	Heavy Thin	Mature	
Moderate Priority											
Ruffed Grouse	forest/shrub	gr	+	√	+	√	√	√	√	√	mix of successional stages
Yellow-billed Cuckoo	forest	can	√	√	√	+	+	+	√	+	
Chuck-will's-widow	forest	gr	√	√	√	–	√	–	√	√	grassy forest openings; juniper
Northern Flicker	forest	cv	–	√	√	√	√	√	√	√	open woodland
Eastern Wood-Pewee	forest	can	–	–	+	√	√	√	+	+	canopy gaps, open structure
Great Crested Flycatcher	forest	cv	–	–	+	√	√	√	+	√	canopy gaps, open structure
Yellow-throated Vireo	forest	can	–	–	+	√	√	√	+	+	canopy gaps, open structure
Blue-gray Gnatcatcher	forest	can	–	–	√	√	√	√	√	+	
Veery	forest	us	–	–	–	√	√	√	–	+	mesic forest; Northeast Ohio
Canada Warbler	forest	gr	–	–	–	√	√	√	–	+	hemlock
American Redstart	forest	us	–	–	–	√	√	√	√	+	multi-layered forest with understory
Black-and-white Warbler	forest	gr	+	+	√	√	√	√	√	+	
Scarlet Tanager	forest	can	–	–	+	√	√	√	√	+	large trees, canopy gaps
Willow Flycatcher	shrub	us	+	+	+	–	–	–	–	–	
Brown Thrasher	shrub	us	+	+	+	–	–	–	+	–	
Yellow-breasted Chat	shrub	us	+	+	+	–	–	–	–	–	
Eastern Towhee	shrub	gr	+	+	+	–	√	–	√	–	
Indigo Bunting	forest/shrub	us	+	+	+	√	+	+	+	–	
Orchard Oriole	open woodland	can	–	+	+	–	–	–	–	–	

	General Habitat Type	Nest	Management prescription								Special features
			Clear- cut	Seed tree	Shelterwood	Single tree	Group Select	Light Thin	Heavy Thin	Mature	
Other regional species											
Wild Turkey	forest	gr	√	√	√	√	√	√	√	+	
Red-bellied Woodpecker	forest	cv	–	–	√	√	√	√	√	+	snags, dead limbs
Downy Woodpecker	forest	cv	–	–	√	√	√	√	√	+	snags, dead limbs
Hairy Woodpecker	forest	cv	–	–	√	√	√	√	√	+	snags, dead limbs
Pileated Woodpecker	forest	cv	–	–	√	√	√	√	√	+	snags, dead limbs
Acadian Flycatcher	forest	us	–	–	–	√	√	√	–	+	
White-eyed Vireo	shrub	us	+	+	+	–	–	–	√	–	
Red-eyed Vireo	forest	us	–	–	√	√	√	√	√	+	
Carolina Chickadee	forest	cv	–	–	√	√	√	√	√	+	snags, dead limbs
Tufted Titmouse	forest	cv	–	–	√	√	√	√	√	+	snags, dead limbs
White-breasted Nuthatch	forest	cv	–	–	√	√	√	√	√	+	snags, dead limbs
Brown Creeper	forest	cv/bark	–	–	√	√	√	√	√	+	snags, dead limbs
Gray Catbird	forest/shrub	us	+	+	+	√	+	+	+	√	multi-layered forest
Ovenbird	forest	gr	–	–	–	√	√	√	–	+	
Louisiana Waterthrush	forest	gr	–	–	–	√	–	√	–	+	forested headwater streams
Northern Parula	forest	can	–	–	√	√	√	√	√	+	riparian forest
Summer Tanager	forest	can	–	–	√	√	+	+	+	√	
Northern Cardinal	forest/shrub	us	+	+	+	√	+	√	+	√	
Rose-breasted Grosbeak	forest	can	–	–	√	√	√	√	√	√	
Baltimore Oriole	forest	can	–	√	+	–	–	–	+	–	

Appendix C. Two hypothetical managed forest landscapes. Green indicates mature or late-successional forest, and yellow colors indicate various stages of early-successional forest. Because landscape A has clustered early-successional habitats to retain large contiguous mature forest, it is expected to better support populations of early and late successional birds. With widely distributed early-successional habitats, landscape B is less suitable for edge and area-sensitive species.



Appendix D. Common and scientific names of bird species included in this guide.

Common Name	Scientific Name
Acadian flycatcher	*Empidonax virescens*
American crow	*Corvus brachyrhynchos*
American redstart	*Setophaga ruticilla*
American woodcock	*Scolopax minor*
Baltimore oriole	*Icterus galbula*
Bell's vireo	*Vireo bellii*
Black-and-white warbler	*Mniotilta varia*
Black-billed cuckoo	*Coccyzus erythropthalmus*
Black-capped chickadee	*Poecile atricapillus*
Blue jay	*Cyanocitta cristata*
Blue-gray gnatcatcher	*Polioptila caerulea*
Blue-winged warbler	*Vermivora cyanoptera*
Broad-winged hawk	*Buteo platypterus*
Brown creeper	*Certhia americana*
Brown thrasher	*Toxostoma rufum*
Brown-headed cowbird	*Molothrus ater*
Canada warbler	*Cardellina canadensis*
Carolina chickadee	*Poecile carolinensis*
Carolina wren	*Thryothorus ludovicianus*
Cerulean warbler	*Setophaga cerulea*
Chimney swift	*Chaetura pelagica*
Chuck-will's-widow	*Caprimulgus carolinensis*
Common yellowthroat	*Geothlypis trichas*
Cooper's hawk	*Accipiter cooperii*
Downy woodpecker	*Picoides pubescens*
Eastern meadowlark	*Sturnella magna*
Eastern screech-owl	*Megascops asio*
Eastern towhee	*Pipilo erythrophthalmus*
Eastern wood-pewee	*Contopus virens*
Field sparrow	*Spizella pusilla*
Golden-crowned kinglet	*Regulus satrapa*
Golden-winged warbler	*Vermivora chrysoptera*
Grasshopper sparrow	*Ammodramus savannarum*
Gray catbird	*Dumetella carolinensis*
Great crested flycatcher	*Myiarchus crinitus*
Hairy woodpecker	*Picoides villosus*
Henslow's sparrow	*Ammodramus henslowii*
Hooded warbler	*Setophaga citrina*
House wren	*Troglodytes aedon*
Indigo bunting	*Passerina cyanea*
Kentucky warbler	*Geothlypis formosa*
Lark sparrow	*Chondestes grammacus*
Least flycatcher	*Empidonax minimus*
Loggerhead shrike	*Lanius ludovicianus*
Louisiana waterthrush	*Parkesia motacilla*
Marsh wren	*Cistothorus palustris*
Northern bobwhite	*Colinus virginianus*
Northern cardinal	*Cardinalis cardinalis*
Northern flicker	*Colaptes auratus*
Northern harrier	*Circus cyaneus*
Northern parula	*Setophaga americana*
Northern saw-whet owl	*Aegolius acadicus*
Orchard oriole	*Icterus spurius*
Ovenbird	*Seiurus aurocapilla*
Peregrine falcon	*Falco peregrinus*
Pileated woodpecker	*Dryocopus pileatus*
Pine warbler	*Setophaga pinus*
Prairie warbler	*Setophaga discolor*
Prothonotary warbler	*Protonotaria citrea*
Purple martin	*Progne subis*
Red-bellied woodpecker	*Melanerpes carolinus*
Red-eyed vireo	*Vireo olivaceus*
Red-headed woodpecker	*Melanerpes erythrocephalus*
Red-shouldered hawk	*Buteo lineatus*
Rose-breasted grosbeak	*Pheucticus ludovicianus*
Ruby-throated hummingbird	*Archilochus colubris*
Ruffed grouse	*Bonasa umbellus*
Scarlet tanager	*Piranga olivacea*
Sedge wren	*Cistothorus platensis*
Sharp-shinned hawk	*Accipiter striatus*
Short-eared owl	*Asio flammeus*
Song sparrow	*Melospiza melodia*
Summer tanager	*Piranga rubra*
Tufted titmouse	*Baeolophus bicolor*
Veery	*Catharus fuscescens*
Whip-poor-will	*Caprimulgus vociferus*
White-breasted nuthatch	*Sitta carolinensis*
White-eyed vireo	*Vireo griseus*
Wild turkey	*Meleagris gallopavo*
Willow flycatcher	*Empidonax traillii*
Wood thrush	*Hylocichla mustelina*
Worm-eating warbler	*Helmitheros vermivorum*
Yellow-billed cuckoo	*Coccyzus americanus*
Yellow-breasted chat	*Icteria virens*
Yellow-throated vireo	*Vireo flavifrons*
Yellow-throated warbler	*Setophaga dominica*