SILVICULTURE AND BIRD HABITAT

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Insights for Managers

The responses of forest bird communities to silvicultural practices vary with the intensity of treatment and time since treatment. Specifically:

- **Overall abundance and species richness peak several years after harvest in shelterwood cuts and overstory removals, then decline over time.**
- **Bird species that specialize on early-successional woody habitats represent the guild of highest conservation concern in the northeastern states.**
- **Overstory removals support a full suite of early-successional bird species, and shelterwoods a nearly full suite.**
- **Shelterwoods tend to retain most late-successional species.**
- **Habitat requirements of many bird species shift after breeding, with most moving into early-successional habitats.**
- **Uneven-age treatments, such as group or single-tree selection, provide too little shrubby habitat to support more than a few early-successional species.**
- **Different stages of even-age silviculture across a landscape tend to allow for greater conservation of multiple guilds and suites of bird species.**

BACKGROUND

Forests, particularly those on public lands, are managed for multiple resources. Forest resources include timber production, watershed protection, carbon sequestration, recreational opportunities, and wildlife habitat, among many others. For most nonindustrial private landowners, sustaining wildlife ranks higher than timber production as a forest ownership goal (Butler and Leatherberry 2004). Until recently, the SILVAH decision support system included only a very minor wildlife component, the ability to record stems as actual or potential den trees (Marquis et al. 1992). Wildlife information has been included in SILVAH training sessions in three ways:

- As part of the forest ecology background.
- As wildlife management suggestions within the SILVAH framework.
- As a synthesis of the effects of various management actions on wildlife.

More recently, a wildlife component has been developed for SILVAH (see Thomasma and Cleveland 2019), and work is ongoing to develop compatibility for the SILVAH and the NED decision support tools (Twery 2019), including the NED wildlife module. All these developments require and are based on a knowledge of wildlife responses to forest management. A synthesis of that information specifically focused on avian responses follows.

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BIRDS AS FOREST DWELLERS

Why focus on birds? In part because a disproportionate share of the research on wildlife responses to forestry practices has focused on birds for numerous reasons, including:

- Birds are highly speciose compared to other terrestrial vertebrate orders. For example, Pennsylvania supports 414 bird species (including pass-through migrants and winter residents), compared to 66 mammal species and 77 species of reptile and amphibian (Steele et al. 2010, Wilson et al. 2012).
- Many birds are habitat specialists, particularly in forests (Stoleson and Larkin 2010). Avian community composition in forests varies with forest structure (Culbert et al. 2013, Niemi and Hanowski 1984), and structure can change drastically with forest management. Birds' ability to fly enables them to leave an area should habitat conditions deteriorate, making them excellent monitors of habitat quality and ecosystem health (Canterbury et al. 2000).
- Because most breeding birds advertise and maintain their territories by song, nonintrusive methods can easily be used to survey these species (Bibby et al. 1992).

Birds also enjoy a large constituency among humans; bird-watching has become the largest and fastest-growing outdoor recreational activity in the United States (Carver 2013). That fact, coupled with birds' ability to be surveyed nonintrusively by song, has resulted in several major citizen-science programs for monitoring bird populations at the regional, national, and international scales, such as the North American Breeding Bird Survey (BBS) (Canterbury et al. 2000). We therefore understand bird population dynamics better than those of any other taxon.

Results from the BBS have shown that populations of many bird species have declined since the program's inception in 1966; in that time, 23 percent of the species of eastern forests have shown significant declines (Rosenberg et al. 2016). These include many of our most characteristic and widespread forest birds, such as the wood thrush (*Hylocichla mustelina*), cerulean warbler (*Setophaga cerulea*), worm-eating warbler (*Helmitheros vermivora*), and black-billed cuckoo (*Coccyzus erythrophthalmus*). More than half of these forest birds are nearctic-neotropical migrants that move seasonally from breeding areas in the United States and Canada to wintering areas in the Caribbean, Central America, and South America. These annual movements constrain the time they can spend on their breeding grounds and consequently their resiliency to environmental changes relative to nonmigrants (Faaborg et al. 2010).

These declines should be cause for general concern, because forest birds provide a wide range of ecosystem services (Şekercioğlu 2006, Whelan and Marquis 1995). From a forestry perspective, perhaps the most important service is pest control, particularly of herbivorous insects. Almost all forest birds (including hummingbirds) consume at least some insects in their diet, and most are wholly or primarily insectivores during the growing season. The biomass of leaf-eating insects consumed by birds, and their effects on plants, can be impressive (Mäntylä et al. 2011, Marquis and Whelan 1994).

Birds also provide additional ecosystem services, including:

- Seed dispersal. Birds function as the primary seed dispersal agents for many plants (Howe and Smallwood 1982, Willson 1986).
- Ecosystem engineering in the form of cavity creation. Tree cavities are recognized as a "keystone resource" in forests globally and can be critical for a variety of wildlife species (Remm and Lõhmus 2011). Cavities can occur naturally through branch breakage or rot or can result from excavation by animals, primarily woodpeckers (Bednarz et al. 2004).

- Pollination. A variety of birds can be effective pollinators (Whelan et al. 2008), although in eastern North American forests only the ruby-throated hummingbird (*Archilochus colubris*) regularly serves this function.
- Energy transfer. Birds function as the primary carrion-eaters in terrestrial ecosystems globally (DeVault et al. 2016). In this role they provide an important, albeit underappreciated, energy transfer pathway (DeVault et al. 2003).

FOREST MANAGEMENT

Understanding how forest management affects forest birds can be critical for forest health and function and for the sustainability of bird populations. Numerous studies have examined the effects of various forestry practices on avian populations and to a lesser degree on nest success (Thompson et al. 1995, Sallabanks et al. 2000). Most such studies report on changes in abundance of birds overall or by species. Much less research has been conducted on demographic effects, such as nest success, fledgling success, fledgling or adult survival, or site fidelity, all of which may be better indicators than abundance of habitat quality (Van Horne 1983). Here I synthesize the results of research on the effects of the specific forest management practices prescribed by SILVAH. This is not meant to be an exhaustive review of the available literature. Studies included here are limited to those conducted in eastern deciduous or mixed forests and therefore relevant to SILVAH. They include research conducted by the USDA Forest Service's NRS-02 research work unit as well as studies published by others. See Stoleson et al. (2011), Ristau et al. (2011), and Trager et al. (2013) for a separate discussion of the effects of herbicides on nontarget species. For this review I have arranged management actions by decreasing intensity of their disturbance to forest structure.

Overstory Removal

The impacts to forest habitats are greatest with overstory removal, whether from true clearcutting or from the end point of a shelterwood sequence (Keenan and Kimmons 1993). Avian communities usually show a nearly complete turnover of species from forest interior species to early-successional specialists after overstory removal. The early-successional specialist species present vary with the time since harvest (DeGraaf et al. 1998, Schlossberg and King 2009, Yamasaki et al. 2014). Early-successional bird communities in overstory removal areas tend to include species that do not typically occur in shelterwoods or group selection openings (Gram et al. 2003, King and DeGraaf 2000). Some species prefer areas with very little ground cover immediately after harvest but leave as woody regeneration develops; others, such as the chestnut-sided warbler, begin to colonize once a dense understory of seedlings becomes established, typically 4 or more years postharvest. Avian abundance, species richness, and species density tend to peak 5-11 years postharvest, depending on forest type and latitude (Schlossberg and King 2009, Steffen 1985). Keller et al. (2003) found species richness and density in 6-year-old stands to be more than twice that of any mature stand sampled.

Mature forest birds begin to recolonize harvested areas 12-15 years postharvest, but most such species do not reappear until at least 25 years postharvest (Connor and Adkisson 1975, Keller et al. 2003). Between 25 years and 100 years after harvest, avian density and species richness increase slowly as tree growth, gap formation, and understory reinitiation create new foraging niches (Keller et al. 2003).

Shelterwood Cut

The term *shelterwood cut* in this chapter signifies the initial cut of a shelterwood regeneration sequence, which typically reduces stand density to 50-70 percent of its original canopy cover. Shelterwoods tend to support a full complement of late-successional birds but also support most local early-successional species (Annand and Thompson 1997, Goodale et al. 2009, King and DeGraaf 2000, Lanham et al. 2002, Newell and Rodewald 2012). Shelterwoods thus often have higher overall diversity and overall abundance than uncut controls or any other silvicultural treatment, although those differences decline with time since harvest (Duguid et al. 2016, Wang et al. 2006).

The effects of shelterwood cuts on birds tend to be guild-specific in response to changes in specific aspects of forest structure. Ground-foraging species tend to decline shortly after a shelterwood harvest because of the typically dense advance regeneration (Augenfeld et al. 2008, Gram et al. 2003, Newell and Rodewald 2012, Stoleson unpublished data[2]). Similarly, the removal of much of the midstory competing vegetation produces declines in midstory-nesting species (Newell and Rodewald 2012). In contrast, the dense understory that develops provides excellent habitat for shrub-nesting species of mature forests and early-successional species (Becker et al. 2011, King and DeGraaf 2000). Newall and Rodewald (2012) note an increase of more than 100 percent in the densities of shrub-nesting species. Response of understory nesters depends on successful regeneration and may be hampered or delayed by excessive deer browsing (Stoleson et al. 2011).

Of particular note is a suite of canopy songbirds that preferentially occupies broken or partially open canopies. This is presumably an adaptation to mature steady-state forests with active gap-phase dynamics (Bakermans and Rodewald 2009). Perhaps the best-known example of these gap-dependent species is the cerulean warbler, which has declined at a faster rate since 1966 than any other species of mature forest, 2.63 percent annually range-wide (Sauer et al. 2017). Other species that show similar habitat preferences include the yellow-throated vireo (*Vireo flavifrons*) and blue-gray gnatcatcher (*Polioptila caerulea*) (Newell and Rodewald 2012).

I conducted research on one example of the response of cerulean warblers to shelterwood harvests. In this study, avian abundance and nest success were monitored in three treatments in mixed-oak forests: shelterwood cut to 50 percent relative density following guidelines in Brose et al. (2008); an uncut buffer adjacent to the shelterwood (to assess edge effects), and an uncut control at least 250 meters from the nearest opening or harvest. All 4 replicate sites supported mature (85- to 110-year-old) second-growth mixed-oak forest on the Allegheny High Plateau in northwestern Pennsylvania. Shelterwoods had been cut 3-5 years earlier, such that understory regeneration was well advanced when the study began. Avian abundance and species diversity consistently peaked in shelterwood stands and was lowest in uncut controls. Several species occurred almost exclusively in shelterwood stands; these included a range of early-successional specialists such as chestnut-sided warbler (*Setophaga pensylvanica*) and indigo bunting (*Passerina cyanea*), shrub-nesting forest interior birds such as black-throated blue and hooded warblers (*Setophaga cerulescens*, *S. citrina*) and veery (*Catharus fuscescens*), as well as canopy gap specialists such as cerulean warbler and yellow-throated vireo. Nest success varied among nesting guilds but varied among treatments only for the shrub-nesting guild: shrub nests in shelterwoods were much more likely to fledge young than in either uncut treatment, probably because the understory density was much greater in shelterwoods. We found no nesting cerulean warblers or other canopy gap specialists in the uncut treatments, suggesting a real reliance on the presence of canopy gaps.

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Group Selection

Various studies have reported on the effects of group selection openings on birds, although the effects seem to vary greatly with the size and density of openings (Tozer et al. 2010). Most studies of group selection document short-term increases in some early-successional bird species (see Campbell et al. 2007, Jobes et al. 2004). However, Costello et al. (2000) show that group selection cuts (of < 0.8 acres) support only a small fraction of the early-successional bird species found in larger even-aged removal harvests (5 vs. 32 species). Annand and Thompson (1997), McDermott and Wood (2009), and Yamasaki et al. (2014) also demonstrate a reduced suite of early-successional species in group cuts compared to removal harvests. Species that are dependent upon larger gaps, such as the yellow-breasted chat (*Icteria virens*), tend to be absent from all group selection cuts. Tozer et al. (2010) report an increase in aerial foraging species, probably in response to opening of the canopy. Uncut portions of the stands containing group openings usually maintain their mature forest species (Annand and Thomson 1997, Campbell et al. 2007), although typically in reduced numbers. These forest-interior species often avoid the immediate area of the openings (Germaine et al. 1997). Fall migrants tend to use group openings more than adjacent uncut stands, perhaps because of the fruit resources produced by the early-successional vegetation that develops in openings (Kilgo et al. 1999).

In terms of demographic effects, Alterman et al. (2005) report no difference in nesting success rates between birds nesting within group openings and the same species nesting in nearby overgrown fields. Moorman et al. (2002) find no effect of proximity to group openings on nest success of shrub-nesting hooded warblers (*Setophaga citrina*). However, King et al. (1998) speculated that greater amounts of edge per unit area associated with group cuts may result in higher rates of nest predation than would be found in uncut stands, because nest predators hunt near edges.

Thinning and Single-Tree Selection Cutting

I consider these two treatments together, even though one is an intermediate treatment and the other is a final harvest option, because their impacts to forest structure are somewhat similar. In both, individual trees are removed, resulting in slightly opened canopies and a slight increase in the amount of light hitting the forest floor, potentially with a subsequent pulse of woody understory vegetation (Yanai et al. 1998).

Avian species richness and abundance in stands that are subject to thinning or single-tree selection tend to be intermediate between those found in unmanaged stands and those in shelterwood seed cuts (Annand and Thompson 1997, DeGraaf 1991, Freedman et al. 1981, Goodale et al. 2009). The magnitude of response by the avian community varies greatly with intensity of harvest (Holmes et al. 2004, Norris et al. 2011). Various researchers have noted declines in closed-canopy species such as ovenbird (*Seiurus aurocapillus*), especially for old forest specialists such as the brown creeper (*Certhia americana*) (Poulin et al. 2010). Overall abundance often declines as well (Hache et al. 2013, Heltzel and Leberg 2006, Holmes and Pitt 2007, Jobes et al. 2004, Robinson and Robinson 1999, but see Holmes et al. 2004).

Studies where canopy disturbance was sufficient to increase sunlight on the forest floor report corresponding increases in a few shrub-nesting species (Annand and Thompson 1997, Doyon et al. 2005, Haché et al. 2013, Heltzel and Leberg 2006, Jobes et al. 2004, Robinson and Robinson 1999). Although little studied, there is no published evidence that postfledgling survival is affected by these treatments relative to uncut controls (Moore et al. 20). For example, demographic parameters of ovenbirds do not differ between selection cuts and uncut controls up to 25 years postharvest (Leblanc et al. 2011).

Diameter Limit Cut/High Grade

Although possibly the most widespread timber management technique employed in eastern deciduous forests, especially on nonindustrial private land (Kenefic and Nyland 2005, Nyland 1992), diameter-limit cutting remains virtually unstudied in terms of its effects on wildlife. To date, a single published paper (Weakland et al. 2002) describes avian responses to light-intensity diameter-limit cutting. They report a higher total abundance of songbirds and higher nest survival in harvested stands than in controls, but few differences overall at their low level of harvest. The effects of heavier (and more typical) harvest levels remain unstudied.

Postbreeding Effects

Most of the information about the various timber management techniques refers specifically to responses of birds during their breeding season. In recent years a focus on full life cycle research has revealed that for many forest-breeding songbirds, habitat preferences are dynamic throughout their life cycle rather than static as once assumed (Faaborg et al. 2010, Zuckerberg et al. 2016). In particular, most late-successional breeders appear to shift to forest edges, riparian areas, and early-successional habitats once their young have fledged (Chandler et al. 2012, Cox et al. 2014, Rappole and Ballard 1987, Stoleson 2013). Regenerating clearcuts are shown to provide valuable postbreeding habitat for adults and fledglings of some late-successional species (Burke et al. 2017, Marshall et al. 2003, Pagen et al. 2000, Vitz and Rodewald 2006). Birds that move to regenerating cuts tend to be in significantly better physiological condition than those that remain in mature forest (Stoleson 2013), suggesting a clear adaptive strategy.

Fencing

Chollet et al. (2015), deCalesta (1994), Holt et al. (2013), McShea and Rappole (2000), Tymkiw et al. (2013), and other researchers have documented a correlation between deer abundance and bird communities. When white-tailed deer populations are abundant in an area, they often inhibit the development of diverse tree regeneration (Horsley et al. 2003). Consequently, high deer densities lead to reductions in understory bird species. When understory inventories indicate a lack of regeneration in a stand with a moderate to high deer impact level, SILVAH will usually prescribe a woven-wire fence to exclude deer to promote regeneration (see Vercauteren et al. 2006). Although fencing has no direct effect on birds, the resulting changes to understory vegetation can affect bird abundance and composition. Nuttle et al. (2011) followed up on the Allegheny Highlands deer enclosure study described by Horsley et al. (2003) and Royo and Stout (2019) by conducting bird surveys in the clearcut areas of that study 28 years after those cuts took place. By that time the stands contained dense pole-sized timber with almost no foliage at browsing level, and fences were down or compromised. Nuttle et al. (2011) show that higher ungulate densities during stand initiation caused significant reductions in tree species diversity, canopy foliage density, canopy insect density, and bird density in young forests.

CONSERVATION IMPLICATIONS

Overall, avian abundance and species richness peak several years after harvest in shelterwood cuts and overstory removals, then decline over time. Of course, not all species are of equal conservation concern, and abundance and species richness have little relevance to conservation value. Species and guilds vary in their level of conservation concern (Nuttle et al. 2003). Fully 45 percent of early-successional species have shown significant declines since 1966 based on BBS trends, in contrast to 23 percent of mature forest species and

19 percent of wetland obligate species (Dettmers 2003). In today's eastern deciduous forests, early-successional habitats are created primarily by timber harvests because many natural disturbance factors such as beavers and fire have been almost totally lost (DeGraaf and Yamasaki 2003, Trani et al. 2001). Overstory removals support a full suite of early-successional bird species, and shelterwoods nearly a full suite. Uneven-age treatments, such as group or single-tree selection, provide too little shrubby habitat to support more than a few early-successional species. Even-aged silviculture tends to allow for greater conservation of multiple guilds and suites of species across a landscape and is therefore preferable in most cases to uneven-age treatments, from a bird conservation perspective.

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