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Long-term effects of different forest regeneration methods on mature forest birds

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ABSTRACT

Changes in forest structure that result from silviculture, including timber harvest, can positively or negatively affect bird species that use forests. Because many bird species associated with mature forests are facing population declines, managers need to know how timber harvesting affects species of birds that rely on mature trees or forests for breeding, foraging, and other purposes. We used generalized linear mixed models to determine effects of clearcutting, shelterwood, single-tree selection, and group selection on detection of 18 species of bird associated with mature forests in the Ouachita Mountains of Oklahoma and Arkansas. We surveyed birds for 16 years after harvest. Most species (67%) responded positively to partial harvest that retained some overstory. Less intensive harvests had positive effects on more species and negative effects on fewer species than more intensive harvests, but responses to different treatments varied among species. Five species showed a significant positive response to the most intensive harvest (clearcuts), whereas 2 species showed a negative response. For the second most-intensive harvest (shelterwoods), 7 species showed a significant positive response and 1 species showed a negative response. For the less-intensive harvests, 9 species showed a positive response and no species had negative responses to single-tree selection, whereas 7 species had positive and no species showed negative responses to group selection. Ovenbird (*Seiurus aurocapilla*) and scarlet tanager (*Piranga olivacea*) responded negatively to all timber harvests; ovenbird appeared to be particularly susceptible to timber harvest, especially more intensive harvests such as clearcut and shelterwood. A variety of regeneration methods, including some more intensive treatments, along with maintenance of mature forest stands that retain well-developed midstories can be used to maintain the full suite of forest birds.

1. Introduction

Many bird species are facing population declines and populations of forest-dependent birds have undergone steady declines since 1970, including species that breed in either early successional or mature forests (State of the Birds, 2014). Consequently, forest managers often manage landscapes to maintain populations of forest-dependent species, including both early successional and mature-forest birds. Changes in forest structure that result from silvicultural practices, such as tree harvest and prescribed burning, can positively or negatively affect bird species that use forests (King and DeGraaf, 2000; Perry and Thill, 2013a; Thompson et al., 1995). Therefore, effects of forest management on bird populations have received considerable attention (e.g., Sallabanks et al., 2000).

Various silvicultural systems are used to remove timber, regenerate forests, and create early successional habitat. Even-aged systems include regeneration methods such as clearcut and shelterwood harvests while uneven-aged systems include single-tree selection and group selection harvests. Effects of clearcutting on forest birds have received considerable study (e.g., Conner and Adkisson, 1975; Dickson et al., 1993; Keller et al., 2003; Thompson et al., 1992), and responses of many bird species to clearcutting are predictable. In the short-term (< 10 years after harvest), disturbance-associated species immigrate to or increase use of clearcuts, whereas species associated with mature forest trees may decline or are extirpated (e.g., Annand and Thompson, 1997; Perry and Thill, 2013a). Around 5–8 years after harvest in the southeast U.S., forest canopies begin to close and early successional species are slowly replaced by species associated with mature trees

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(e.g., Conner and Dickson, 1997). However, less is understood about responses of mature-forest birds to forest harvests that retain some mature trees (Sallabanks et al., 2000). Although a substantial number of studies have investigated the effects of different silvicultural systems on forest birds, most of these studies were short duration, only examining bird responses immediately after harvest or for periods of < 5 years after harvest. Few studies have examined long-term (> 10 years) responses of forest birds after harvest. Long-term studies can provide information that is lacking in short-term studies, such as how long species utilize or are extirpated from a forest stand after harvest.

The Ouachita National Forest is consistently among the top 5 national forests in annual timber output in the U.S. (U.S. Forest Service, 2017) and managers need information on how forest harvesting affects forest birds, especially those associated with mature forests. Our goal was to determine the long-term (16 years after harvest) responses of mature-forest species to different regeneration methods in shortleaf pine (*Pinus echinata*)-dominated stands to determine which methods positively or negatively affected birds known to require mature trees or mature forests. This study represents one of the longest duration studies of forest bird responses to timber harvest in the eastern U.S. We modeled responses of 18 bird species associated with mature forests or mature trees (Table 1) to 4 regeneration methods; one method (clearcut) that removed most overstory trees, and 3 methods (shelterwood, group selection, and single-tree selection) that removed only a portion of the mature overstory. We also compared bird responses in these treated stands to untreated mature forest stands. We hypothesized that detections of most species associated with mature trees would be similar or increase after partial harvests (single-tree selection, group selection, and shelterwood), and all would decrease after clearcutting. We also predicted some species such as ovenbird (*Seiurus aurocapilla*) and scarlet tanager (*Piranga olivacea*), would decrease or disappear in stands subjected to intensive regeneration method such as clearcut.

2. Methods

2.1. Study areas

We conducted the study in the Ouachita Mountains of west-central Arkansas and east-central Oklahoma, within the Ouachita National Forest and Magazine District of the Ozark-St. Francis National Forests. The Ouachita Mountains extend from central Arkansas into east-central Oklahoma. Elevations in the region range from 100 to 800 m; mean annual precipitation ranges from 112 to 142 cm; mean annual temperature ranges from 16.0 to 17.0 °C; and the growing season is 200–240 days (McNab and Avers, 1994).

We selected 20 second-growth, mixed pine-hardwood stands, grouped into 4 geographic blocks (5 stands/block; Baker, 1994). Prior to harvest, stands had little management history other than fire suppression. These stands developed after most of the region was heavily logged in the early 1900s (Smith, 1986). Each stand was > 70 years, > 14 ha, and located on southerly aspects with slopes generally < 20%. As a group, stands were dominated by shortleaf pine (*Pinus echinata*), but also contained numerous hardwood species including post oak (*Quercus stellata*), white oak (*Q. alba*), sweetgum (*Liquidambar styraciflua*), and hickories (*Carya* spp.). Prior to harvesting, there were no statistical differences among stands in total pine and hardwood BA or any other habitat variable measured when grouped by future treatment (Thill et al., 1994).

2.2. Treatments

We randomly assigned 1 of 5 treatments to each stand within each of the 4 geographic blocks (north, south, east, and west); thus, each treatment was replicated 4 times in a randomized complete-block design (Fig. 1). Each block contained 4 regeneration methods, plus an unharvested control. Harvesting was conducted between late May and mid-September 1993; site preparation occurred the following winter.

Four regeneration methods were implemented; single-tree selection, group selection, shelterwood, and clearcut. Clearcuts were planted with shortleaf pine seedlings, but all other methods relied on natural regeneration. Clearcut treatments were modified to retain scattered overstory hardwoods with 0.5–1.1 m^2/ha of basal area (BA) and snags were created (mean density of 24.8 ± 1.4 snags/ha, Perry and Thill, 2013b) by injecting non-merchantable trees with herbicide. Shelterwoods retained 49–99 overstory pines and hardwoods per hectare with retained BAs of 6.9–9.2 m^2/ha pine; all other trees were felled or removed. Group selections had all pines and most hardwoods removed in openings (0.04–1.9 ha in size) with openings constituting 6–14% of the stand area. Pines within the matrix surrounding the openings were thinned and openings retained 1.1–2.3 m^2/ha of BA in hardwoods. Single-tree selection stands had some overstory pines and hardwoods removed uniformly throughout the stand, with target retained pine BA of 10.3–14.9 m^2/ha and hardwood BA of 1.1–4.6 m^2/ha. Most midstory trees (< 15 cm dbh) were felled in shelterwood, single-tree selection, and openings of group-selection stands. Unharvested buffer strips, or greenbelts (also commonly referred to as stringers, or inclusions), were established for water-quality protection at 15 m on each side of stream drains (30-m total width) in most stands, including clearcuts. Total percentage retained in each stand as greenbelt was 4–20% (mean = 10.9%) across all 16 harvested stands. For more specific details on each harvest treatment, see Perry and Thill (2013a).

2.3. Bird surveys

We established 5 permanent bird sampling plots in each stand prior to harvest. Plots were > 150 m apart and ≥ 90 m from stand boundaries based on limitations in the size of our stands. We used 10-min, 40-m-radius point counts, centered on each plot to survey breeding birds. We sampled each plot three times in 1992 (one year before harvest), 1993 (year of harvest), and 1994 (1 year after harvest); six times in 1996 (3 years after harvest), 1998 (5 years after harvest), 2001 (8 years after harvest), and 2005 (12 years after harvest); and five times in 2009 (16 years after harvest). Survey effort was increased in each stand in 1996 to reduce potential variability in detection and only 5 surveys were conducted in each stand in 2009 due to scheduling conflicts. Surveys in 1993 were conducted approximately one month prior to harvesting. We conducted surveys between May 3 and June 12 to

Table 1
Bird species associated with mature forests or mature trees and total number of detections for each species modeled for effects of timber harvest on birds over time in the Ouachita Mountains of Arkansas and Oklahoma, 1992–2009.

Species	Scientific name	Total detections
Black-and-white warbler	*Mniotilta varia*	846
Blue-gray gnatcatcher	*Polioptila caerulea*	386
Carolina chickadee	*Poecile carolinensis*	338
Downy woodpecker	*Dryobates pubescens*	82
Eastern wood-pewee	*Contopus virens*	158
Great crested flycatcher	*Myiarchus crinitus*	187
Ovenbird	*Seiurus aurocapilla*	281
Northern flicker	*Colaptes auratus*	47
Pine warbler	*Setophaga pinus*	2415
Pileated woodpecker	*Dryocopus pileatus*	217
Red-eyed vireo	*Vireo olivaceus*	1223
Scarlet tanager	*Piranga olivacea*	155
Summer tanager	*Piranga rubra*	522
Tufted titmouse	*Baeolophus bicolor*	327
White-breasted nuthatch	*Sitta carolinensis*	99
Worm-eating warbler	*Helmitheros vermivorum*	54
Yellow-billed cuckoo	*Coccyzus americanus*	83
Yellow-throated vireo	*Vireo flavifrons*	70

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