Influence of Clearcut Age on Avian Species Composition, Abundance, and Reproductive Success

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Abstract: Clearcutting has been reduced in frequency in national forests of Arkansas. This will affect populations of birds that require early successional forest habitat. I studied avian distribution, abundance, and reproductive success in young (i.e., 7 to 10 years post-harvest) and old (i.e., 17 to 19 years post-harvest) forest clearcuts from 1993 to 1995. The number of species was greater in young than old clearcuts, with abundance of 5 species, white-eyed vireo (*Vireo griseus*), common yellowthroat (*Geothlypis trichas*), prairie warbler (*Dendroica discolor*), yellow-breasted chat (*Icteria virens*), and indigo bunting (*Passerina cyanea*) higher in young clearcuts. No difference in fledging success was detected between young and old clearcuts for any species; however, the ratio of hatching-year to after hatching-year birds captured in mist-nets was lower in older clearcuts for every species studied. Given the documented peaks in numbers of species and population size for early successional birds, maintaining habitat structure similar to that found on young clearcuts 7 to 10 years after site preparation is recommended to sustain early successional species in forests in Arkansas.

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Breeding bird censuses reveal population declines for several species of neotropical migrant birds (NMB's) that require early successional habitat (James et al. 1992, Hunter et al. 1993, Robbins et al. 1993). Some of these population declines are associated with changes in regional availability of early serial stages in forests (Witham and Hunter 1992). Before European colonization, succession was initiated in extensive forests by fire, insect outbreaks, and climatic events (Rotenberry et al. 1993). Now, natural disturbances are supplanted by timber harvesting as the major source of early successional habitats on forest lands. Because fire and insect outbreaks are controlled to the extent possible on national forests of the southeastern United States, acreage in shrubby habitats will be reduced if the frequency of clearcutting decreases. These successional changes in vegetation will exacerbate regional declines in species of NMB's that require shrubby habitats.

In this paper I present data on productivity and abundance of birds in young

(7 to 10 years post-harvest), and old (17 to 19 years post-harvest) sapling-stage clearcuts. Two objectives of my investigation were: 1) to compare species of young and old clearcuts and, 2) to examine the effect of time since cutting on abundance and reproductive success of birds.

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Methods

Avian species composition, abundance, and reproductive success were studied in 8 young (7–10 years post-harvest) and 4 old (17–19 years post-harvest) sapling-stage clearcuts. All of the clearcuts were located in the Winona District of the Ouachita National Forest in central Arkansas. Vegetation of the sites was typical of pine regeneration areas of the region. Shortleaf pines (*Pinus echinata*) were mixed with stump-sprouts and seedlings from a variety of oaks (*Quercus* spp.), hickories (*Carya* spp.), maples (*Acer* spp.), elms (*Ulmus* spp.), and gums (*Nyssa* spp. and *Liquidambar* spp.). The understory was composed of various shrubs including sumac (*Rhus* spp.), hawthorne (*Crataegus* spp.), and vines including blackberry (*Rubus* spp.) and greenbriar (*Smilax* spp.). The understory was less-well developed in the older cuts. At the end of the study, trees on the younger cuts averaged 5.5 m tall (average dbh = 8.8 cm, basal area 1.6 m^2/ha) and trees on the older cuts averaged 9.1 m tall (average dbh = 13.8 cm, basal area 3.2 m^2/ha). The 8 young clearcuts averaged 163 ha in size, while the 4 old clearcuts averaged 185 ha.

I used 3 methods to achieve my objectives: 1) birds were censused to determine avian species composition and abundance, 2) nests were located and monitored to determine reproductive success and further evaluate avian species composition, and 3) birds were captured in mist-nets and banded to obtain an index of productivity and further evaluate species composition in young and old sapling-stage clearcuts.

Censuses were conducted at 5–6 points (150-m inter-point distance, with points ≥50 m from the nearest edge) in each clearcut. Forty-one points were located in young clearcuts and 22 points were located in old clearcuts. During censuses, all birds detected during a 5-minute period in an area extending 40 m around each point were recorded. Each cut was censused once a year between 14 May and 15 June. In general, censuses of young and old cuts were alternated to avoid any seasonal biases. I used a Kruskal-Wallis non-parametric analysis of variance to compare the mean number of individuals of each species detected per point.

Nests were located and monitored between 15 June and 14 July of each year. Once located, nests were checked every 2–5 days until birds were about to fledge, at which time nests were checked every day. Due to the difficulty in locating recently fledged birds in clearcuts, I classified as successful any nest in which ≥1 young developed to the stage at which they would have left the nest if approached by a predator (Martin 1993). This represents a potential overestimation in fledging success among the habitats; however, the bias is equally distributed among all of the sites. Abandoned nests were not used in analyses because human disturbance associated with monitoring the nests may have caused nest desertion.

Birds were captured in mist-nests between 15 June and 15 July of each year. Two older clearcuts and 3 to 4 younger clearcuts were netted each year. Captured birds were banded with an individually-marked aluminum leg band, and, to the extent possible, aged based on criteria in Pyle et al. (1987). I calculated ratios of hatching-year (HY: young of the year) to after hatching-year (AHY: birds born in a previous year). The ratio of HY/AHY is an index of productivity and represents an estimate of the number of young produced per adult in the habitat (DeSante 1992). Chi-square statistical comparisons were used to evaluate differences in HY/AHY ratios between habitats.

Species use of young and old sapling-stage clearcuts was evaluated by comparing all species censused and netted within each clearcut age-class. A potential bias results from unequal sampling of the cuts, as young cuts were sampled more intensively. I partitioned the data to reduce this bias by comparing species composition of cuts that were 7 years old in 1993 to the old cuts (i.e., 20 vs. 22 census points).

Results

Species Composition Among Habitat Classes. Combined data from censuses and mist-netting indicate that 50 species used the younger clearcuts and 29 species used older clearcuts (Table 1). This decrease in number of avian species as clearcuts age from 7 to 19 years reflects a real process of species turn-over; however, as mentioned above, my estimates of species compositions are slightly biased due to unequal sampling among age classes. Comparison of the numbers of species detected in the 4 youngest cuts sampled ($N = 48$) to the 4 old cuts ($N = 29$) were not biased, however.

Nests of 17 species were found in young clearcuts, compared to nests of 8 species in old cuts. The wild turkey (*Meleagris gallopavo*) was the only species whose nest was found only in older cuts (Table 2); thus, the nesting community of the old clearcuts appears to be an abbreviated version of the community in younger sapling-stage cuts.

Influence of Habitat Age on Population Size of Birds. Five species of early successional birds were significantly more common in young versus old clearcuts. Prairie warblers and common yellowthroats were abundant in young sapling-stage clearcuts and absent or nearly absent from older cuts (Table 3). Yellow-breasted chats were significantly more common in young cuts than older cuts (Table 3). Chats were not found in the 19-year-old cuts, but nested in cuts that were 17 years old. White-eyed vireos and indigo buntings were fairly common breeders in both young and old cuts; however, both species were significantly more common in sapling-stage cuts (Table 3).

Presumably, older clearcuts supported larger populations when they were younger, but when does avian abundance decline? Statistical comparisons among years indicate that as cuts age from 7–10 years, avian populations remain stable (Table 3), suggesting that abundance does not decline until after 10 years of regeneration.

Table 1. Species recorded among different age-classes and types of cuts. ** designates species that were recorded during a census, and *nn* designates species that were recorded only in mist-nets. Total species represents the total number of different species detected in a cut (the number in parentheses represents the number detected only in mist-net samples).

Species	Young	Old	Both
Broad-winged hawk (*Buteo platypterus*)	—	**	
Red-shouldered hawk (*Buteo lineatus*)	**	**	**
Ruby-throated hummingbird (*Archilochus colubris*)	**	**	**
Pileated woodpecker (*Dryocopus pileatus*)	**	**	**
Red-bellied woodpecker (*Melanerpes carolinus*)	nn	**	
Red-headed woodpecker (*Melanerpes erythrocephalus*)	**	—	
Downy woodpecker (*Picoides pubescens*)	**	—	
Wild turkey (*Meleagris gallopavo*)	—	**	
Northern bobwhite quail (*Colinus virginianus*)	**	**	**
Mourning dove (*Zenaida macroura*)	**	—	
Yellow-billed cuckoo (*Coccyzus americanus*)	**	**	**
Eastern kingbird (*Tyrannus tyrannus*)	**	—	
Eastern phoebe (*Sayornis phoebe*)	nn	—	
Great-crested flycatcher (*Myiarchus crinitus*)	**	**	**
Acadian flycatcher (*Empidonax virescens*)	nn	—	
Least flycatcher (*Empidonax minimus*)	nn	—	
Eastern wood pewee (*Contopus virens*)	**	**	**
Olive-sided flycatcher (*Contopus borealis*)	**	—	
Barn swallow (*Hirundo rustica*)	**	—	
Purple martin (*Progne subis*)	**	—	
Blue jay (*Cyanocitta cristata*)	**	**	**
Carolina chickadee (*Parus carolinensis*)	**	**	**
Tufted titmouse (*Parus bicolor*)	**	**	**
Brown-headed nuthatch (*Sitta pusilla*)	**	—	
Carolina wren (*Thryothorus ludovicianus*)	**	**	**
Northern mockingbird (*Mimus polyglottos*)	**	—	
Brown thrasher (*Toxostoma refum*)	**	nn	
Wood thrush (*Hylocichla mustelina*)	nn	nn	**
Eastern bluebird (*Sialia sialis*)	**	—	
Blue-gray gnatcatcher (*Polioptila caerulea*)	**	**	**
White-eyed vireo (*Vireo griseus*)	**	**	**
Red-Eyed vireo (*Vireo olivaceus*)	**	**	**
Yellow-throated vireo (*Vireo flavifrons*)	**	—	
Black-and-white warbler (*Mniotilta varia*)	**	**	**
Worm-eating warbler (*Helmitheros vermivorus*)	nn	—	
Tennessee warbler (*Vermivora perigrina*)	**	—	
Pine warbler (*Dendroica pinus*)	**	**	**
Prairie warbler (*Dendroica discolor*)	**	—	
Ovenbird (*Seiurus aurocapillus*)	nn	**	
Yellow-breasted chat (*Icteria virens*)	**	**	**
Common yellowthroat (*Geothlypis trichas*)	**	—	
Kentucky warbler (*Oporornis formosus*)	**	**	**
Hooded warbler (*Wilsonia pusilla*)	**	—	
Brown-headed cowbird (*Molothrus ater*)	**	**	**
Orchard oriole (*Icterus spurius*)	**	—	
Scarlet tanager (*Piranga olivacea*)	**	**	**
Sumer tanager (*Piranga rubra*)	**	**	**
Northern cardinal (*Cardinalis cardinalis*)	**	**	**
Blue grosbeak (*Guiraca caerulea*)	**	**	**
Indigo bunting (*Passerina cyanea*)	**	**	**
American goldfinch (*Carduelis tristis*)	**	—	
Rufus-sided towhee (*Pipilo erythropthalmus*)	**	—	
Field sparrow (*Spizella pusilla*)	**		
Total species	48 (7)	29 (2)	19 (0)

Table 2. Number of successful (numerator) and unsuccessful (denominator) nests for each species.

Species	Young	Old
Whip-poor will	1/2	1/2
Red-headed woodpecker	?/2	
Wild turkey	—	0/1
Yellow-billed cuckoo	4/6	0/1
Eastern kingbird	?/1	
Carolina wren	1/1	0/1
Brown thrasher	0/1	
Blue-gray gnatcatcher	2/2	
White-eyed vireo	4/13	2/3
Prairie warbler	4/9	
Common yellowthroat	0/4	
Yellow-breasted chat	22/50	0/1
Kentucky warbler	1/1	
Orchard oriole	?/2	
Northern cardinal	1/3	0/1
Blue grosbeak	0/1	
Indigo bunting	6/22	4/7
Field sparrow	0/2	

Influences of Habitat Age on Reproductive Success. Nests of 7 species were located in both young and old clearcuts (Table 2); however, the small sample of nests located in clearcuts prevents valid statistical comparisons. Examination of the data indicates that several species are capable of reproduction in both young and old clearcuts (Table 2).

Comparisons of HY/AHY ratios between young and old sapling-stage cuts yielded significant relationships for northern cardinals (*Cardinalis cardinalis*) and indigo buntings (Table 4). Both species were significantly more productive in the younger clearcuts. Regardless, most species were statistically uniform in productivity for young and old sapling-stage clearcuts (Table 4).

Table 3. Abundance [mean number per point (S.E.)] and statistical comparisons of census data for each species between age-classes of clearcuts (years pooled). X^2 = Kruskal-Wallis statistic.

	Clearcut age-class				
Species	Young	Old	X^2	N	P
Yellow-breasted chat	0.92 (0.09)	0.06 (0.03)	22.37	36	>0.0001
Common yellowthroat	0.35 (0.08)	0.02 (0.02)	11.67	36	0.0006
Prairie warbler	0.54 (0.07)	0.0 (0.0)	20.91	36	>0.0001
White-eyed vireo	0.54 (0.07)	0.28 (0.11)	4.37	36	0.0364
Indigo bunting	0.57 (0.08)	0.21 (0.07)	7.05	36	0.0079

Table 4. HY-AHY ratios of selected species (actual sample in parentheses) and results of Chi-square comparisons between young and old clearcuts.

	Clearcut Age-class					
Species	Young	Old	χ^2	*N*	df	*P*
Carolina wren	1.22 (22/18)	2.40 (12/5)	1.20	49	1	0.2720
White-eyed vireo	0.51 (24/47)	0.52 (10/19)	0.02	100	1	0.8760
Yellow breasted chat	0.18 (29/161)	0.14 (1/7)	0.04	198	1	0.8309
Prairie warbler	0.96 (24/25)	0.00 (0/0)	0.00	00	0	0.0000
Kentucky warbler	0.60 (12/20)	0.91 (10/11)	0.53	53	1	0.4646
Indigo bunting	0.27 (13/47)	0.00 (0/14)	3.67	74	1	0.0550
Northern cardinal	0.92 (12/13)	0.18 (2/11)	6.73	38	1	0.0345

Discussion

Influence of Clearcut Age on Avian Abundance. I found a decrease in species number and abundance between young and old clearcuts as did Conner and Adkisson (1975) and Childers et al. (1986). Other investigators have found similar species composition and numbers of species between young and old clearcuts (Nobel and Hamilton 1976, Dickson and Segelquist 1979, Dickson et al. 1993). The dissimilarity may be due to variation in vegetative characteristics among studies. For instance, canopy development, tree height, average dbh, and extent of shrubs in the understory influence species composition within clearcuts (Titterington et al. 1979, Crawford et al. 1981, Niemi and Hanowski 1984). If successional changes in vegetation are delayed as would be expected in areas of poor site-quality or short growing seasons, then avian population responses would also be delayed.

The pattern of individual species response to clearcut age also varies among studies. For example, red-eyed vireos (*Vireo olivaceus*) were located in every young and old clearcut censused in this study. Niemi and Hanowski (1984) and Degraaf (1991) also found red-eyed vireos present in young and old clearcuts. In contrast, Conner and Adkisson (1975), Noble and Hamilton (1976), Dickson and Segelquist (1979), Childers et al. (1986), and Yahner (1987) found that red-eyed vireos were either absent from young clearcuts or absent from both young and old clearcuts.

Influence of Clearcut Age on Reproductive Effort. Reproduction and survival are critical components of habitat suitability (Van Horne 1983, Kellner et al. 1992, Martin 1992); therefore, I consider habitat in which species do not attempt to breed to be unsuitable. Several species were commonly observed in clearcuts, but showed no signs of nesting. Unfortunately, locating nests is often difficult, and nests of some species may have escaped detection. For instance, only 1 Kentucky warbler (*Oporornis formosus*) nest was located, in a young clearcut; Distraction displays of adult warblers, and captures of recently fledged young in mist-nets, imply that Kentucky warblers nested in several young and old clearcuts. Species that nest in the tops of trees could have escaped detection in older cuts because of the tall canopy. For example, observations of adult pine warblers (*Dendroica pinus*), feeding young in an old clearcut, indicate breeding. Nevertheless, no evidence of breeding was documented for many species that were commonly observed in both young and old clearcuts. If red-eyed vireos or black-and-white warblers (*Mniotilta varia*) commonly nested in young or old clearcuts, nest-building behavior or family groups containing recently fledged young should have been observed.

Species that were encountered infrequently and primarily in mist-net samples probably did not breed in the clearcuts. Such species were either never heard singing on a clearcut (e.g., wood thrushes (*Hylocichla mustelina*) and ovenbirds (*Seiurus aurocapillus*) in young clearcuts), or heard very infrequently (e.g., hooded warblers (*Wilsonia pusilla*) heard in 1 young clearcut during 1995). Because singing is a means of attracting a mate (Welty 1975), species encountered only in mist-nets probably did not nest in clearcuts. Consequently, clearcuts are probably not suitable habitat for many of the species found in them.

Why do some species occupy clearcuts without attempting to breed? As succession proceeds, avian species will occupy a particular site several years before attempting to breed (Krementz and Sauer 1982) because resources necessary for survival may become available before all of the resources necessary for breeding are present. For instance, pine warblers were commonly observed foraging in young and old clearcuts; however, they probably bred only in the old clearcuts as indicated by observations of adults feeding recently fledged young. The resource missing in young clearcuts for pine warblers is probably tall trees for nesting (Harrison 1984). For other species, suitability of clearcuts for foraging may extend beyond the successional stage where resources for breeding are available. For instance, common yellowthroats, were infrequently recorded in older cuts and probably did not attempt breeding at those sites.

Successful breeding is a necessary requirement of habitat suitability (Kellner et al. 1992, Van Horne 1983), but what sort of nesting success would be required to support a viable population? That question cannot be answered based on this study because I have no estimates of adult and post-fledging survival. Several species had HY/AHY ratios of approximately 1 (i.e., 1 young of the year per adult in the population), which might be adequate reproduction given sufficient overwinter survival. Consistently low HY/AHY ratios indicate that yellow-breasted chats and indigo buntings do not maintain self-sustaining populations in clearcuts; however, the ratio may be biased by non-breeding floaters in the population (Nur and Geupel 1993) or unequal capture probabilities between adults and young (Remsen and Good 1996). Among-species comparison of the frequency of young in mist-nets versus the abundance index of censused adults, indicates that chats and buntings reproduce less successfully than other species; thus, chats and buntings may not reproduce particularly well in clearcuts.

How Does Age of a Clearcut Influence Habitat Quality? Habitat suitability is best described as a binomial variable, based on a habitat's ability to maintain a viable population (Kellner et al. 1992); with suitable habitats sustaining viable populations and unsuitable habitats not sustaining viable populations. In contrast, habitat quality is a continuous variable that should be measured in terms of a habitat's contribution to the fitness of individual birds (Kellner et al. 1992). Because fitness is correlated with lifetime reproductive success (Newton 1989), habitat-associated differences in reproductive success should correlate with habitat-associated differences in fitness.

My results and results of Yahner (1991) indicate that reproductive success for most species of birds nesting in young and old clearcuts was similar; thus, habitat quality of young and old clearcuts was equal. However, avian abundance was significantly smaller on older cuts. Therefore, older cuts would require larger areas of habitat to support minimum critical population sizes necessary for species persistence (Primack 1993). In short, my results indicate that viable populations of avian species that require early successional habitats could be maintained more easily on sapling-stage clearcuts of a given size than older clearcuts.

Conclusions. Important findings of my study are: 1) 7- to 10-year-old clearcuts in central Arkansas support more species than 17- to 19-year-old cuts, 2) reproductive success of most avian species was similar on young and old clearcuts, 3) clearcuts provide breeding habitat for white-eyed vireos and indigo buntings for up to 19 years post-harvest; however, chats and yellowthroats were essentially absent by 19 years post-harvest and prairie warblers were eliminated between 10 to 17 years after cutting. Based on my findings, management procedures to maintain early successional species should focus on providing young sapling-stage as breeding habitat.

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