SEASONAL AVIFAUNA RESPONSES TO FUEL REDUCTION TREATMENTS IN THE UPPER PIEDMONT OF SOUTH CAROLINA: RESULTS FROM PHASE 1 OF THE NATIONAL FIRE AND FIRE SURROGATE STUDY

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Abstract—We examined avian species and assemblage responses to prescribed burns and thinning in a southeastern Piedmont pine and mixed pine-hardwood forest as part of the National Fire and Fire Surrogate Study (NFFS) examining the effects of fuel reduction on forest health. Point counts conducted during the non-breeding and breeding seasons of 2000-2002 showed that winter bird species abundance and evenness (J') did not change significantly between pre- and posttreatment winter surveys. However, bird species richness increased significantly between years. No differences were found between treatments for species abundance, richness, or evenness during the breeding season. However, foliage-gleaning and canopy-nesting breeding species were detected significantly more often in thinned than burned or control sites. Nest searches and monitoring found 79 nests (thin, n = 30; burn, n = 27; control, n = 22) with a 49-percent failure rate over the 2-year period. Most of these failures (41 percent) occurred in thinned stands.

INTRODUCTION

Fire exclusion and suppression have historically been accepted as appropriate means of managing forests in the United States (Johnson and Hale 2000). As a result of these long-held philosophies, fuel loads in many U.S. forests have reached excessive proportions that increase the probability of catastrophic wildfire in many regions. The use of prescribed fire has grown slowly in popularity since World War II as a management tool to reduce fuel loads (Johnson and Hale 2000). However, due to logistical constraints that may preclude or delay burning programs (i.e., climate or smoke abatement issues), other management alternatives, such as the mechanical removal of understory and diseased or insect-infected trees, which also reduce fuel loads in forests, are needed. Thinning may mimic prescribed fire in its reduction of fuel loads by physically removing flammable materials from forested areas. However, the ecological, economic, and social impacts of using one fuel reduction technique over the other are not fully understood. To facilitate a better understanding of how such practices might affect the aforementioned impacts, the USDI-USDA Joint Fire Science Program initiated a national study to research the consequences of prescribed fire and alternative "fire-surrogate" methods, such as thinning, on fuel and fire behavior, vegetation, wildlife, entomology, pathology, soils, utilization and economics, and social science (Fire and Fire Surrogate 2000). The Clemson Experimental Forest in Clemson, SC, along with 12 other study sites nationwide, was selected to participate in the National Fire and Fire Surrogate Study (NFFS). The primary objective of the wildlife component of the NFFS is to assess the impacts that fuel reduction has on small mammal, herpetafauna, and avian communities.

There is a dearth of information regarding the impacts of prescribed fire and fuel reduction on wildlife and their habitats even though many prescribed burns are applied with the intent of benefiting various wildlife species. In the southeastern landscape, many wildlife species, including various passerines, have evolved in habitats mediated by wild and human-induced fires (Brennan and others 1998, Johnson and Hale 2000, Landers 1987). The relationships between passerines and fire management are particularly important since passerines comprise a vital ecological component in southeastern forests. In particular, early successional species, or those requiring open woodlands, may be affected by forest management activities using prescribed fire. Forest management plans and activities must consider biodiversity; therefore, it is critical that we gain a better understanding of the relationships between prescribed fire, thinning, and songbird communities in forested habitats.

METHODOLOGY

Study Area

Nine study sites were selected within the Clemson Experimental Forest (CEF) in the Upper Piedmont of South Carolina. The CEF comprises 7,100 ha of reclaimed agriculture land within three South Carolina counties, Anderson, Oconee, and Pickens. This forest exists in a nearly contiguous block and is dissected only by the city of Clemson and lakes Hartwell and Issaqueena. The CEF's northern parcel resides within the Lower Foothills of the Piedmont Foothills region, which have clayey soils that are moderately deep to thin and well-drained (Meyers and others 1986). The southern portion of the CEF is located in the Interior Plateau of the Midlands Plateau region, and the soils are usually relatively thin and composed mostly of clay (Meyers and others 1986). The nine sites selected for this study are composed mainly of naturally regenerated and planted pine stands. Dominant coniferous species include loblolly (*Pinus taeda*), shortleaf (*P. echinata*), and Virginia (*P. virginiana*) pines (Radford and others 1968).

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The hardwood component, existing as co-dominants or as the under- and mid-story, is comprised of various oak species (i.e. *Quercus nigra*, *Q. falcata*, *Q. coccina*, *Q. alba*, *Q. stellata*), sweetgum (*Liquidambar styrraciflua*), tulip popular (*Liridendron tulipefera*), holly (*Ilex opaca*), persimmon (*Diospyros virginiana*), and blackgum (*Nyssa sylvatica*)(Radford and others 1968).

Study Sites

Based upon National Fire and Fire Surrogate protocol (Fire and Fire Surrogate 2000), sites were selected based on size, stand age, and management history. Each site was a minimum of 14 ha and comprised of a 10-ha sample area with a buffer of approximately 20 m. The sites were also judged to be in danger of uncharacteristically severe wildfire due to heavy fuel loads. None of the sites had been thinned during the last 10 years or burned (wild or prescribed) in at least 5 years. Stand ages varied from 15 to 60 years so age was used as a blocking factor to reduce variability. Within each block, three treatments—prescribe fire, thinning, or untreated control—were randomly assigned.

Treatments

Prescribed fires were applied to three study sites during early April 2001. Spot, flanking, backing, and strip head fires were set depending on site characteristics. Fire prescriptions were intended to kill a few overstory trees. Flame heights generally ranged from 0.5 to 2 m but reached 3 to 4 m in spots where fuel loading was high. Thinning occurred on three of the study sites between the months of December 2000 and February 2001. A target basal area of 18 m^2 per ha was determined sufficient to reduce the chance of severe wildfire occurring.

Avian Sampling

Non-breeding birds were censused between November 15 and January 15 of 2000 and 2001, and breeding birds were censused between April 15 and June 15 of 2001 and 2002 using a 50-m fixed radius point count method (Ralph and others 1993). Approximately three to four point-count stations were established in each of the nine study sites with a minimum of 200 m between each point and at least 100 m from the treatment boundary. Points were visited between sunrise and 1100 EST on days with no precipitation and minimal wind velocity (< 20 kph) (Ralph and others 1993). The duration of each point count was 10 minutes in which every bird heard or seen within a 50-m radius was recorded. Each point was visited twice in the winter and three times in the spring during each census period. Point-count stations and treatment areas were randomly visited and then rotated for subsequent counts to minimize within season temporal bias. Birds flying through the stands or over the canopy were not included in the analysis.

Monitoring natural nests can help determine the breeding productivity (quality) of a particular habitat unlike counts of bird densities within the same habitat (Van Horne 1983). Nest searching and monitoring took place on the nine study sites from the first week in April until the first week of July of 2001 and 2002. Sites were systematically searched for "high" activity (i.e., carrying nest material, nest building, or distraction displays) and birds exhibiting parental behaviors (Martin and Geupel 1993). Active nests were monitored every 2 to 3 days to record pertinent data like nesting species, location, nesting stage (building, laying, incubating, and nestling), number of eggs or young, and fate of nest.

Statistical Analysis

Winter and spring bird species abundance, richness (S_1; Margalef 1958), evenness (J'; Pielou 1969), and foraging and nesting guilds (Hamel and others 1982) were statistically analyzed within and between years across all treatments using PROC GLM (SAS 1996). Foraging guild assemblages were categorized as follows: (a) ground-gleaning, (b) foliage-gleaning, (c) bark-gleaning, (d) hawking, and (e) carnivore. Categorization of nesting strategies was as follows: (1) ground/shrub, (2) canopy, and (3) cavity. These guild assemblages represent important life-history traits that clarify habitat utilization for nonbreeding and breeding birds. The most abundant winter and spring species were categorized by mean-count frequency (PROC FREQ) and chi-square analysis (SAS 1996). Nest success, or survivability, was determined by the percentage of nests fledged or failed in each treatment type. To evaluate significant differences between fate of nests and treatments, PROC FREQ and chi-square analysis were used. Differences were significant at the 0.10 level.

RESULTS

Winter Birds

A total of 39 species and 1,399 individuals was detected during the winter point counts in 2000 and 2001. Winter bird species abundance was not significantly different across treatments in either 2000 or 2001 or between winters. Significant differences were detected across treatments for bird species richness ($p = 0.0955$) and bird species evenness ($p = 0.0344$) in the pretreatment winter of 2000 but not in the post treatment winter of 2001. Between year differences were detected for bird species richness ($p = 0.0231$) (table 1). Among foraging guilds in 2000 or 2001, bark-gleaners were significantly more abundant ($p = 0.0510$) in the thinned stands. Golden-crowned kinglet (*Regulus satrapa*), ruby-crowned kinglet (*Regulus calendula*), Carolina chickadee (*Poecile carolinensis*), eastern tufted titmouse (*Baeolophus bicolor*), American crow (*Corvus brachyrhynchos*), pine warbler (*Dendroica pinus*), and Carolina wren (*Thryothorus ludovicianus*)

Table 1—Comparison of mean avian species richness (S_1) between pre- and post-treatment winters at the Fire and Fire Surrogate study sites, Clemson, SC

	Burn	Control	Thin
Pre-treatment	6.46b	7.66a	5.60b
Post-treatment	10.10a	8.13a	9.26a

Values with different letters down columns are significantly different ($p \leq 0.10$)

(Sibley 2000) were the most abundant species detected during the winter. Golden-crowned kinglet abundance was significantly lower after treatment application (p = 0.0003) while Carolina wren (p = 0.0028) and pine warbler (p = ≤ 0.0001) abundance increased significantly (fig. 1).

Breeding Birds

During the spring point counts of 2001 and 2002, 2,746 individuals representing 61 species were detected. No significant differences were detected for breeding bird abundance, richness, or evenness across treatments within 2001 or 2002. However, significant differences were detected for bird species abundance (p = 0.0253) and bird species richness (p = 0.0965) between years (table 2). Increases between years were detected for ground-foragers (p = 0.0016) and foliage-gleaners (p = 0.0139). Ground-foragers increased in all of the treatment areas whereas foliage-gleaners increased in the burn and untreated control stands. Canopy-nesters and ground/shrub-nesters increased in abundance between years (p = 0.0559 and p = 0.0032, respectively). Pine warbler, red-eyed vireo (*Vireo olivaceus*), northern cardinal (*Cardinalis cardinalis*), eastern tufted titmouse, and blue jay (*Cyanocitta cristata*) (Sibley 2000) were the most abundant species recorded during the spring point counts. There was no significant increase or decrease of any of these species between the two spring sample periods.

Seventy-nine nests (2001, n = 20; 2002, n = 59) were discovered and monitored. Out of the 79 nests, 44.3 percent were successful in fledging young, 49.3 percent failed due to predation, abandonment, or weather, and 6.4 percent of the nests' fates were undetermined (table 3). The fate of nests was not determined by treatment application for either 2001 or 2002. Cavity-nesters were more successful in completing a nesting attempt than ground/shrub- or canopy-nesters.

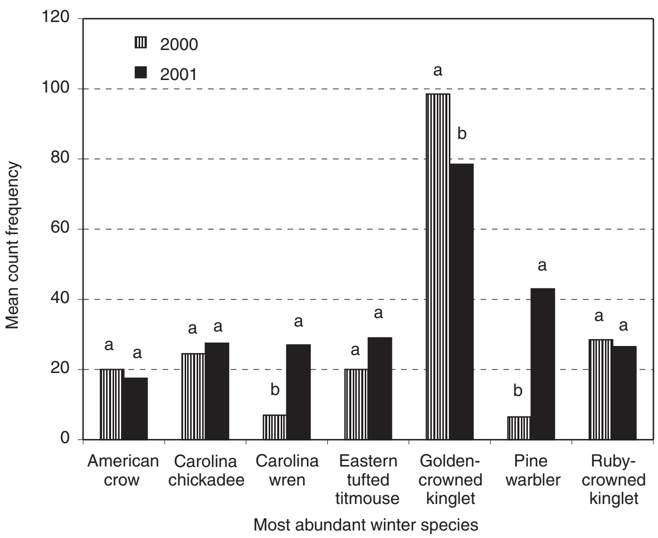

Figure 1—Comparisons between the winter of 2000 and 2001 of the most abundant species detected. Columns with different letters for each species grouping are significantly different (p ≤ 0.10).

Table 2—Comparisons of spring avian species abundance and richness (S_1) means between years at the Fire and Fire Surrogate study sites, Clemson, SC

Treatments	Burn	Control	Thin
Abundance 2001	21.66b	23.66b	25.00a
2002	28.66a	26.66a	25.00a
Richness 2001	10.06b	10.87a	11.18a
2002	12.27a	11.58a	10.56a

Values with different letters down columns are significantly different (p ≤ 0.10)

Table 3—Number of nests and nest survivorship for treatments by year at the Fire and Fire Surrogate study sites, Clemson, SC

Treatment	Successful	Failed	Unknown	Total
		2001		
Burn	0	2	0	2
Control	2	1	1	4
Thin	4	6	4	14
Total nests (%)	6 (30)	9 (45)	5 (25)	20 (100)
		2002		
Burn	14	10	1	25
Control	8	9	1	18
Thin	7	9	0	16
Total nests (%)	29 (49)	28 (48)	2 (3)	59 (100)

CONCLUSIONS

Initial response data on the effects of prescribed fire and thinning as fuel reduction treatments on breeding and winter bird communities showed that the treatments alter aspects of the forest that may favor certain species or assemblages. In the case of winter bird species richness, treatments diversified the forest structure, thereby supporting a broader range of bird species during the winter months. However, these changes may not favor other species. Significantly fewer golden-crown kinglets were recorded in the winter of 2001 after treatment applications. Golden-crowned kinglets breeding densities have been observed to decrease in burned or logged areas or habitats with open canopies (Ingold and Galati 1997). Carolina wren abundance increased significantly during the winter of 2001. This change may be due to an increase in coarse woody debris on the thin sites, which offer cover and foraging sites. Pine warbler abundance also increased after treatment application. These increases may be attributable to reductions in understory cover that the species may favor during the nonbreeding season (Rodewald and others 1999). The thin and burn treatments probably attracted more pine warblers because those treatments had reduced understories yet retained a developed overstory pine component.

Breeding bird abundance and richness changed between years, which may be due to the change in vegetation composition over time. The lack of an observable response across treatment types by breeding birds may be due to a number of factors including the limited temporal scope, the study, southern pine beetle (*Dendroctonus frontalis*) (Payne 1980) infestation, landscape context, or a multitude of other variables that were not measured. The application of prescribed fire and thinning increased abundance of certain foraging and nesting guilds like foliage-gleaners and ground/shrub-nesters. Both of these guild types include species that are either neotropical migrants and/or early-successional species. Many species of both assemblages have undergone declines in many regions (Robbins and others 1989).

In terms of songbird productivity, habitat manipulation may enhance the quality and quantity of nesting habitat for many bird species. However, it may also predispose treated habitats to increased predation events (Barber and others 2001, Duguay and others 2000). We found higher rates of nest failures in thinned sites (41 percent) compared to the burned (32 percent) and untreated controls (27 percent). It is possible that most of the nests failed due to predation, as it has been found to account for up to 80 percent of nest losses in other studies (Martin 1992, Martin 1993). However, without additional observations or data (such as remote cameras or predatory species densities), it is difficult to determine fates by nest remains (Lariviere 1999).

Continued research over the next 2 to 3 years is likely to show additional responses by avian species and assemblages to treatment application because vegetation will continue to respond to increased light levels and decreased competition. However, as succession progresses and fuel loads accumulate, the bird community will probably return to pretreatment composition.

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