Site Preparation Influences on Vegetative Composition and Avian and Small Mammal Communities in the South Carolina Upper Coastal Plain

William E. O'Connell[1], *Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602*

Karl V. Miller, *Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602*

Abstract: The composition and diversity of redeveloping plant communities, along with associated small mammal and bird communities, were compared on hexazinone and mechanically-prepared sites at 2, 3, and 5 years post-treatment. Diversity of herbaceous vegetation was higher on the mechanically-prepared sites at 5 years post-treatment, while the diversity of woody vegetation did not differ in any of the age classes. Small mammals were sampled by removal trapping and birds by circular census plots. On the 2-year post-treatment sites, small mammal capture rates were greater on the mechanically-prepared areas than on the hexazinone sites. Capture rates and species composition did not differ between treatments on the 3- and 5-year post-treatment sites. Bird diversity was higher on the hexazinone-prepared sites at 2 and 3 years post-treatment and apparently was related to greater numbers of residual snags. Differences in the abundance of individual bird species were related to habitat structure and were no longer evident in the 5-year post-treatment sites.

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Use of herbicides for site preparation in the southeastern United States is an effective alternative to mechanical methods. Increases in survival and growth of planted pines have been reported with both chemical and mechanical site preparation (Knowe et al. 1985, Zutter et al. 1991, Dougherty 1990), but research on the effects on wildlife has been limited (Miller et al. 1990). Herbicides generally are not toxic to wildlife when applied at label rates (U.S. Dep. Agric. For. Serv. 1986), but their use can result in changes in redeveloping plant com-

[1] Present address: U.S. Forest Service, Southeastern Forest Experiment Station, Dry Branch, GA 31020.

munities. Differences in habitat conditions including abundances of food plants and structural diversity have been documented with various herbicide treatments (Hurst and Blake 1987, Hurst and Palmer 1988, Witt 1991). Mechanical site preparation may result in lowered structural diversity (e.g., snags), but create features such as stumps and windrows favorable to some mammals (Dueser and Shugart 1978).

Few studies have investigated the effects of herbicides on plant species diversity. Blake (1986) and Neary et al. (1990) found lower plant diversity on intensively-treated areas early in succession and that differences compared to less intensively treated areas declined over time. In the second growing season post-treatment, Hurst and Blake (1987) reported that a hexazinone-treated site had more species of legumes, grasses, and vines but fewer other forbs than an untreated site. Zutter and Zedaker (1988) reported decreasing woody plant diversity with increasing hexazinone rates during the first 2 years post-treatment in a loblolly pine (*Pinus taeda*) release treatment.

Changes in vegetation in young pine plantations have been linked to changes in small mammal populations (Perkins 1973, Atkeson and Johnson 1979, Langley and Shure 1980). Small mammal captures were correlated with plants valuable as either food or cover. Structure as well as composition plays an important role in small mammal habitat selection (Dueser and Shugart 1978, Geier and Best 1980, McComb and Rumsey 1982). Alterations in plant species composition and stratification likewise produce changes in bird populations (Balda 1975, White et al. 1976, Webb et al. 1977, Meslow 1978). A variable understory for nesting and foraging is an important aspect of avian habitat (McComb and Rumsey 1983, Morrison and Meslow 1984, Malefyt 1987, McPeek et al. 1987).

We evaluated vegetative communities and compared the abundance and composition of avian and small mammal populations between hexazinone and shear/root raking site preparations at 2, 3, and 5 years post-treatment. We also identified potential components of the vegetation that influenced these populations.

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Methods

Study sites were located within the Sandhills physiographic province, on the 79,292-ha Savannah River Site in Aiken and Barnwell counties, South Carolina. Soils on the study sites were of the Blanton-Lakeland association of excessively drained, infertile, loamy sands (U.S. Dep. Agric. Soil Conserv. Serv. 1990). The study design used 3 replications of 2 treatments in the age classes of 2, 3 and 5 years post-treatment. Sites ranged from 11 to 24 ha. Chemical treatment consisted of a broadcast of Pronone 10G™ (hexazinone) at rates from 1.4 to 2.3 kg a.i./ha. Mechanical treatment included shearing of residuals with a V-blade and windrowing site material with a root rake.

Numbers and species of herbaceous vegetation were recorded in August 1991 in 30 quadrats (0.25-m^2) on each site using a systematic, unaligned, random sampling scheme (Yeates 1974). In March 1992, woody vegetation was examined using the same scheme in thirty 4-m^2 quadrats. A 50-m buffer zone from the boundaries of the site was established and not sampled.

Small mammals were sampled by removal trapping in December 1991. Four parallel transects located 25-m apart were established without regard to ordinal direction. On each transect, 15 traps were set 10-m apart, with composition of traps 40% Museum Special™, 50% Victor™ mice traps, and 10% Victor™ rat traps. Traps were baited with peanut butter and rolled oats. A 50-m buffer zone at the site boundaries was not sampled. Captured animals were identified and donated to the University of Georgia Museum of Natural History.

Birds were censused in spring 1992 on the same sites. Five circular plots with a 25-m radius were censused twice on each of the 18 sites. All censuses occurred within the first 3 hours of daylight on days when wind or rain were not present. Five minutes were spent at each station recording all birds seen or heard within the plot but flyovers were not counted.

Vegetation data, mean captures of mammals, and census totals of birds were compared between treatments using *t*-tests and significance was determined at $P < 0.10$. Vegetative characteristics of potential importance to small mammals (Dueser and Shugart 1978, McComb and Rumsey 1982) were chosen including herbaceous and woody plant richness, abundance of grasses, legumes, other forbs, and all herbaceous vegetation. Comparisons were made by Spearman's correlation between vegetative characteristics and small mammal captures. Bird diversity was correlated to herbaceous richness and diversity, woody richness and diversity, abundance of grasses, legumes, other forbs and all herbaceous vegetation.

Diversity values were compared within years and between treatments. Due to low numbers of individuals and species, small mammals were compared only with the Shannon-Wiener diversity index (H′). Birds were compared using (H′) plus the Shannon evenness (J′) and the Margalef (M) index of species richness.

Additionally, plants of value as northern bobwhite (*Colinus virginianus*) and white-tailed deer (*Odocoileus virginianus*) forage were chosen. These group abundances were compared between treatments and within a respective age class.

Results

On the 2-year post-treatment sites, no differences in the frequency of occurrence were found in the groupings of herbaceous and woody plant species examined (Table 1). Among individual species, the chemically-prepared area had greater abundance ($P < 0.01$) of turkeyfoot (*Andropogon gerardii*), fireweed (*Erechtites hieracifolia*), and rabbit tobacco (*Gnaphalium obtusifolium*), whereas the mechanical treatment had more prickly pear (*Opuntia compressa*). As a group, plants of value as northern bobwhite foods occurred more frequently ($P < 0.10$) in the hexazinone-treated sites at 3 years post-treatment. This group included many of the legumes, panic grasses (*Panicum* spp.), and ragweed (*Ambrosia artemisiifolia*). Vines used as deer forage occurred more frequently in the mechanical sites at both 3 and 5 years post-treatment. There were no differences in the amount of woody deer forage in any of the age classes examined. At 5 years post-treatment, there was no difference in the abundance of the herbaceous groupings. Among individual species, maypops (*Passiflora incarnata*) and yellow jessamine (*Gelsemium sempervirens*) occurred most frequently on the mechanical treatment, whereas skullcap (*Scutellaria integrifolia*), beggarweed (*Desmodium strictum*), and winged sumac (*Rhus copallina*) occurred more frequently on the hexazinone treatment.

Woody species diversity (Shannon index) tended to be higher in the mechanical treatment for all age classes, although differences were not significant. Species richness of woody plants (Margalef index) was similar at all age classes. On the 5-year post-treatment sites, diversity, richness, and evenness of herbaceous vegetation was higher on the mechanical treatments. Similar trends were observed on the 2- and 3-year-old sites, although the differences were not significant.

We captured 60 mammals representing 7 species in 3,240 trapnights. Oldfield mice (*Peromyscus polionotus*) accounted for 70.0% of all captures followed by cotton mice (*P. gossypinus*), 11.6%; least shrews, (*Cryptotis parva*), 6.6%; eastern woodrats (*Neotoma floridana*), 5.0%; cotton rats (*Sigmodon hispidus*), 3.3%; short-tailed shrews (*Blarina carolinensis*), 1.6%; and house mice (*Mus musculus*), 1.6%. Species diversity of captured small mammals was greater on the mechanically-treated sites at 3 years post-treatment, but did not differ between treatments on the 2- or 5-year post-treatment sites (Table 2). Capture rates, by species, did not differ between treatments on any of the age classes (Table 3). Total small mammal captures were higher on the mechanical treatment than in the chemical treatment on 2-year-old sites, but were not different on 3- and 5-year-old sites.

Correlation analyses indicated that cotton mice were weakly associated with areas of high legume abundance ($r = 0.48$, $P = 0.04$). Both cotton rats ($r = 0.53$, $P = 0.02$) and woodrats ($r = 0.69$, $P = 0.001$) were associated with forb abundance other than legumes. Differences in the diversity of small mammal populations were only detected at 3 years post-treatment, when the mechanically-treated sites had higher mammal diversity.

Avian populations were similar between treatments, but certain species were more abundant in some sites. At 2 years post-treatment, brown-headed cowbirds (*Molothrus ater*), eastern bluebirds (*Sialia sialis*), and mourning doves (*Zenaida macroura*) were significantly ($P < 0.10$) more abundant on the hexazi-

Table 1. Abundance and diversity of vegetation on sites 2, 3, and 5 years after a chemical (hexazinone) or mechanical (root rake/windrow) site preparation treatment (N = 3/treatment/year). Abundance values represent mean occurrence of individuals per plot within compositional groupings. Standard errors are represented parenthetically.

Group	2 years post-treatment		3 years post-treatment		5 years post-treatment	
	Hexazinone	Mechanical	Hexazinone	Mechanical	Hexazinone	Mechanical
All herbaceous	32.2(16.1)	17.6 (7.3)	34.7(15.5)	38.4 (8.6)	13.7 (1.3)	15.8 (5.4)
Asters	23.6(15.4)	5.6 (2.6)	28.6(16.5)	16.9 (5.0)	5.6 (1.8)	4.6 (1.3)
Grasses	3.9 (0.6)	3.4 (1.0)	3.2 (0.7)	7.9 (3.0)	3.9 (0.6)	2.9 (0.9)
Legumes	1.0 (0.4)	1.1 (0.1)	0.4 (0.2)	1.2 (0.4)	1.8 (0.7)	0.9 (0.7)
Other forbs	3.6 (2.6)	7.5 (5.7)	2.5 (0.8)	12.3 (5.0)	2.2 (1.1)	7.1 (3.6)
All woody	11.4 (3.5)	8.4 (2.5)	12.4 (4.7)	11.3 (2.5)	14.2 (4.0)	9.9 (1.9)
Vines	2.2 (0.6)	2.6 (0.6)	1.5 (0.2)*	2.9 (0.5)	1.2 (0.5)**	3.3 (0.2)
Wildlife food plants						
Quail foods	2.0 (0.5)	0.7 (0.1)	1.1 (0.2)*	0.5 (0.1)	1.9 (0.3)	0.9 (0.1)
Deer forage-vines	2.0 (0.6)	2.4 (0.6)	1.4 (0.2)*	2.5 (0.4)	1.1 (0.5)*	3.1 (0.2)
Deer forage-woody	1.5 (0.7)	0.9 (0.4)	3.3 (0.7)	1.9 (0.4)	2.9 (1.5)	1.5 (0.9)
Herbaceous diversity						
Shannon index (H')	2.12(0.28)	2.47(0.16)	1.95(0.69)	2.14(0.33)	2.67(0.00)**	3.07(0.03)
Shannon evenness (J')	0.63(0.12)	0.66(0.06)	0.53(0.17)	0.59(0.09)	0.72(0.00)*	0.78(0.03)
Margalef index	4.98(0.88)	6.37(0.28)	5.46(1.15)	6.43(1.25)	6.41(0.15)***	8.04(0.07)
Woody diversity						
Shannon index (H')	1.35(0.25)	1.61(0.11)	1.34(0.44)	1.68(0.22)	1.79(0.53)	2.19(0.19)
Shannon evenness (J')	0.55(0.08)	0.65(0.07)	0.53(0.13)	0.67(0.01)	0.68(0.13)	0.83(0.09)
Margalef index	1.96(0.32)	1.93(0.09)	1.97(0.32)	2.07(0.48)	3.14(1.45)	2.24(0.46)

*Within a year, $0.05 < P < 0.10$.
**Within a year, $0.01 < P < 0.05$.
***Within a year, $P < 0.01$

Table 2. Mean (SE) small mammal and bird diversity on sites 2, 3, and 5 years after a chemical (hexazinone) or mechanical (root rake/windrow) site preparation treatment, Savannah River Site, 1991–92 (N = 3/treatment/year).

Group	Index[a]	Hexazinone	Mechanical
2 years post-treatment			
Small mammal	H′		0.52(0.22)
Bird	H′	2.47(0.08)**	2.15(0.05)
	J′	0.95(0.01)	0.92(0.02)
	M	3.92(0.38)	3.24(0.20)
3 years post-treatment			
Small mammal	H′	0.16(0.16)*	0.79(0.12)
Bird	H′	2.39(0.07)**	2.10(0.03)
	J′	0.92(0.01)	0.92(0.03)
	M	3.80(0.21)	3.03(0.41)
5 years post-treatment			
Small mammal	H′	0.42(0.42)	
Bird	H′	2.04(0.08)	1.91(0.05)
	J′	0.91(0.02)	0.92(0.01)
	M	3.07(0.22)	2.70(0.17)

[a]H′ = Shannon index; J′ = Shannon evenness; M = Margalef index
*Within a row, *$0.05 < P < 0.10$.
**Within a row, $0.01 < P < 0.05$.

Table 3. Mean (SE) small mammal capture per 100 trapnights on sites 2, 3, and 5 years after a chemical (hexazinone) or mechanical (root rake/windrow) site preparation treatment, Savannah River Site, 1991 (N = 3/treatment/year).

	Species[a]							
	OFM	CM	CR	SS	LS	HM	WR	ALL
2 years post-treatment								
Hexazinone	1.6(0.3)							1.6(0.3)*
Mechanical	4.4(0.4)	0.4(0.1)		0.2(0.1)			0.2(0.1)	5.2(0.4)
3 years post-treatment								
Hexazinone	1.1(0.3)			0.2(0.1)				1.3(0.3)
Mechanical	0.5(0.2)		0.4(0.1)	0.2(0.1)			0.4(0.2)	1.5(0.1)
5 years post-treatment								
Hexazinone	0.5(0.2)	0.4(0.2)		0.2(0.1)	0.2(0.0)			1.3(0.4)
Mechanical		0.4(0.1)				0.2(0.1)		0.6(0.0)

[a]OFM = oldfield mice, CM = cotton mice, CR = cotton rat, SS = short-tailed shrew, LS = least shrew, HM = house mice, WR = woodrat, ALL = all species combined.
*Within a year, $0.05 < P < 0.10$.

none treatment sites whereas yellow-breasted chats (*Icteria virens*) were more numerous on the mechanical treatment. On the 3-year post-treatment sites, chipping sparrows (*Spizella passerina*) were more abundant on the hexazinone treatment, whereas Carolina wrens (*Thryothorus ludovicianus*) and yellow-breasted chats were more abundant on the mechanical treatment. On the 5 year post-treatment sites, differences in the abundances of individual bird species were not detected. Total avian abundance for all species combined did not differ between treatments on any of the age classes. At both 2 and 3 years post-treatment, avian diversity was higher on the hexazinone-treated sites than the mechanically-treated sites (Table 2). Avian diversity was weakly associated with herbaceous diversity ($r = 0.48$, $P = 0.05$), herbaceous richness ($r = 0.57$, $P = 0.02$) and woody diversity ($r = 0.49$, $P = 0.04$).

Discussion

Vegetative responses to different site preparation techniques were similar, although some differences occurred in some vegetational groupings. The hexazinone-treated areas were dominated by asters in years 2 and 3, while in the mechanical sites other forbs consistently represented a sizable segment of the community. Similar patterns were reported in 2-year-old sites by Hurst and Warren (1982) in Mississippi. This pattern may be in part due to the timing of hexazinone application which create a suitable seed bed at a time favoring aster development. At 3 years post-treatment, grasses in the mechanical-treated sites may have displaced asters through greater competitive ability in obtaining moisture (Odum 1960).

Woody species diversity did not differ between treatments. Woody plant species vary in susceptibility to hexazinone (Zutter and Zedaker 1988). Least susceptible species include blueberries (*Vaccinium* spp.), sassafras (*Sassafras albidum*), and pines, while oaks (*Quercus* spp.) are highly susceptible (Gonzalez 1983, Miller 1984). Zutter and Zedaker (1988) found reductions in woody diversity with increasing rates of hexazinone, but differences between untreated and treated areas were small after 2 years. Similarly, Conde et al. (1983) reported a recovery in woody diversity 2 years after mechanical site preparation.

The open nature of the predominately snag overstory on the chemically-treated sites provided suitable habitat for *Peromyscus* species (Dueser and Shugart 1978). The low capture rates of shrews may be because they are less susceptible to snap traps when compared to pitfalls (Briese and Smith 1974, Szaro et al. 1988) and they prefer moist habitats not characteristic of the well drained sandy soils of these sites.

Abiotic factors also play an important role in determining small mammal populations. Features such as rocks, logs, and water influenced small mammal captures in the Southern Appalachians (McComb and Rumsey 1982). Other microsite components including stumps and leaf cover can affect small mammal captures (Dueser and Shugart 1978, Geier and Best 1980). Kirkland (1977) found the addition of slash to the forest floor increased small mammal populations.

Cotton rats were caught only in the mechanically-treated sites at 3 years post-treatment. This corresponded to areas with high grass abundance, an important element of cotton rat habitat selection (Goertz 1964). Woodrats were captured only in mechanical treatments, and when captured were always in the proximity (<5m) of windrows. These windrows provide cover and materials used in construction of the nest (Chamberlain 1928).

Structural components influenced avian populations differences between treatments. The hexazinone treatment had many standing snags while the mechanical had few. Snags on the hexazinone sites served as perches for brown-headed cowbirds and potential nest sites for cavity nesters such as the eastern bluebird. Windrows promoted thick growth of vines and were utilized by yellow-breasted chats and Carolina wrens. The 3 species of woodpeckers were seen only on the hexazinone treatment and always in snag trees. Mourning doves were more numerous on the hexazinone treatment at 2 years post-treatment.

The higher diversity of birds at 2 and 3 years post-treatment likely was attributable to the greater structural diversity in the hexazinone sites. MacArthur and MacArthur (1961) suggested that bird species diversity is linked with foliage height diversity, but not plant diversity. Although foliage diversity data were not collected, the addition of snags in the hexazinone treatment obviously created niches for certain species (e.g., woodpeckers). Our findings are similar to Johnson (1982) who found higher bird diversity in 2-year-old plantations than in plantations 1 or 6 to 15 years old, and related this to snags left during site preparation. The 5-year-old sites sampled had many of the same species of birds as 20-year-old sites (Johnston and Odum 1956) on abandoned agricultural fields.

The choice of site preparation technique can influence populations of wildlife, especially through alteration of structural diversity. However, differences in the vegetative communities and in the abundance and diversity of small mammals and birds between hexazinone-treated and mechanically-treated generally are short-lived. By 5 years post-treatment differences in examined species were no longer evident, and habitat values were likely similar.

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