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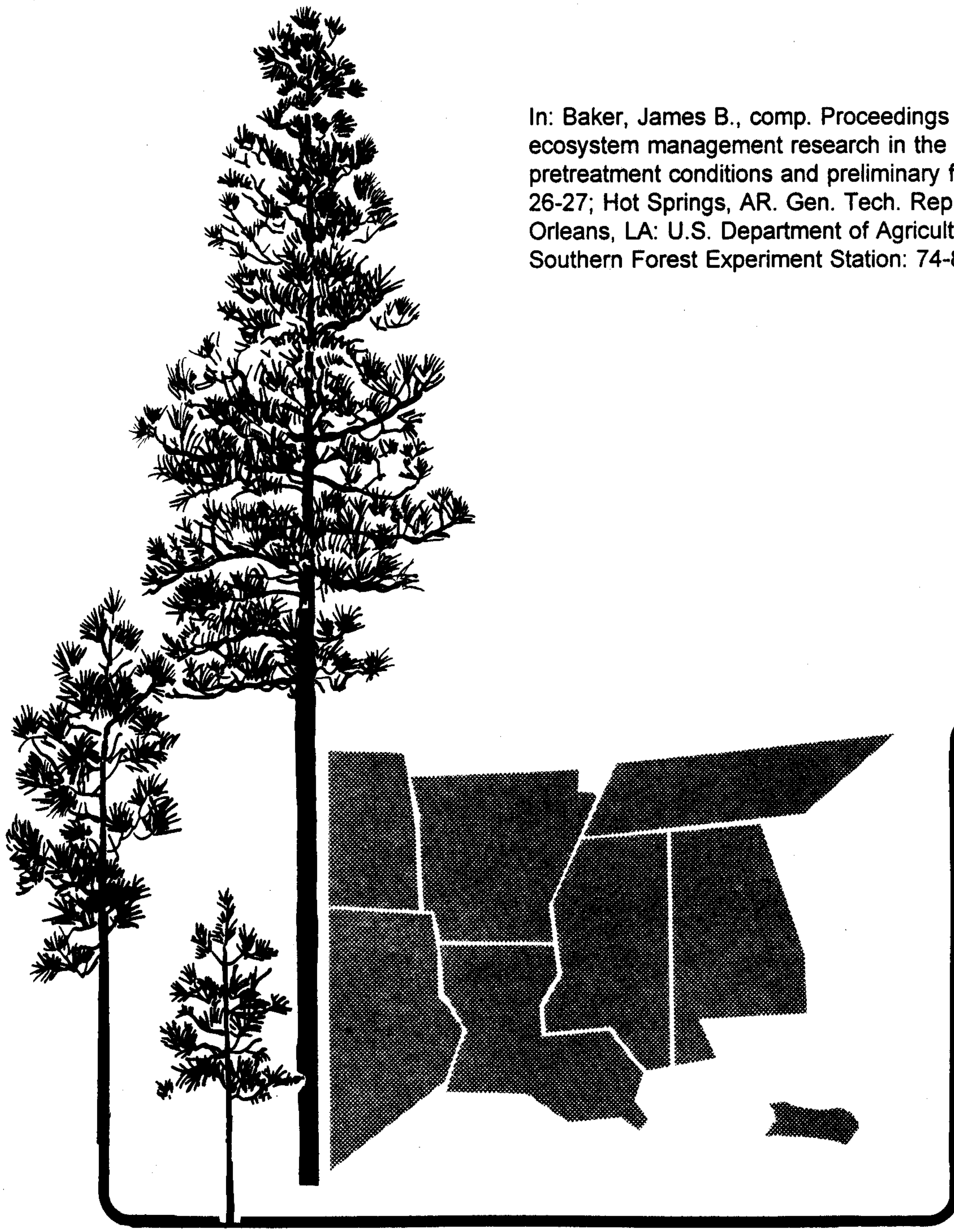

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Small Mammal Communities of Mature Pine-Hardwood Stands in the Ouachita Mountains[1]

Philip A. Tappe, Ronald E. Thill, Joseph J. Krystofik, and Gary A. Heidt[2]

ABSTRACT

A study was conducted on the Ouachita and Ozark National Forests in Arkansas to evaluate the effects of alternative pine-hardwood reproduction cutting methods on small mammal abundance and diversity. Pretreatment characteristics of small mammal communities on 20 late-rotation mixed pine-hardwood stands in four physiographic zones of the Ouachita Mountain region of Arkansas are presented. Each physiographic zone (block) contained one replication of five treatments (four future treatments and an untreated control). The most commonly captured small mammal species were *Peromyscus* spp., *Blarina carolinensis*, and *Ochrotomys nuttalli*. Capture success varied between years but most likely reflected changes in probabilities of capture of individual animals and not fluctuations in community composition. Small mammal species richness, diversity, evenness, and relative abundance did not differ between physiographic zones or future treatments.

INTRODUCTION

There is currently a paucity of information concerning the implications of even- and uneven-aged mixed pine-hardwood management for small mammals. In extensive literature searches on the topic of silvicultural effects on wildlife habitat (covering the years 1953 through 1990), Harlow and Van Lear (1981, 1987) and NCASI (1993) did not cite a single paper specifically addressing the effects of reproduction cutting methods in mixed pine-hardwood stands on small mammal communities. Coupled with increasing concerns over the impacts of silvicultural practices on wildlife, research on the effects of alternative silvicultural practices is particularly warranted for small mammal communities. Small mammals are the primary prey base for many mammalian and avian predators. Mycophagous species facilitate dispersal of fungal spores that form root-inhabiting ecotomycorrhizae required by most higher plants for adequate nutrient procurement, enhanced water absorption, and protection from root pathogens (Maser and others 1978). Consumption of pine seeds by some species may adversely affect regeneration success (Pank 1974, Smith and Aldous 1947). In addition, fossorial species may significantly influence hydrological processes on forested watersheds (Ursic and Esher 1988).

The objective of this study is to evaluate the effects of alternative pine-hardwood reproduction cutting methods on small mammal abundance and diversity. Pretreatment characteristics of small mammal communities in late-rotation stands in the Ouachita Mountain region of Arkansas are presented in this paper.

METHODS

Study Areas and Treatments

Twenty late-rotation mixed pine-hardwood stands in four physiographic zones of the Ouachita Mountain region were selected for study. These stands are located in the Ouachita National Forest and Ozark-St. Francis National Forest and are characterized by: size ranges from 14.2 to 16.2 ha; predominantly south, southeast, or southwest aspects; and slopes of 5 to 20 percent. Locations and habitat characteristics of the stands are described by Thill and others (1994).

Four replications of five treatments, blocked by physiographic zone, were randomly assigned to 20 stands. These treatments consist of an untreated control and four reproduction cutting methods: clearcut, shelterwood, group selection, and single-tree

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selection. All silvicultural treatments, except for the clearcut, provide for the retention of overstory hardwoods. These treatments were implemented in the summer of 1993. For a detailed description of treatments and physiographic zones, see Baker (1994).

Small Mammal Surveys

Small mammals were trapped prior to treatment installation during December of 1991 and 1992 using Sherman livetraps (7.62 cm by 8.89 cm by 22.86 cm). These traps are of sufficient size to capture eastern woodrats (*Neotoma floridana*), flying squirrels (*Glaucomys volans*), and smaller mammals. Eighty trap stations per stand were located at 15-m intervals along permanent transects established for small mammal trapping, habitat sampling, and biodiversity surveys. To ensure adequate coverage of each study area, each stand was subdivided into 50-m wide, parallel bands. One randomly selected transect was located within each band so that no transect was closer than 30 m from another transect. The number of transects and their lengths varied by stand size and shape. To minimize potential edge influences, no traps were placed closer than 50 m from the stand boundaries. A more detailed description of transect establishment is given by Thill and others (1994). In 1991, one trap was placed at each station. Sampling effort was increased to two traps per station in 1992 to ensure ample opportunities for multiple captures per trap station.

Traps were baited with commercial horse and mule feed and checked for 10 consecutive days. A wad of cotton was placed in each trap for nesting material to minimize trap mortality. Captured mammals were marked and released at the site of capture after recording species, sex (when possible), and location (station number) of capture. A tally was also kept on the number of empty/sprung traps so that total available trap nights could be computed. Because of insufficient discriminating physical characteristics available from field observations, animals of the genus *Peromyscus* (including *P. leucopus, P. gossypinus, P. maniculatus, and P. attwateri*) were not identified to the species level.

Data Analyses

A number of diversity measures were computed for each stand. These included species richness (i.e., the number of species encountered), Shannon's diversity index (Shannon and Weaver 1963), and species evenness (i.e., the distribution of individuals among species). In addition, an index of relative species abundance was obtained by computing small mammal captures per 100 trap nights, excluding recaptures and after correcting for sprung/empty traps. Though sampling intensity was doubled in 1992, very few multiple captures occurred. Thus, to ensure that data were comparable between years, 1992 trap nights were based on the number of trap stations as opposed to the number of individual traps. Diversity, evenness, richness, and relative abundance of small mammals were compared by year using Wilcoxon matched-pairs signed-ranks tests and by physiographic zone and future treatment using one-way analysis of variance (ANOVA) and Tukey's HSD. In addition, small mammal community composition was evaluated among physiographic zones and among future treatments using Sorensen's Similarity Index (Mueller-Dombois and Ellenberg 1974). This index is computed as: $SI = 200C/(A + B)$, where A = the number of species in zone or treatment A, B = the number of species in zone or treatment B, and C = the number of species that areas A and B have in common. Similarity can range from 0 percent (no species in common) to 100 percent (identical species composition). So that community composition could be readily compared between any two blocks or treatments, an index value was computed for each combination of both physiographic zones (6 combinations) and future treatments (10 combinations).

RESULTS

After correcting for sprung traps and differential sampling intensity, 21,165 trap nights were accumulated over 2 years across all stands. A total of 502 small mammals of 10 species were captured (table 1). Trapping success across years was 2.37 new captures per 100 trap nights. The most commonly captured species were *Peromyscus* spp., *Blarina carolinensis*, and *Ochrotomys nuttalli*, comprising 94 percent of all animals captured (table 1).

Differences by Year

Capture success was different between 1991 and 1992. Total captures varied significantly between years ($Z = -3.6773$, $P < 0.001$), and numbers of individuals within the species were different for the three most commonly caught species (table 1). New captures per 100 trap nights also differed between years for the three most commonly captured species (table 1): *Peromyscus* spp. ($Z = -2.6880$, $P = 0.007$), *Blarina carolinensis* ($Z = -2.7253$, $P = 0.006$), and *Ochrotomys nuttalli* ($Z = -3.0102$, $P = 0.003$).

Because of these differences in capture success, measures of diversity also differed between years. Species richness among stands differed by year ($Z = -2.1993$, $P = 0.028$), averaging 3.35 (SE = 0.24) for 1991 and 2.55 (SE = 0.20) for 1992. Species diversity also differed by year ($Z = -2.3146$, $P = 0.021$), averaging 0.90 (SE = 0.08) for 1991 and 0.71 (SE = 0.07) for 1992. However, species evenness did not differ between years ($Z = -0.8213$, $P = 0.412$), averaging 0.73 (SE = 0.06) for 1991 and 0.75 (SE = 0.06) for 1992.

Table 1- *Species, numbers of captured individuals, and relative abundance (new captures per 100 trap nights) of small mammals captured by year in Ecosystem Management research stands in the Ouachita Mountains of Arkansas*

Species	1991 Captures	1991 Captures/100 trap nights	1992 Captures	1992 Captures/100 trap nights	Total captures	Total captures/100 trap nights
Peromyscus spp.*	170	1.62	84	0.79	254	1.20
Blarina carolinensis	127	1.21	31	0.29	158	0.75
Ochrotomys nuttalli	51	0.49	9	0.08	60	0.28
Neotoma floridana	8	0.08	5	0.05	13	0.06
Reithrodontomys fulvescens	5	0.05	1	0.01	6	0.03
Glaucomys volans	3	0.03	2	0.02	5	0.02
Microtus pinetorum	2	0.02	1	0.01	3	0.01
Orzomys palustris	1	0.01	0	0.00	1	<0.01
Sigmodon hispidus	1	0.01	0	0.00	1	<0.01
Mus musculus	0	0.00	1	0.01	1	<0.01
Total	368	3.51	134	1.26	502	2.37

*Includes *P. leucopus, P. gossypinus, P. maniculatus, and P. attwateri.*

Because habitat characteristics did not change appreciably between years, differences in relative abundance and diversity were probably related to differences in the inherent probabilities of capture of individual animals and not to yearly fluctuations in the actual abundance and/or composition of small mammal species. Species that were captured only 1 year were likely present both years, but their populations may have been so low that capture was unlikely given our sampling intensity. When richness, diversity, and evenness values were computed for pooled 1991 and 1992 data, mean values across all stands were 3.70 (SE = 0.21) for species richness, 0.98 (SE = 0.07) for species diversity, and 0.75 for species evenness.

Differences by Physiographic Zones

Physiographic zones were compared for each year and for pooled data across years. In 1991, 1992, and 1991-92 combined, no differences between zones were found for relative abundance, richness, diversity, or evenness (tables 2, 3). Likewise, few habitat parameters were significantly different by physiographic zone (Thill and others 1994). Small mammal community similarity between physiographic zones ranged from 61.5 percent to 87.5 percent (table 4), and averaged 74.1 percent. However, *Peromyscus* spp., *Blarina carolinensis*, and *Ochrotomys nuttalli* were present in all zones. Because all other species comprised only 6 percent of the animals captured, these areas may be more similar than indicated by Sorensen's index.

Differences by Future Treatments

Groups of stands targeted for future treatments were also compared for each year and for pooled data across years. In 1991 and 1991-92, no differences between future treatments were found for relative abundance, richness, diversity, or evenness (Tables 5 and 6). In 1992, there were no differences between future treatments for relative abundance, richness, or diversity; however, the mean evenness value for the group of stands to receive the shelterwood treatment differed from all other groups of stands except the control group (tables 5, 6). Likewise, only one of 69 habitat parameters (volume of down pine logs, decay class 3) differed significantly among future treatments (Thill and others 1994). Small mammal community similarity between future treatments ranged from 57.1 percent to 92.3 percent (table 4) and averaged 78.5 percent. Similar to physiographic zones, *Peromyscus* spp., *Blarina carolinensis*, and *Ochrotomys nuttalli* were present in all treatment areas. In addition, the next most abundant species, *Neotoma floridana* (table 1), was also present in all treatment areas. Thus, these areas may also be more similar in small mammal composition than indicated by Sorensen's index.

Table 2– *Relative abundance (new captures per 100 trap nights) of small mammals and the three most commonly captured species ($\bar{x}\pm$ SE) in Ecosystem Management research stands in the Ouachita Mountains of Arkansas by physiographic zone, 1991-92*

Species	Year	Zone				F*	P†
		North	South	East	West		
All species	1991	3.21 ± 1.13	3.27 ± 1.23	4.88 ± 0.91	2.75 ± 1.35	0.637	0.60
	1992	1.29 ± 0.44	1.11 ± 0.22	1.46 ± 0.47	1.15 ± 0.36	0.173	0.91
	Pooled	2.25 ± 0.66	2.19 ± 0.69	3.17 ± 0.75	1.95 ± 0.71	0.584	0.63
Peromyscus spp.‡	1991	2.01 ± 0.80	1.99 ± 1.32	1.46 ± 0.37	0.98 ± 0.47	0.351	0.79
	1992	0.88 ± 0.33	0.63 ± 0.15	0.93 ± 0.39	0.69 ± 0.24	0.245	0.86
	Pooled	1.45 ± 0.45	1.31 ± 0.67	1.19 ± 0.27	0.84 ± 0.26	0.346	0.79
Blarina carolinensis	1991	0.30 ± 0.09	0.75 ± 0.27	2.53 ± 1.03	1.35 ± 1.68	2.193	0.13
	1992	0.22 ± 0.09	0.29 ± 0.09	0.34 ± 0.21	0.30 ± 0.10	0.306	0.82
	Pooled	0.26 ± 0.06	0.52 ± 0.15	1.44 ± 0.61	0.83 ± 0.40	1.847	0.16
Ochrotomys nuttalli	1991	0.72 ± 0.29	0.34 ± 0.17	0.81 ± 0.33	0.08 ± 0.05	2.022	0.15
	1992	0.07 ± 0.07	0.04 ± 0.04	0.15 ± 0.09	0.08 ± 0.05	0.514	0.68
	Pooled	0.40 ± 0.18	0.19 ± 0.10	0.48 ± 0.20	0.08 ± 0.11	1.695	0.19

*One-way ANOVA *F*-value.
†Probability associated with one-way ANOVA *F*-value.
‡Includes *P. leucopus, P. gossypinus, P. maniculatus, and P. attwateri.*

Table 3– *Species richness, diversity, and evenness ($\bar{x}\pm$ SE) in Ecosystem Management research stands in the Ouachita Mountains of Arkansas by physiographic zone, 1991-92*

Variable	Year	Zone				F*	P†
		North	South	East	West		
Richness	1991	3.20 ± 0.20	3.40 ± 0.51	3.20 ± 0.21	3.60 ± 0.87	0.133	0.94
	1992	2.20 ± 0.37	2.80 ± 0.37	2.60 ± 0.40	2.60 ± 0.51	0.362	0.78
	Pooled	3.60 ± 0.24	3.83 ± 0.48	3.40 ± 0.25	4.00 ± 0.63	0.346	0.79
Diversity‡	1991	0.88 ± 0.10	0.94 ± 0.20	0.88 ± 0.12	0.89 ± 0.23	0.028	0.99
	1992	0.55 ± 0.17	0.84 ± 0.13	0.76 ± 0.09	0.70 ± 0.19	0.694	0.57
	Pooled	0.96 ± 0.14	1.02 ± 0.21	0.89 ± 0.13	1.06 ± 0.05	0.214	0.89
Evenness	1991	0.77 ± 0.09	0.76 ± 0.12	0.76 ± 0.09	0.65 ± 0.17	0.210	0.89
	1992	0.61 ± 0.17	0.84 ± 0.04	0.87 ± 0.07	0.67 ± 0.17	0.936	0.45
	Pooled	0.74 ± 0.09	0.72 ± 0.13	0.73 ± 0.08	0.81 ± 0.05	0.173	0.91

*One-way ANOVA *F*-value.
†Probability associated with one-way ANOVA *F*-value.
‡Shannon's diversity index (Shannon and Weaver 1963).

Table 4— *Sorensen's similarity indices (Mueller-Dombois and Ellenberg 1974) for small mammal communities in Ecosystem Management research stands in the Ouachita Mountains of Arkansas by future treatments and physiographic zones, 1991-92*

Analysis	Comparison	Similarity index (percent)
Future treatments	Clearcut-single tree selection	92.3
	Clearcut-shelterwood	90.9
	Control-single tree selection	85.7
	Control-shelterwood	83.3
	Single tree selection-shelterwood	83.3
	Control-clearcut	76.9
	Group selection-clearcut	76.9
	Group selection-single tree selection	71.4
	Group selection-shelterwood	66.7
	Group selection-control	57.1
Physiographic zones	South-West	87.5
	North-East	80.0
	North-South	76.9
	North-West	76.9
	South-East	61.5
	East-West	61.5

DISCUSSION

Small mammals play an important role in several ecological processes of forested communities and can be greatly influenced by forest management activities. To effectively evaluate the impacts of imposing specific treatments on forest stands, pretreatment conditions relative to small mammal abundance and community composition should be as similar as possible. In this study, no differences were found in small mammal relative abundance, richness, diversity, or evenness by physiographic region, and with only one exception, no differences were found in these same parameters by future treatment. Thus, future analyses of posttreatment data should not be confounded by pretreatment differences in respect to small mammal community composition and stand location (physiographic zone).

Though differences in trap types and trapping methodologies prevent direct comparisons with other studies, all stands sampled in this study appeared to be characterized by a relatively low density and diversity of small mammals. Several studies have shown that small mammal abundance and diversity is influenced by successional vegetation patterns and structural habitat characteristics (Goodwin and Hungerford 1979; Kirkland 1977, 1990; McComb and Noble 1980; Mengak and others 1989a, 1989b). In general, early successional seres are characterized by higher small mammal abundance and diversity than later seres, as well as differences in species composition.

Small mammal abundance, diversity, and species composition is often positively related to understory cover and down woody material. Stands in this study generally had very little down woody material (averaging 3.3 percent ground coverage), and the percentage of cover was low (averaging 0.3 to 2.3 percent) for woody plants, forbs, and graminoids (Thill and others 1994). Numerical and compositional responses of small mammals following treatments will most likely reflect associated increases in the above habitat parameters. The magnitude and temporal characteristics of these responses will probably vary by treatment, and total numbers of some species may increase substantially. Though increasing sampling intensity during pretreatment trapping did not increase trapping success, retaining two traps per station will probably be necessary to sample increased small mammal populations following certain treatments.

The three most commonly captured species in this study represented three different trophic groups: insectivores (*Blarina carolinensis*), granivores (*Ochrotomys nuttalli*), and omnivores (*Peromyscus* spp.). If sufficient numbers of additional species

Table 5– *Relative abundance (captures per 100 trap nights) of small mammals and the three most commonly captured species (x± SE) in Ecosystem Management research stands in the Ouachita Mountains of Arkansas by future treatment, 1991-92*

Species	Year	Treatment						
		Clearcut	Shelterwood	Single-tree selection	Group selection	Control	F*	P†
All species	1991	1.06 ± 0.23	3.90 ± 1.62	4.77 ± 1.22	3.54 ± 1.54	4.36 ± 0.88	1.437	0.27
	1992	0.60 ± 0.11	1.30 ± 0.67	1.65 ± 0.31	1.39 ± 0.35	1.31 ± 0.35	0.951	0.46
	Pooled	0.83 ± 0.15	2.60 ± 0.95	3.21 ± 0.83	2.47 ± 0.84	2.83 ± 0.73	1.475	0.23
Peromyscus spp.‡	1991	0.55 ± 0.16	2.57 ± 1.61	1.45 ± 0.62	2.06 ± 1.00	1.41 ± 0.32	0.704	0.60
	1992	0.37 ± 0.13	0.88 ± 0.50	1.04 ± 0.29	0.78 ± 0.29	0.84 ± 0.28	0.614	0.66
	Pooled	0.46 ± 0.10	1.73 ± 0.84	1.25 ± 0.32	1.42 ± 0.54	1.13 ± 0.23	0.942	0.45
Blarina carolinensis	1991	0.46 ± 0.12	0.74 ± 0.37	2.16 ± 1.08	0.47 ± 0.18	2.32 ± 1.22	1.508	0.25
	1992	0.18 ± 0.07	0.19 ± 0.08	0.28 ± 0.12	0.42 ± 0.09	0.38 ± 0.11	1.280	0.32
	Pooled	0.32 ± 0.08	0.46 ± 0.21	1.22 ± 0.62	0.45 ± 0.10	1.35 ± 0.68	1.298	0.29
Ochrotomys nuttalli	1991	0.23 ± 0.18	0.48 ± 0.36	0.67 ± 0.31	0.72 ± 0.42	0.33 ± 0.15	0.486	0.75
	1992	0.00 ± 0.00	0.14 ± 0.09	0.14 ± 0.09	0.10 ± 0.10	0.05 ± 0.05	0.676	0.62
	Pooled	0.12 ± 0.09	0.31 ± 0.18	0.41 ± 0.18	0.41 ± 0.23	0.19 ± 0.09	0.629	0.65

*One-way ANOVA *F*-value.
†Probability associated with one-way ANOVA *F*-value.
‡Includes *P. leucopus, P. gossypinus, P. maniculatus, and P. attwateri.*

Table 6– *Species richness, diversity, and evenness (x ± SE) in Ecosystem Management research stands in the Ouachita Mountains of Arkansas by future treatment, 1991-92*

Variable	Year	Treatment						
		Clearcut	Shelterwood	Single-tree selection	Group selection	Control	F*	P†
Richness	1991	3.25 ± 0.25	2.75 ± 0.25	3.50 ± 0.50	3.00 ± 0.71	4.25 ± 0.75	1.152	0.37
	1992	2.00 ± 0.00	2.50 ± 0.87	3.00 ± 0.41	2.75 ± 0.25	2.50 ± 0.29	0.647	0.64
	Pooled	3.25 ± 0.25	3.40 ± 0.40	4.25 ± 0.48	3.50 ± 0.29	4.25 ± 0.75	1.062	0.41
Diversity‡	1991	1.03 ± 0.06	0.82 ± 0.21	0.97 ± 0.06	0.76 ± 0.26	0.93 ± 0.26	0.328	0.89
	1992	0.62 ± 0.04	0.48 ± 0.28	0.88 ± 0.10	0.86 ± 0.12	0.73 ± 0.14	1.167	0.36
	Pooled	1.04 ± 0.11	0.90 ± 0.22	1.13 ± 0.12	0.99 ± 0.07	0.87 ± 0.23	0.360	0.83
Evenness	1991	0.88 ± 0.03	0.77 ± 0.17	0.81 ± 0.08	0.59 ± 0.20	0.62 ± 0.11	0.875	0.50
	1992	0.89 ± 0.06 *A*	0.34 ± 0.20 *B*	0.84 ± 0.05 *A*	0.86 ± 0.06 *A*	0.80 ± 0.10 *AB*	4.212	0.02
	Pooled	0.88 ± 0.04	0.70 ± 0.16	0.79 ± 0.05	0.80 ± 0.04	0.59 ± 0.10	1.196	0.35

*One-way ANOVA *F*-value. Means within rows followed by unlike letters are statistically different ($P < 0.05$).
†Probability associated with one-way ANOVA *F*-value.
‡Shannon's diversity index (Shannon and Weaver 1963).

are captured during posttreatment sampling, changes in community structure relative to trophic groups will be of interest, particularly in respect to fungi- and seed-consuming species due to their potential effects on natural regeneration.

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