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WILDLIFE HABITAT CONDITIONS IN MATURE PINE HARDWOOD STANDS IN THE OUACHITA/OZARK NATIONAL FORESTS

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Wildlife Habitat Conditions in Mature Fine-Hardwood Stands in the Ouachita/Ozark National Forests[1]

Ronald E. Thill, Philip A. Tappe, and Nancy E. Koerth[2]

ABSTRACT

A long-term, stand-level, interdisciplinary research and demonstration project was initiated on the Ouachita (ONF) and Ozark-St. Francis National Forests in Arkansas in 1990 to compare the impacts of alternative reproduction cutting methods on commodity and noncommodity forest resources including wildlife habitat and populations. Habitat measurement procedures ad pretreatment habitat conditions for 20 of the 52 stands included in this study are summarized kre. The wildlife component of this study consists of a completely randomized block design involving four physiographic zones (blocks), each containing one replication of five treatments (four future treatments and an untreated, late-rotation control). Of the 69 habitat parameters analyzed to date, 11 differed significantly ($P < 0.05$) by physiographic zone, but only 1 differed by future treatment. From a wildlife standpoint, these late-rotation stands primarily consisted of south-facing, relatively xeric sites character&d by high canopy coverage, an abundance of mostly small hardwoods, very limited winter herbage and browse supplies, moderate snag abundance, and limited amounts ofdownwood. Most of the hardwoods are too small to produce much mast, and densities of the larger (≥35 cm in dbh.) snags are insufficient to accommodate high populations of several of the larger resident cavity-dependent wildlife species. Snags and down logs of recent origin were generally scarce. Recent amendment of the USDA Forest Service ONF Forest Plan should klp to ameliorate these conditions.

INTRODUCTION

Even-aged silviculture employing clearcutting, site preparation, and planting of pines has been the primary method of regeneration on southern national forests for more than 25 years. Although young plantationa provide excellent habitat fa many wildlife species, even-aged management on short rotations is generally detrimental to those species that require an abundance of snags, cavity and den trees, hardwoods, hard mast, large down wood, and other mature-forest features (Thill 1990). The USDA Forest Service has been under increasing pressure to consider alternatives to even-aged management (especially to clearcutting), such as single-tree and group selection and expanded management fa pine-hardwood mixtures.

In response to growing public concern over management of the national forests in Arkansas, a long-term, multidisciplinary, stand-level research and demonstration project was initiated on the Ouachita and Ozark-St. Francis Naticmal Forests in 1990 to compare alternative reproduction cutting methods relative to their silvicultural feasibility and their impacts on commodity and noncommodity forest resources (Baker, this volume). Determining the effects of these treatments on wildlife populations and habitat features is a primary objective of this research.

The objective in this paper is to characterize pretreatment wildlife habitat conditions in 20 stands (table 1) that are being studied under this initiative. Habitat measurements ad procedures are described, the 20 stands are characterized, ad differences by physiographic zones and future treatments are presented Pretreatment bird and small mammal data are presented in separate papers within this proceedings.

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Table 1.—*Identification of wildlife research plots by physiographic zone (block), future treatment, district, compartment, and stand*

ID no.	Zone	Treatment	District	Compartment	Stand
1	North	Clearcut	Fourche	458	16
2	North	Shelterwood	Fourche	457	12
3	North	Group selection	Magazine*	46	18
4	North	Single-tree selection	Magazine*	70	10
5	North	Untreated control	Cold Springs	284	11
6	East	Clearcut	Oden	1067	15
7	East	Shelterwood	Oden	1119	21
8	East	Group selection	Oden	1124	11
9	East	Single-tree selection	Jessieville	609	9
10	East	Untreated control	Jessieville	605	5
11	South	Clearcut	Womble	1658	5
12	south	Shelterwood	Caddo	21	1
13	south	Group selection	Caddo	35	42
14	south	Single-tree selection	Womble	1649	13
15	south	Untreated control	Caddo	23	10
16	West	Clearcut	Poteau	1292	2
17	West	Shelterwood	Mena	833	1
18	West	Group selection	Choctaw	62	6
19	West	Single-tree selection	Kiamichi	248	17
20	West	Untreated control	Mena	896	7

*Ozark-St. Francis National Forest; all others on the Ouachita National Forest.

SELECTED HABITAT PARAMETERS

For the eventual development of wildlife-habitat relationship models, data were collected on a host of habitat parameters that are: (a) nondestructive to obtain, (b) relatively easy to collect, and (c) often correlated with and/or useful in predicting wildlife abundance and diversity (Gysel and Lyon 1980, Hays and others 1981). These parameters are described below.

Overstory Conditions

Characteristics of the forest overstory (e.g., tree density, spacing, and height; species composition; and the number of vertical layers) greatly influence understory floral composition and production, vertical structural complexity, microclimate, and a host of other habitat parameters that influence wildlife diversity and abundance. For example, hardwood retention within pine stands typically improves habitat conditions significantly for a broad range of wildlife species by increasing habitat and microsite diversity, forage substrate (e.g., bole, bark, leaves, and fruits), vertical structural complexity, dens and cavities, and/or through the amelioration of microclimatic influences. Forest avifaunal diversity is generally positively correlated with stand structural complexity (Dickson and Segelquist 1979, MacArthur and MacArthur 1961, Meyers and Johnson 1978), but dense. multilayered hardwood midstories can drastically limit available forage for vertebrate herbivores (Blair and Brunett 1976, Blair and Feduccia 1977).

Information on sizes, densities, and species composition of hardwoods is useful in predicting hard mast production (Goodrum and others 1971) and availability of natural cavities (Allen and Corn 1990).

Snags and Stumps

Snags provide foraging substrate, roosting and hiding sites, and cavity sites for numerous vertebrate and invertebrate species (Thomas and others 1979a). Stumps also provide additional structure, cover, and foraging substrate used by some species (Maser and others 1979). Absence of suitable nest sites is often a limiting factor for cavity nesting birds (Thomas and others 1979a), which comprise an ecologically important component of southeastern forest avifauna. Consequently, wildlife abundance and diversity can be increased through retention of snags of appropriate sizes. Snag preferences of cavity nesting species are dependent on a number of factors including tree species, diameter, height, and stage of decay (Evans and Conner 1979, Thomas and others 1979a).

Down Wood

Down woody material serves many crucial ecological functions, many of which have only recently been appreciated (Harmon ad others 1986, Maser and others 1979). Tkse functions influence floral and faunal diversity, site productivity, nutrient cycling, ad soil and sediment transport ad storage (Harmon ad others 1986). From a wildlife standpoint, these materials are used as hiding cover, feeding sites, and reproduction sites (Maser and others 1979). For example, many *Plethodon* salamanders require moist, rotting logs and litter far egg development and adult cutaneous respiration (Stebbins 1966). Down woody material provides an energy/nutrient source and kbitat for many bacteria and fungi. Some small mammals prefer to travel along down logs and branches rather than directly on the ground (Planz and Kirkland 1992). Capture success for deer mice (*Peromyscus maniculatus*) was highly correlated with coverage of down logs and stumps per acre in Arizona ponderosa pine (*Pinus ponderosa* Dougl. Ex Laws.) forests (Goodwin and Hungerford 1979).

Factors influencing animal use of down wood include size (diameter and length), species, decay state, and overall abundance/distribution of down wood (Harmon and others 1986). Larger down logs provide more cover and generally persist longer than smaller logs (Maser and others 1979, Maser and Trappe 1984). Transitional stages of decay afford different kbitat features. For example, loose bark provides hiding and thermal cover for small vertebrates. In advanced stages of decay, small mammals can excavate burrows, which, in turn, may be utilized by amphibians and reptiles (Harmon and others 1986). Over a wide range of forest types and seral stages, Harmon and others (1986) indicated that small mammals that use down woody materials comprise 70 to 90 percent of the species richness and 75 to 99 percent of the total number of individuals.

Much less is known regarding herpetofaunal communities and their reliance on down wood. However, Pacific Northwest reptiles and amphibians that use down wood comprise 93 percent of the species and 99 percent of the individuals (Harmon and others 1986).

Ground Cover

Rocks and rock piles provide a host of habitat elements (e.g., sunning sites, thermal and hiding cover, and habitat structure) for smaller organisms including many amphibians, reptiles, and small mammals.

Litter depth influences a number of important biological processes including soil moisture evaporation, water infiltration, and soil heating and cooling. Litta provides forage and foraging sites, thermal and hiding cover, and can significantly influence microclimatic conditions for many amphibians and reptiles (Jones 1986), small mammals, and other smaller organisms. It also provides habitat for invertebrates that serve as food far vertebrates. Litter cover, thickness, and composition also influence nutrient cycling and soil erosion, which, in turn, influence long-term site productivity. Understory herbage production is generally inversely related to litta depth (Gaines and others 1954).

Plant Cover

To a large extent, wildlife abundance and diversity are closely related to tk abundance, diversity, structure, and nutritional quality of available herbaceous and woody plants, mainly through tkir influences on forage availability and cover conditions. Forage and cover are generally man limiting during late winter; consequently, late-winter measures of these variables were assumed to k more highly correlated with animal abundance and diversity than growing season measures. Ocular estimates of percent cover (proportion of an area covered by tk vertical projection of plant crowns to the ground surface) are much less expensive to collect than forage production data and are generally sufficiently correlated with forage production to derive meaningful inferences (Gysel and Lyon 1980).

Horizontal foliage cover (often referred to as security or hiding cover to distinguish from thermal cover) is a measure of the concealment that vegetation and other structural features (e.g., rock or down wood) afford an animal from its predators. Many animals have evolved preferences for certain cover conditions; consequently, cover measurements are often useful in developing wildlife-habitat relationships (Thomas and others 1979b). Patchiness, a structural habitat measure describing vegetation distribution in a horizontal plane, can k computed as the variance among horizontal cover estimates for each vertical layer measured (Anderson and Ohmart 1986). Measures of patchiness, together with vertical structure, are useful in predicting avian community structure (Rotenberry and Wieos 1980).

METHODS

Study Areas and Treatments

Four replications of twelve silvicultural treatments are currently being implemented on an operational basis in forty-eight 14.2- to 16.2-ha late-rotation stands. Four untreated control stands of this size and type were also established; these plots will remain untreated (except for insect and fire protection) to provide a minimum management scenario for comparative purposes. These treatments were randomly assigned to 13 late-rotation stands in each of 4 physiographic zones of the Ouachita National Forest and 2 southern clisuicts of the Ozark-St. Francis National Forest Logging was initiated during May 1993 and completed by the fall of that year.

Because of limited resources, habitat and wildlife responses are being monitored on only four replications of the following five treatments: untreated control, clearcut, shelterwood, single-tree selection, and group selection An overstory hardwood component (approximately 5 m^2/ha) will be maintained in the latter three treatments to enhance wildlife and esthetic values.

AU stands selected for this study have a predominantly south, southeast, or southwest aspect and slopes of 5 to 20 percent. Prior to treatment, selected stands contained 13.8 to 25.3 m^2 of merchantable pine basal area (BA) and 4.6 to 11.5 m^2 of merchantable hardwood BA (Baker, this volume). Shortleaf pine (*Pinus echinata* Mill.), post oak (*Quercus stellata* Wangenh.), winged elm (*Ulmus alata* Michx.), and blackjack oak (*Q. marilandica* Muenchh.) tend to dominate these slopes (Clapp 1990). On south-facing slopes in the Crystal Mountain area, white oak (*Q. alba* L.) was dominant on lower slopes, blackjack oak on middle slopes, and post oak on upper slopes (Mayo and Raines 1986). For a complete description of climate, geology, treatments. physiographic zones, and stand selection and randomization procedures, see Baker (this volume).

Transects

Permanent transects were established in each of the 20 wildlife research stands for small mammal napping, habitat measurements, and biodiversity surveys. To ensure systematic coverage and adequate spacing between transects for small mammal trapping, the following procedures were used to establish these transects. An azimuth was selected that roughly paralleled the elevation contour of the stand. Each stand was then divided into imaginary 50-m-wide bands along this selected azimuth. One transect was then randomly established within each band across the width of the stand, with the limitation that no two transects could be closer than 30 m apart (fig. 1). Starting 50 m from the stand boundary, unnumbered stake flags were then placed at 15-m intervals along all transects to within 50 m of the opposite end of each transect This ensured at least a 50-m buffer zone around the entire sampling area. Stake flags were then removed in concentric circles from the outside inward until 100 points remained in each stand; 80 of these points were randomly selected for use as small mammal trapping stations and associated habitat measurements. The entire transect length is being used for biodiversity surveys by another research team. Under this arrangement, actual buffer-zone widths varied depending on the size and shape of each stand- Where sufficient greenbelt areas (buffer strips that will be retained along drainages having a defined channel) were present, eight (10 percent) of the trap stations were placed in what were presumed to be future greenbelts. Thirty of the eighty stations were randomly selected to serve as permanent habitat sampling points for monitoring long-term habitat changes. Data from all 80 stations will eventually be used to develop small mammal habitat relationship models. However, only 1992 data from the 30 permanent sampling points were used in the analyses presented here.

Habitat Measurements

Habitat measurements at each station were confined to three adjacent 2- by 2-m quadrats (each containing a nested 1- by l-m quadrat), a 5-m-radius semicircle, and a 15-m-wide belt transect (fig. 2). With the exception of growing season (June/July 1992) measures of horizontal cover, all measurements were taken during late winter (February and early March) 1992.

Percent coverage of rock, bare ground, and litter were estimated ocularly within the three 1- by l-m quadrats. Litter depth was measured at three points in each 1- by l-m quadrat, averaged, and assigned to a 2-m increment class (0.00 to 1.99, 2.00 to 3.99, etc.). Percent coverage of all down wood >2.54 cm in diameter was ocularly estimated within each of the three 2- by 2-m quadrats. Percent coverage of forbs and graminoids (grasses and grasslike plants, collectively) during late winter was estimated within each 1- by l-m quadrat; percent coverage of browse (leaves of evergreen and tardily deciduous woody plants to a height of 2 m) was estimated within the three 2- by 2-m quadrats. Data collected in each of the three equal-sized quadrats were averaged, yielding one value per station,

Dead logs lying within the 5-m-radius semicircle and having an average diameter ≥10 cm were measured for volume, identified as pine or hardwood, and classified into one of four classes (from least to most decayed): (1) branches and small

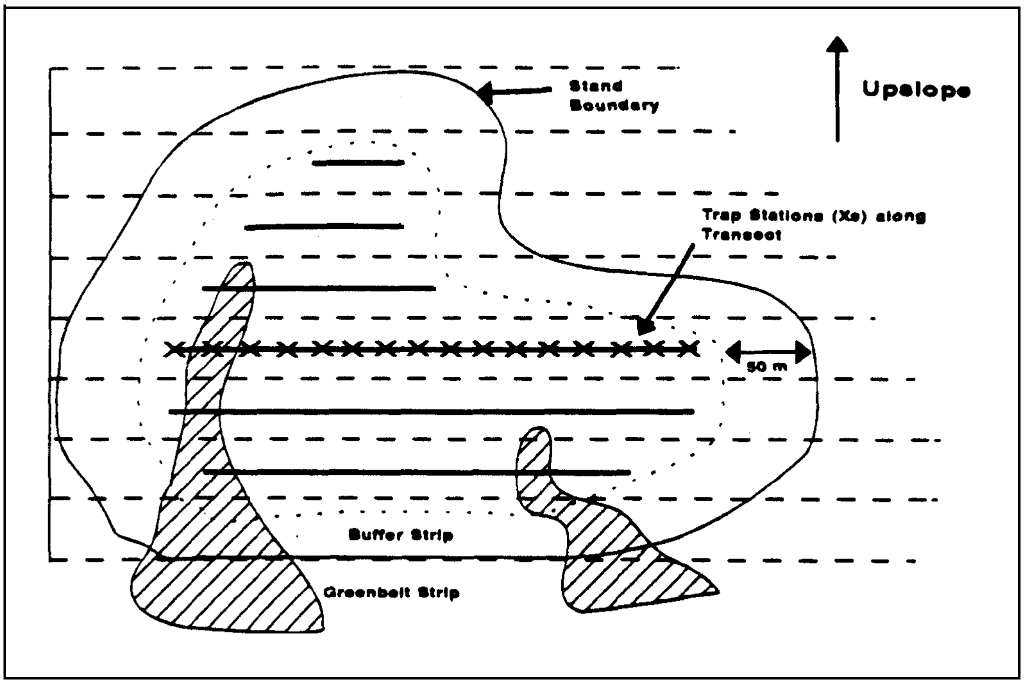

Figure 1.—*Layout of small mammal trap stations at 15-m intervals along randomly selected transects within 50-m-wide bands (dashed lines). A buffer strip of at least 50 m separates sampling points from adjacent stun&.*

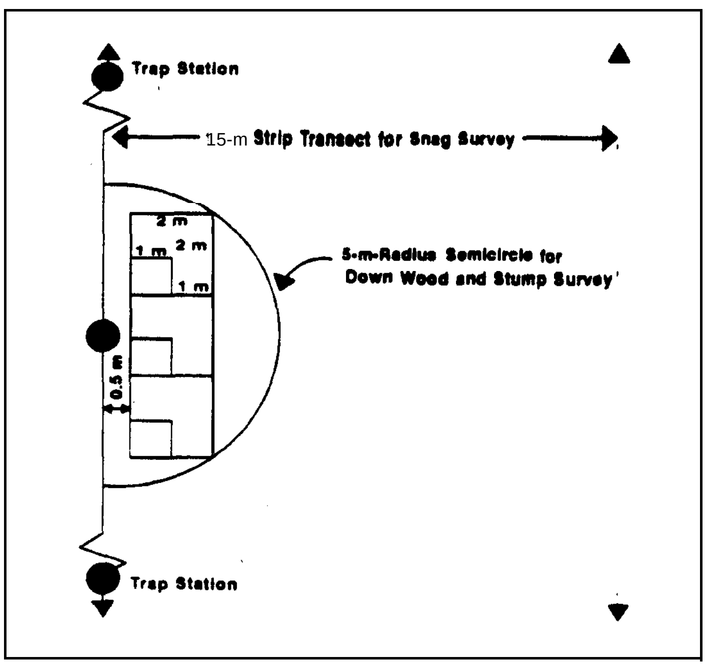

Figure 2.—*Location of nested 1- by l-m and 2- by 2-m quadrats, 5-m-radius semicircle, and 15-m-wide strip transects relative to small mammal trap stations. Trap stations (solid circles) are located at IS-m intervals along permanent transects.*

twigs still intact; (2) larger branches still intact and often holding the log above ground; (3) lying on the ground but with most of the length still intact; (4) rotten and soft with much of the length reduced and the bole partly buried in litter.

Data on hardwood densities (means for each species by stand) were furnished by the Silvicultural Research Group.[3] One measurement of pine and hardwood basal area was also taken from the center of each 5-m-radius semicircle using a 10-factor (English) prism; all dam were converted to metric values. All snags (standing dead trees ≥10 cm in d.b.h. and ≥1 m tall) were tallied within the 15-m-wide belt transect (fig. 2) along its entire length (1,365 to 1,425 m depending on stand size and shape; 2.05 to 2.14 ha/stand) by decay class and measured for d.b.h. Decay classes were modified from Neiuo and others (1985): (1) full height with branches and fine twigs; (2) some major branches remaining, may have lost up to one-half of upper bole; (3) no major branches remaining, >2 m tall, more than half the upper boie gone or trunk less than half its original diameter; (4) sapwood gone, <2 m tall, more decayed than class 3. Snag data presented here were grouped into three diameter classes based on minimum diameter requirements of primary cavity nesters (Hamel 1992): (1) below minimum size (10.0 to 14.9 an), (2) adequate for smaller cavity nesters (15.0 to 34.9 cm), and (3) suitable for larger cavity nesters (≥35.0 cm). All stumps within the 5-m-radius semicircle having a diameter of ≥15.2 cm were tallied. Stump and snag data were converted to densities (number/ha).

Horizontal foliar cover was estimated using a 0.5- by 0.5-m density board (Nudds 1977). Readings were taken perpendicular to transect lines across the center of each 2- by 2-m quadrat from a fixed distance of 15 m between the density board (positioned on the transect side of each quadrat) and the observer. Three vertical read@ (density board resting on the ground and centered at 1 and 2 m) were taken across each quadrat. Readings were averaged, yielding one value pa height per station. The variance among readings for each zone across the 30 stations was computed as a measure of habitat patchiness (Anderson and Ohmart 1986).

Data being colkcted by several other research teams will eventually be used to complement our habitat data. For example, the Biodiversity Research Group is collecting foliage cover data by species for herbaceous and woody plants during summer. Inferences on availability of key wildlife forage species will be based on these dam. Data being collected by the Silvicultural Research Group on hardwood diameters, species, and dominance (canopy position) will be used to compare relative hard mast production potentials for each of the treatments. These data were not available for inclusion in this report. Avian micro-habitat data that are being collected by Petit and others (this volume) on five to six 40-m-radius bird censusing plots located in each stand will be summarized at a later date.

ANALYSES

Two hypotheses were tested: (1) there were no differences in various habitat parameters among the four physiographic zones prior to treatment implementation and (2) there were no differences in habimt parameters among stands (grouped by future treatments) before treatment.

Differences among zones (blocks) and future treatments in horizontal cover, litter depth, ground/foliar cover (rock, bare ground, litter, down wood, forbs, graminoids, and woody plants), stump density, and basal area of pines and hardwoods were analyzed in a randomized block design with both experimental error and sampling error ($n = 600$ [20 experimental units by 30 pints] except forb, graminoid, and woody plant cover [$n = 597$]). If the ratio of experimental error to sampling error waa significant ($P < 0.05$), experimental error was used to test fa effects of future treatments and zones; if not, sampling error was used. This ratio was significant in all but two cases: percent bare ground ($P = 0.3399$) and percent woody cover ($P = 0.5907$).

Differences in horizontal patchiness (variance of horizontal cover in each stand), snag density (based on one value per stand), and hardwood density (obtained as a mean fa each stand) data were tested using experimental error. Down log volume was also analyzed using experimental error because of the high incidence of zeros (81 to 100 percent of values).

Dam were examined fa normality and homogeneity of variance. For one+way ANOVAs, densities of stumps, snags, and hardwoods and volume of down logs were rank-transformed and analyzed using Conover and Iman's (1981) nonparametric procedure. Percentage dam (cover and density board) were arcsine square root-transformed to improve variance homogeneity. Tukey's HSD was used fa separation of means. All tests were at the 0.05 level of significance.

[3] Unpublished data file "T3NS.DAT" on file with USDA Forest Service, Southern Forest Experiment Station, Nacogdoches, TX 75962.

RESULTS

Habitat Characteristics—Study Wide

Descriptive statistics for the various habitat parameters collected on all 20 wildlife stands are shown in table 2. With the exception of snag densities (which are based on a 15-m-wide by 1,365- to 1,425m-long belt transect through each stand), each mean is an average across 20 stand means, each of which is based on data from 30 sampling plots.

From an overall wildlife standpoint, these stands are characterized by high canopy coverage, an abundance of mostly small hardwoods, very limited winter herbage and browse supplies, moderate snag densities (see discussion section), and small amounts of down woody materials.

Differences by Zones

When habitat parameters were compared among physiographic zones ($n = 5$ stands/zone), means of only 11 of the 69 variables (tables 3 through 5) were different ($P < 0.05$). Even among these 11 variables, however, tk magnitude of differences was generally small Although these dam indicate that these stands are relatively uniform across zones, future statistical tests for some habitat parameters are likely to be more powerful if zones are included as a separate source of variation.

Differences by Future Treatments

Only 1 of the 69 variables (volume of down pine logs, decay clam 3) differed significantly among future treatments ($n = 4$ replications/treatment) (tables 6 through 8). Only ok additional variable (total volume of down logs, decay class 3) kd a significance level of <0. 10 (table 8).

DISCUSSION

Within inherent edaphic and climatic limitations, forest management practices in the Ouachita Mountains are the primary determinants of wildlife kbitat sufficiency. Although snag densities and volume of down wood are partially a function of natural disturbance events (lightning, windthrow, wild fire, insects, and disease) and natural &cay rates, forest management activities (such as rotation length, frequency and extent of thinning operations, season and frequency of prescribed burning, and hardwood control practices) can greatly influence their abundance and availability over time.

The availability of snags in Southeastern and South Central States varies widely by forest type and stand age (McComb and others 1986); however, the range in densities is much narrower when only pine types are compared (table 9). Due to differences in diameter classes, data in table 9 are not directly comparable; however, they suggest that snag densities in this study fall within ranges typical of other regional sites.

The minimum snag requirements fa cavity-nesting bird populations that kve ken developed fa different regions vary widely depending on whether reserve snags are included to account for unsuitable/unused snags and those required as replacement snags (Carmichael and Guynn 1983, Evans and Conner 1979). Based on the very conservative minimum snag requirements developed by Carmichael and Guynn (1983). which included no provision fa reserves, snag densities in this study are insufficient to support high populations of cavity nesters that require snags ≥35 cm in d.b.h.—such as pileated woodpeckers (*Dryocopus pileatus*), red-bellied woodpeckers (*Melanerpes carolinus*), red-beaded woodpeckers (*Melanerpes erythrocephalus*), or barred owls (*Strix varia*) (*Had* 1992). Pretreatment bird surveys also support this premise. Compared with other pine-associated forest types in tk Southeast, these 20 stands had comparable numbers of bird species within all but the cavity nesting guild (Petit and others, this volume). A shortage of suitable cavity trees is most likely tk primary cause fa this difference. Furthermore, because few of the snags are of recent origin (decay class 1, tables 4 and 7), sustainable supplies of snags over time should k of concern

Given their abundance and insectivorous diet, cavity-nesting birds play an important role in control of forest insect pests. As primary cavity nesters, woodpeckers create cavities needed by a wide variety of vertebrates and invertebrates. Consequently, cavity nesters (especially woodpeckers) are of major ecological importance, and their welfare should k a primary concern under ecosystem management.

The importance of large down woody debris has not been adequately assessed for southeastern forests. Nevertheless, based on extensive research in the Pacific Northwest, woody debris is presumably of major ecological significance elsewhere. Even though trees as small as 10 cm in diameter were included, volume of down wood was low on all sites. Furthermore, quantities of down logs within decay classes 1 and 2 (recent origin) were much lower than in decay classes 3 and 4 (tables 5 and 8), suggesting that down-log abundance will k even lower as decay classes 3 and 4 disappear. Down logs in decay

Table 2.—*Descriptive statistics for habitat measurements from wildlife research stands in the Ouachita Mountains of Arkansas, 1992*[*]

Habitat parameter	Mean	SE	Minimum	Maximum	Coef. var. (%)
Basal area (m^2/ha)					
Pine	17.6	0.9	12.5	24.2	22.4
Hardwood	a.4	0.6	4.3	14.2	33.4
All	26.0	1.0	18.1	37.1	16.8
Hardwoods (no./ha)					
9.1-24.3 cat d.b.h.	351.2	18.9	218.9	538.3	24.1
24.4-39.5 cm d.b.h.	27.1	3.9	5.2	72.7	64.1
39.CW.E cm d.b.h.	3.5	0.9	0.4	18.0	111.9
≥54.9 cm d.b.h.	0.4	0.2	0.0	4.0	205.9
Snags (no./ha)[†]					
10.0-14.9 cm d.b.h.	10.1	1.3	0.9	20.6	59.7
15.0-34.9 cm d.b.h.	6.7	1.0	1.4	17.8	68.9
≥35.0 cm d.b.h.	0.8	0.2	0.0	28	95.6
Stumps (no./ha)	101.9	17.6	0.0	339.5	77.4
Down wood volume (m^3/ha)[‡]					
Decay class 1	0.09	0.1	0.0	0.8	273.6
Decay class 2	0.31	0.2	0.0	3.7	238.2
Decay class 3	270	0.4	0.1	6.3	70.3
Decay class 4	3.87	0.6	0.1	11.2	75.1
All	7.02	0.9	1.6	14.9	58.4
Ground/foliar cover (%)					
Rock	2.2	0.4	0.2	6.1	85.8
Bare ground	1.4	0.2	0.2	4.0	69.2
Litter	93.1	0.6	87.7	9a.1	2.7
Down wood[§]	3.3	0.2	1.4	5.2	33.9
Forbs	2.3	0.5	0.6	9.4	88.2
Graminoids	1.4	0.3	0.1	5.4	96.4
Woody plants	0.3	0.1	0.0	1.4	122.5
Litter depth (cm)	21	0.1	1.7	3.1	14.9
Horizontal cover (%)[¶]					
0.00-0.50 m	53.0	3.1	26.9	86.0	26.5
0.75-1.25 m	32.1	27	i5.a	60.7	37.0
1.75-225 m	3a.7	3.5	21.a	76.8	40.3
Horizontal patchiness					
0.00-0.50 m	976.9	59.3	546.6	1445.5	27.1
0.75-1.25 □	911.3	52.a	2a5.9	1444.8	25.9
1.75-2.25 m	971.9	521	714.4	1364.3	24.0

[*] Values were computed using stand averages (n = 20 stands). Witb tbt exception of snag densities (derived from one strip transect/stand), each stand average was based on 30 sampling points.

[†] Totals across pines, hardwoods, and four decry classes.

[‡] Values are totals for pine and hardwoods (≥10 cm average diameter); decay class 1 is least decayed, 4 it most dtaytd (see tea).

[§] All woody material z2.54 cm in diameter.

[¶] Percent obscurity from 15 m.

Table 3.—*Habitat characteristics* ($\bar{x} \pm SE$) in *wildlife* research *stands* in *the Ouachita Mountains of Arkansas* by *physiographic zone, 1992*

Habitat parameter	F*	P†	West		North		South		East	
Basal area (m^2/ha)										
Pine	3.73	0.0331	15.9AB	0.6	21.2A	2 0	14.98	1.0	18.5AB	1.8
Hardwood	1.10	0.3768	7.8	0.7	9.a	1.7	6.8	1.2	9.0	1.1
All	12.45	0.0002	23.8AB	0.2	31.0C	1.6	21.7A	1.0	27.5BC	1.3
Hardwoods (no./ha)										
9.1-24.3 cm d.b.h.										
Oaks	0.59	0.6331	287.0	526	2125	18.5	2111.5	37.6	206.2	35.8
Hickoria	2.42	0.1038	27.5	24	67.1	120	68.1	16.9	64.6	18.8
Others	1.05	0.3971	53.3	21.0	61.4	13.8	90.0	21.9	48.7	168
All	0.22	0.8844	367.a	46.4	341.0	30.7	376.7	50.1	319.5	26.5
x4-39.5 cm d.b.h.										
Oaks	0.71	0.5619	23.1	5.9	30.5	9.a	22.0	7.7	14.3	20
Hickoria	0.28	0.11361	1.6	1.3	1.7	0.6	1.5	0.9	27	1.3
Others	0.66	0.5858	2.8	1.4	3.6	1.6	3.6	1.8	1.1	0.8
All	0.66	0.5899	27.5	5.2	35.8	11.1	27.1	9.2	18.1	3.6
39.6-54.8 an d.b.h.										
Oaks	0.31	0.8199	3.7	1.3	4.5	25	2.1	0.8	23	0.5
Hickoria	a34	0.7967	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Others	0.85	0.4865	0.0	0.0	0.7	0.6	0.3	0.3	0.1	0.1
All	0.08	0.9701	3.a	1.4	5.4	3.2	25	0.9	24	0.6
≥54.9 cm d.b.h.										
Oaks	0.65	0.5950	0.2	0.1	0.7	0.6	0.3	0.2	0.1	0.1
Hickories*			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Others	0.24	0.8669	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1
All	0.62	0.6147	0.3	0.1	0.9	0.0	0.5	0.2	0.1	0.1
Stump density (no./ha)	256	0.0913	54.3	23.3	146.0	50.9	69.6	9.8	137.5	324
Ground/foliar cover (%)§										
Rock	0.05	0.9860	25	1.2	25	1.1	1.8	0.4	20	0.7
Bare ground	3.98	0.0080	0.7A	0.2	1.5AB	0.2	1.2AB	0.3	2.3B	0.6
Litter	2.04	0.1492	94.a	1.1	92.4	1.3	93.9	1.0	91.5	0.8
Down wood	0.60	0.6223	3.0	0.6	3.0	0.6	3.4	0.4	3.8	0.5
Forts	1.47	0.2593	23	0.7	1.3	0.6	3.6	1.5	21	0.6
Graminoids	7.63	0.0022	3.0A	0.7	0.3B	0.2	1.0B	0.4	1.2AB	0.3
Woody plants	0.64	0.5918	0.1	0.1	0.3	0.1	0.5	0.3	0.3	0.1
Litter depth (cm)	1.56	0.2387	21	0.1	22	0.2	22	0.1	1.9	0.1
Horizontal cover (I)										
0.00-0.50 m	1.15	0.3590	51.2	1.9	47.3	4.5	50.9	8.6	62.4	7.6
0.75-1.25 m	0.46	0.7174	3i.a	1.7	28.7	1.3	37.7	7.5	30.3	7.9
1.75-2.25 m	3.66	0.0351	34.9A	2.6	32.0AB	4.2	55.6B	9.5	32.4AB	4.6
Horizontal patchiness										
0.00-0.50 m	3.03	0.0598	am	49	1200	88	844	113	1044	140
0.75-1.25 m	2.65	0.0841	a56	64	1015	77	721	119	1053	106
1.75-2.25 m	2.14	0.1357	886	a9	1048	130	825	54	1128	95

*One-way ANOVA F value (stump and hardwood density data were rank-transformed); means within rows followed by unlike letters are statistically different ($P < 0.05$).

†Probability associated with am-way ANOVA F value.

*All values were zero.

§Woody (≤2 m tall) and herbaceous plant cover measured in late winter.

Table 4.—*Snag densities (no./ha; $\bar{x} \pm SE$) in wildlife research stands by decay and diameter classes and by physiographic zones, 1992*[*]

Decay class[†]	Diameter class (MI)	F[‡]	P[§]	West		North		South		East	
1	10.0-14.9	13.73	0.0001	2.31AB	0.67	0.19BC	0.12	3.83A	0.80	0.00C	0.00
	15.0-34.9	7.77	0.0020	0.19A	0.12	0.00A	0.00	1 %B	0.73	0.29A	0.29
	235.0	0.95	0.4386	0.19	0.12	0.09	0.09	0.09	0.09	0.00	0.00
2	10.0-14.9	2.67	0.0824	2.78	0.84	1.14	0.32	2.62	0.82	2.68	0.34
	15.0-34.9	1.29	0.3133	1.73	0.43	0.57	0.46	1.59	0.48	1.24	0.45
	≥35.0	0.34	0.7967	0.19	0.19	0.10	0.10	0.09	0.09	0.00	0.00
3	10.0-14.9	1.26	0.3210	2.78	1.12	4.41	1.77	6.64	1.68	4.02	0.74
	15.0-34.9	0.95	0.4398	2.21	0.54	239	1.23	4.21	1.74	3.06	0.57
	≥35.0	2.21	0.1263	0.48	0.15	0.58	0.18	0.19	0.12	0.28	0.19
4	10.0-14.9	2.07	0.1440	0.67	0.36	2.11	0.62	1.40	0.51	2.78	0.87
	15.0-34.9	5.00	0.0124	0.96AB	0.42	2.38AB	1.21	0.47A	0.21	3.468	0.95
	≥35.0	1.75	0.1981	0.00	0.00	0.30	0.28	0.00	0.00	0.38	0.24
N1	10.0-14.9	0.98	0.4260	8.55	2.78	7.86	2.72	14.50	3.17	9.49	1.57
	15.0-34.9	1.22	0.3347	5.09	1.05	5.34	2.86	a.23	2.68	8.06	1.24
	≥35.0	1.03	0.4049	0.86	0.28	1.15	0.49	0.38	0.27	0.67	0.19

'Includes all pines and hardwoods ≥10 cm in d.b.h. and ≥1 □ tall.

[†]Decay classes described in text

*One-way ANOVA F value; data were rank-transformed. Means within rows followed by unlike letters are statistically different (P <0.05).

[§]Probability associated with au-way ANOVA F value on rank-transformed data.

Table 5.—*Volume of down logs (m^3/ha; $\bar{x}$ ± SE) in wildlife research stands by decay class and physiographic zone, 1992*[*]

Decay class[†]	Class	F[‡]	P[§]	West		North		South		East	
1	Pine	1.00	0.410	0.00	0.00	0.00	0.00	0.16	0.16	0.00	0.00
	Hardwood	2.66	0.0837	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.00
	Unknown	1.00	0.4182	0.00	0.00	0.00	0.00	0.0)	0.0)	0.00	0.00
	All	5.90	0.0065	0.00A	0.00	0.00A	0.00	0.35B	0.18	0.00A	0.00
2	Pine	1 %	0.0635	0.07	0.07	0.00	0.00	a15	0.07	0.00	0.00
	Hardwood	1.26	a3199	0.29	0.13	0.75	0.75	a23	0.23	0.00	0.00
	Unknown[¶]			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	All	1.66	0.2157	0.35	0.16	0.75	a75	0.38	0.29	0.00	0.00
3	Pine	1.61	a2257	0.66	a34	2.16	0.80	203	0.67	1.93	0.62
	Hardwood	0.88	0.4745	0.42	0.37	212	1.07	a32	0.29	0.97	0.57
	Unknown	1.75	0.1966	0.13	0.10	0.00	0.00	0.07	0.06	0.00	0.00
	All	3.11	0.0558	1.21	0.68	4.27	0.93	242	0.75	2 %	a57
4	Pine	3.03	0.0599	224	0.92	234	1.26	2.08	0.34	6.17	1.46
	Hardwood	1.50	0.2527	0.50	0.50	0.67	0.22	0.12	0.12	0.49	0.43
	Unknown	8.25	0.0015	0.43A	0.12	0.00B	0.00	0.44AB	0.28	0.00B	0.00
	All	2.89	0.0677	3.17	1.12	3.01	1.45	263	a42	665	1.36
All	Pine	1.95	0.1628	2 %	1.23	4.50	1.96	4.42	0.95	8.10	1.13
	Hardwood	0.83	0.4955	1.21	0.50	3.53	1.86	0.81	au	1.45	0.98
	Unknown	11.45	0.0003	0.56A	0.15	0.00B	0.00	0.55A	0.37	0.00B	0.00
	All	1.39	0.2808	4.73	1.66	8.03	241	5.78	1.12	9.55	1.63

● locloda all logs with an average diameter of ≥10 cm.

[†]Decay classes described in text.

[‡]One-way ANOVA F value; data were rank-transformed. Means within rows followed by unlike letters are statistically different (P <0.05).

[§]Probability associated with am-way ANOVA F value on rank-transformed data.

[¶]All values were zero.

Table 6.—*Habitat characteristics ($\bar{x}$ ± SE) in wildlife research stands in the Ouachita Mountains of Arkansas by future treatment, 1992*

Habitat parameter	F*	P†	Clearcut		Shelterwood		Single-tree selection		Group selection		Control	
Basal area (m^2/ha)												
Pine	0.45	0.7706	17.5	1.4	18.1	1.8	la.2	2.9	15.3	0.5	19.0	2.9
Hardwood	0.40	0.8032	7.2	0.8	a.1	1.5	7.8	1.5	9.6	1.8	a.9	1.6
All	0.28	0.8859	24.8	1.4	26.2	2.0	26.0	1.5	25.0	1.4	27.9	4.2
Hardwoods (no./ha)												
9.1-24.3 cm d.b.h.												
Oaks	0.70	0.6469	254.2	34.4	177.4	36.0	232.1	56.6	278.0	522	213.6	325
Hickories	1.06	0.4082	33.1	a.5	79.4	23.5	63.5	19.3	67.5	14.7	40.6	9.2
Others	1.16	0.3686	2a.7	2.8	71.0	15.7	74.6	31.9	53.8	15.3	88.7	23.1
All	0.64	0.6418	315.9	33.9	327.1	20.2	370.2	77.6	399.3	30.4	342.9	36.8
24.4-39.5 cm d.b.h.												
Oaks	0.84	0.5220	27.5	6.5	16.4	4.6	27.3	8.0	25.4	13.3	15.6	5.1
Hickories	0.01	0.9965	1.5	0.9	2 3	1.4	20	1.6	2 3	1.4	12	0.5
Others	1.03	0.4228	0.6	0.5	24	0.9	4.2	22	1.4	1.1	s.l	20
All	0.48	0.1499	29.6	6.6	21.0	5.8	33.6	9.5	29.1	14.9	220	6.9
39.6-54.8 cm d.b.h.												
Oaks	0.36	0.8320	2 3	1.0	2.8	1.5	3.4	1.1	5.2	3.1	21	0.4
Hickotia	0.50	0.1326	0.2	0.2	0.0	0.0	0.1	0.1	0.2	0.2	0.0	0.0
Others	1.05	0.4143	0.0	0.0	0.1	0.1	0.5	0.3	0.7	0.7	0.0	0.0
All	0.67	0.6218	2.5	1.1	29	1.5	4.0	1.1	6.1	4.0	21	0.4
≥54.9 cm d.b.h.												
Oaks	1.10	0.3942	0.2	0.1	0.1	0.1	0.3	0.2	1.0	0.1	0.1	0.1
Hickories‡			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
others	0.52	0.7258	0.1	0.1	0.0	0.0	0.1	0.1	0.2	0.2	0 2	0.1
All	0.60'	0.6682	0.3	0.2	0.1	0.1	0.4	0.2	1.2	1.0	0.3	0.2
Stump density (no./ha)	0.61	0.6647	104.0	39.6	163.4	58.8	99.7	45.4	61.5	20.3	80.6	19.8
Ground/foliar cover (%)§												
Rock	0.4 1	0.797 5	2 7	0.8	1.1	0.4	1.5	0.7	2.2	1.5	2.8	1.2
Bare ground	1.41	0.2304	0.8	0.2	1.2	0.2	1.4	0.3	1.8	0.6	1.9	0.5
Litter	1.08	0.3992	93.6	1.5	94.2	0.4	93.9	0.8	93.2	22	90.8	0.3
Down wood	0.74	0.5799	3.1	0.7	3.0	0.2	3.4	0.5	29	0.8	4.0	0.5
Forbs	0.52	0.7238	1.7	0.5	21	1.0	1.6	0.6	2.6	0.7	3.6	20
Graminoids	0.41	0.154 1	0.7	0.4	1.6	0.8	1.1	0.6	1.9	1.2	1.1	0.2
Woody plants	0.90	0.4608	0.1	0.0	0.3	0.1	0.4	0.2	0.2	0.1	0.6	0.4
Litter depth (cm)	0.40	0.8048	2.1	0.1	20	0.1	2.1	0.1	23	0.3	22	0.2
Horizontal cover (%)												
0.00-0.50 m	0.77	0.5597	42.1	5.7	54.2	1.2	55.3	11.1	54.3	a.7	59.0	5.0
0.75-1.25 m	0.79	0.5514	25.4	5.4	29.7	0.7	39.2	7.2	34.8	7.1	31.5	7.4
1.75-2.25 m	0.56	0.6967	31.2	5.0	39.7	3.8	46.9	a.3	40.9	122	34.8	9.0
Horizontal patchiness												
0.00-0.50 m	0.42	0.7920	923	128	1131	124	919	190	920	69	991	166
0.75-1.25 m	0.69	0.6080	M1	187	863	108	1083	155	925	51	au	32
1.75-2.25 m	1.24	0.3349	972	113	1083	121	1113	144	858	117	833	53

*One-way ANOVA *F* value (stump and hardwood density data were rank-transformed); means within tows followed by unlike letters are statistically different (*P* <0.05).

†Probability associated with one-way ANOVA *F* value.

‡All values were zero.

§Woody (≤2 m tall) and herbaceous plant cover measured in late winter.

Table 7.—Snag densities (no./ha; $\bar{x} \pm SE$) in wildlife research stands by decay and diameter classes ad by future treatments, 1992*

Decay class†	Diameter class (cm)	F‡	P§	Clearcut		Shelterwood		Single-tree selection		Group selection		Control	
1	10.0-14.9	0.20	0.9353	225	1.33	1.28	1.28	1.30	0.80	1.89	1.07	1.19	0.74
	15.0-34.9	0.15	0.9589	0.35	0.22	0.23	0.23	0.94	0.94	1.06	0.90	0.4:	0.34
	235.0	1.09	a3985	a12	0.12	0.00	0.00	0.12	0.12	0.24	0.14	0.00	0.00
2	10.0-14.9	0.88	0.5006	261	0.49	1.40	0.43	1.79	0.63	2.85	0.77	2.88	1.11
	15.0-34.9	0.25	0.9060	1.30	0.76	1.17	0.40	1.55	0.56	1.56	0.64	0.84	0.37
	≥35.0	1.56	0.2359	0.00	0.00	0.23	0.23	0.24	0.14	0.00	0.00	0.00	0.00
3	10.0-14.9	1.78	0.1863	4.86	1.38	1.7s	au	3.54	1.96	6.87	1.61	5.31	1.45
	15.0-34.9	0.92	0.4804	249	0.92	1.63	a73	4.38	2.18	4.16	1.06	216	0.57
	235.0	0.76	0.5647	0.36	0.23	0.35	0.22	0.48	0.00	0.60	0.23	0.12	0.12
4	10.0-14.9	0.92	0.476 1	1.42	0.46	a94	0.51	1.19	0.49	237	1.14	278	0.86
	15.0-34.9	0.90	0.4896	214	0.89	0.47	0.27	1.44	au	274	1.56	230	1.44
	≥35.0	1.20	0.3516	0.24	0.24	0.00	0.00	0.12	0.12	0.59	a36	0.00	0.00
All	10.0-14.9	1.43	0.2725	11.14	3.47	5.37	2.23	7.82	3.08	13.99	271	1216	276
	15.0-34.9	1.69	0.2047	6.29	1.50	3.50	1.04	8.30	3.34	9.52	237	5.79	2.48
	235.0	2.17	0.1221	0.72	a24	0.58	0.35	0.96	0.28	1.43	0.51	0.12	0.12

*Includes all pines and hardwoods ≥10 cm in d.b.h. and ≥1 m tall.

†Decay classes described in text.

‡One-way ANOVA F value; data were rank-transformed.

§Probability associated with m-way ANOVA F value on rank-transformed data.

Table 8.—*Volume of down logs* (m^3/ha; $\bar{x} \pm SE$) *in wildlife research stands by decay class and future treatments, 1992*[*]

Decay class[†]	Class	F[‡]	P[§]	Clearcut		Shelterwood		Single-tree selection		Group selection		Control	
1	Pine	1.00	0.4380	0.00	0.00	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00
	Hardwood	0.75	0.5725	0.00	0.00	0.01	0.01	0.17	0.17	0.00	0.00	0.00	0.00
	Unknown	1.00	0.4380	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.00
	All	0.50	0.7328	0.00	0.00	0.21	0.21	0.17	0.17	0.05	0.05	0.00	0.00
2	Pine	0.26	0.8975	0.00	0.00	0.05	0.05	0.10	0.10	0.05	0.05	0.08	0.08
	Hardwood	0.52	0.7258	0.18	0.18	0.00	0.00	0.36	0.27	0.93	0.93	0.10	0.10
	Unknown[¶]			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	All	0.31	0.6691	0.18	0.18	0.05	0.05	0.46	0.36	0.98	0.92	0.18	0.18
3	Pine	3.26	0.0111	1.47A	0.70	0.76A	0.31	1.74AB	0.29	0.78A	0.42	3.72B	0.68
	Hardwood	1.52	0.2472	0.12	0.09	0.35	0.35	1.50	0.85	1.97	1.33	0.84	0.48
	Unknown	0.88	0.5005	0.00	0.00	0.13	0.13	0.00	0.00	0.08	0.08	0.04	0.03
	All	2.61	0.0775	1.59	0.72	1.23	0.23	3.24	0.91	2.84	1.23	4.59	0.61
4	Pins	1.42	0.2758	3.67	2.52	299	1.40	1.92	0.84	201	0.21	5.46	0.93
	Hardwood	0.44	0.7766	0.10	0.10	0.67	0.61	0.73	0.52	0.38	0.21	0.33	0.33
	Unknown	0.55	0.7039	0.42	0.24	0.11	0.11	0.03	0.03	0.44	0.32	0.09	0.09
	All	1.02	0.4294	4.19	234	3.76	1.59	2.68	1.26	2.83	0.45	5.88	1.16
All	Pine	2.27	0.1096	5.14	3.11	3.99	1.15	3.75	0.97	2.84	0.63	9.26	1.12
	Hudwoal	1.15	0.3704	0.40	0.23	1.02	0.61	2.77	1.06	3.29	243	1.27	0.73
	unknown	0.30	0.8709	0.42	0.24	0.24	0.24	0.03	0.03	0.57	0.45	0.13	0.12
	All	1.14	0.3755	5.95	281	5.25	1.51	6.55	1.81	6.70	21	10.66	1.56

● Includs all logs with an avenge diameter of ≥10 cm.

[†]Decay classes described in text.

[‡]One-way ANOVA F value; data were rank-transformed. Means within rows followed by unlike letters are statistically different (P <0.05).

[§]Probability associated with an-way ANOVA F value cm rank-transformed data.

[¶]All values were zero.

Table 9.—*Comparative snag densities for pine forest types of the Southeastern United States*[*]

State (region)	Forest type	Diameter class	Snag density	Reference
		-----cm-----	no./ha	
South Carolina (Upper Piedmont)	Pine-hardwood	10.1-40.0	30.1	Carmichael and Guynn 1983
		≥40.1	0.8	
Texas[†] (eastern forests)	Loblolly-shortleaf	12.7-32.8	12.1	Rudis 1988a
		≥33.0	1.5	
Louisiana[†] (Statewide)	Loblolly-shortleaf	12.7-32.8	9.5	Rudis 1988b
		≥33.0	1.3	
Arkansas (this study)	Shortleaf pine-hardwood	15.0-34.9	6.7	This study
		≥35.0	0.8	
Mississippi[‡] (unknown)	Pine-hardwood	≥10.0	6.4	McComb 1979
Florida (Statewide)	Loblolly pine	≥12.7	5.4	McComb and others 1986
South Carolina (Coastal Plain)	Pine and pine-hardwood mix	12.7-35.6	3.0	Harlow and Guynn 1983
		≥38.1	0.5	

[*]Data adapted from references shown.

[†]Values include salvable and nonsalvable dead trees.

[‡]Region unknown; cited by McComb and others 1986.

class 1 were absent in three of the physiographic zones, nor were any in decay class 2 found in east zone stands (table 5).

Production of hard mast (acorns and nuts) is dependent on many factors including density and species of mast-producing trees, site quality, tree age, canopy position, and canopy form. Reliable estimates of mast production are costly to obtain and were not attempted in tbis study. However, based on hardwood-stocking information and available literature, several general statements can be made regarding hard-mast availability.

Given their relatively young age (average of 65 years for all 52 stands) and low site indices (Guldin and others, this volume), these stands would not be expected to have an abundance of mature, large hardwoods regardless of past management practices. On a density basis, hardwoods ≥9.1 cm in d.b.h. comprise 51 percent (mean across 20 stands) of the trees in these stands, and hard mast producing species (oaks and hickories) comprise a majority of the hardwoods (table 3). However, most of the oaks and hickories are too small to produce much mast. Based on research from eastern Texas, oaks less than about 25.4 cm in dbh produce little or no mast (Goodrum aod others 1971).

In managed forests, sufficient supplies of critical habitat features (like large snags and den trees) must be achieved through intentional actions. Recent changes in management on the Ouachita National Forest reflect a more socially acceptable and ecologically sensitive management approach. For example, Amendment 12 (approved July 22.1993) to the Forest Plan far the Ouachita National Forest will, among other things, ensure retention of additional hardwoods in pine management types. Where seed tree and shelterwood regeneration systems are to be employed, this amendment also requires that a mixed overstory (≥1.15 m^2 of hardwood and 2.30 to 3.44 m^2 of pine BA/ha) be retained indefinitely to enhance structural diversity, visual quality, sad ecological complexity. Longer retention of more pines and hardwoods will eventually result in additional larger snags and down logs and greater hard mast supplies. This should improve wildlife abundance and species richness, especially far cavity nesters and bark-gleaning birds (Stribling and others 1990).

Low densities of small mammals captured on these sites (Tappe and others, this volume) are most likely due to a combination of factors including limited winter forage and down wood. All of the reproduction cutting methods being tested should increase forage availability, amounts of down wood, and cover for a number of years, and total numbers of small mammals should increase markedly. Responses of seed-eating species will be of special interest under those management systems dependent on natural regeneration.

Greenbelt strips along ephemeral drainages comprise a significant amount of area within these and similar stands and afford an excellent opportunity to increase habitat features that are in short supply within the surrounding stand. Management of these strips should be designed to increase supplies of snags, large down wood, hard mast, and den trees.

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