Streamside and Adjacent Upland Forest Habitats in the Ouachita Mountains

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Abstract: Habitat characteristics of 2 landforms, flood plain and adjacent upland forest, were sampled along perennial streams in 3 regions of the Ouachita Mountains, Arkansas. Stand density, basal area, and den tree density were not different between landforms or among mountain regions. However, the proportions of stand density and basal area comprised of hardwood species and nut-producing species were usually different between landforms and regions. Differences in species composition were consistent, with more hardwoods in flood plains than in uplands, and more in the Crystal and Zig Zag mountains than in the Fourche Mountains. All dens (cavity entrances $\geq$2.5 cm) were in hardwoods. Important den tree species were American sweetgum (*Liquidambar styraciflua*), blackgum tupelo (*Nyssa sylvatica*), and white oak (*Quercus alba*).

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Pine plantations account for roughly 1 out of 3 ha of pine forests in the southeastern United States, and over 162,000 ha of harvested forestland per year are being regenerated to pine plantations (Knight 1984, 1985). On private industrial timberlands, where pine management is implemented most intensively, and on most public forestlands, streamside management zones have become a standard practice. Although approaches vary by landowner and location, the most common practice involves retention of strips or stringers of hardwood or mixed pine-hardwood along perennial and intermittent streams to protect water quality and maintain habitats different than adjacent pine plantations. The importance of riparian habitats to fish and wildlife communities has been demonstrated in the arid Southwest (Johnson and Jones 1977), and riparian areas have become a focal point of forest management in the Pacific Northwest (Natl. Counc. Pap. Ind. for Air and Stream Improvement

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(NCASI) 1987, Raedeke 1988). The retention of streamside management zones with natural riparian vegetation has been recommended for the integration of wildlife and forest management in southern pine forests (Buckner 1982, 1983; Owen 1984; Wigley 1986). Streamside management zones contribute to the maintenance of diverse wildlife communities in managed forests, but quantitative data on wildlife impacts, associated with streamside management activities, are needed by forest-land managers.

We conducted a study of streamside habitats in the Ouachita Mountains of Arkansas. The purpose of this paper is to provide information on forest stand characteristics of existing streamside and adjacent upland habitats in the Ouachita Mountains and to make recommendations for sampling procedures. Stand density and basal area, pine-hardwood composition, density of live trees with dens, and important nut-producing and den tree species are discussed.

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Methods

The study was conducted in forest habitats adjacent to 9 second- and third-order perennial streams in the Ouachita Mountains of Garland, Perry, and Yell counties, Arkansas. The Ouachita Mountains are characterized by rugged topography and a natural second-growth forest of shortleaf pine (*Pinus echinata*) and upland hardwoods. Sample stands were located along reaches of 3 streams in each of 3 distinct mountain regions: the Zig Zag, Crystal, and Fourche mountains. According to stand inventory information (Weyerhaeuser Co. files), dominant trees in all the sample stands were approximately 40 to 90 years old, and no selective logging had occurred in the last 20 years.

The Zig Zag Mountains, a complicated system of parallel plunging anticlines and synclines formed mostly from shale and sandstone, and the Crystal Mountains, an anticlinal system of parallel ridges formed mostly from sandstone, lie within the Novaculite Uplift Province. The Fourche Mountain Province is an extensive system of ridges with sandstone exposed on upper slopes and side slopes laminated with shales. Gravel content of alluvial soils is highest in the Fourche Mountains and lowest in the Zig Zag Mountains (DeWit and Steinbrenner 1981). Streams have lower base flow in the Fourche Mountains than in the Novaculite Uplift Province.

Characteristics of flood plain and adjacent upland forest habitats were sampled in summer 1980 using a strip transect method. The first transect for each stream was randomly located at a point at least 50 m from a road crossing; thereafter, a total of 20 strips was laid out on 1 side of, and perpendicular to, the stream at 40-m intervals. At each transect location along the stream, flood plain (1 side of stream) and channel widths (Platts et al. 1983) were measured. Flood plains were defined according to the extent of relatively flat topography and the effects of high water during flood flows (exposed tree roots, unconsolidated gravels, and deposits of leaves and small woody debris). The forest habitat sampling strips began at the edge of the stream channel and were 20 m long by 10 m wide. Species, diameter at breast height (dbh), and distance from the channel were recorded for all live trees ≥15 cm dbh within the sampling strips. The presence of dens (cavity entrances ≥2.5 cm) in live trees, as determined by visual observation from ground level, was also recorded.

Density and basal area of all live trees, and relative density and basal area of hardwoods and nut-producing hardwoods (*Quercus* spp., *Carya* spp., *Juglans* spp.) were calculated. Variation in sample data, due to binomial proportions, was normalized by arc sine transformation. Density of live den trees was also calculated. Differences in stand characteristics between floodplain and upland landforms, and among the mountain regions, were tested with analysis of variance and orthogonal contrasts between and within mountain provinces. Differences in channel and floodplain widths were also tested with analysis of variance. Statistical significance was accepted at $P = 0.10$ for all tests.

Due to sampling procedures, the sample of live trees was approximately 2.3 times greater in flood plains ($N = 812$) than in uplands ($N = 347$). Sample area within strip transects totaled 2.58 ha in flood plains and 1.02 ha in uplands. This difference in sample size precluded direct statistical comparison of species richness and diversity between landforms.

Results

Mean channel width of sample streams ranged from 3.8 to 7.1 m and averaged (± *SE*) 5.2 ± 0.1, 4.6 ± 0.4, and 5.2 ± 0.9 in the Zig Zag, Crystal, and Fourche mountain regions, respectively. Mean flood plain width ranged up to 51.0 m and averaged 21.5 ± 7.8, 29.2 ± 7.6, and 37.7 ± 9.0 in the 3 mountain regions, respectively. Channel widths ($P > 0.685$) and flood plain widths ($P > 0.426$) were not different among the mountain regions.

For the combinations of mountain regions and landforms, mean stand density ranged from 280 to 380 trees/ha (Table 1); however, there were no differences between streamside and upland habitats ($P > 0.180$), or among mountain regions ($P > 0.439$). Similarly, stand basal area ranged from 14.5 to 20.6 m^2/ha, but was not different between landforms ($P > 0.448$) or among regions ($P > 0.394$). The most common species (% of trees sampled) in flood plain habitats were shortleaf pine (27%), white oak (20%), American sweetgum (17%), mockernut hickory (*Carya tomentosa*) (5%), and blackgum tupelo (5%). The common species in adjacent uplands were shortleaf pine (38%), white oak (22%), mockernut hickory (10%), northern red oak (*Quercus rubra*) (7%), and American sweetgum (7%). All other species had <5% frequency of occurrence in both habitat types.

Though the study areas and habitats had similar tree densities, basal areas, and common species, there were differences in other stand characteristics (Table 1). For density and basal area, the proportion of hardwoods in sample stands was 41% to 54% higher ($P < 0.014$) for mountains in the Novaculite Uplift Province (Zig Zag

Table 1. Forest stand characteristics of flood plain and adjacent upland habitats along perennial streams in 3 mountain regions of the Ouachita Mountains, Arkansas, 1980.

Landform and mountain region	Density ($\bar{X}$ ± SE)			Basal area ($\bar{X}$ ± SE)		
	Trees/ha	% harwood	% nut-producing	m^2/ha	% hardwood	% nut-producing
Flood plain						
Zig Zag	305 ± 35	94.5 ± 3.0	34.1 ± 10.1	18.5 ± 3.2	93.6 ± 3.1	36.2 ± 11.5
Crystal	340 ± 17	87.1 ± 5.5	53.6 ± 2.1	19.0 ± 0.2	82.6 ± 9.4	50.3 ± 4.5
Fourche	280 ± 28	40.4 ± 9.8	17.6 ± 2.7	14.5 ± 2.3	37.4 ± 7.8	14.2 ± 2.3
Upland						
Zig Zag	319 ± 39	71.3 ± 7.0	50.4 ± 4.4	17.2 ± 4.4	70.4 ± 8.7	53.0 ± 2.7
Crystal	380 ± 35	68.6 ± 4.8	54.4 ± 10.1	20.6 ± 0.7	68.4 ± 8.5	55.8 ± 12.8
Fourche	379 ± 47	28.0 ± 13.0	24.6 ± 9.7	18.5 ± 3.0	26.5 ± 11.3	23.9 ± 8.8

and Crystal) than for mountains in the Fourche Province (Fourche). In the Fourche Mountains we sampled 1.6 pine trees per each hardwood, whereas in the Zig Zag and Crystal mountains we sampled 5.1 hardwoods per each pine. The relative density of white oak, American sweetgum, and mockernut hickory, respectively, averaged 16%, 10%, and 7% higher in the Crystal and Zig Zag than in the Fourche mountains. The hardwood component of forest habitats was also 16% to 18% higher ($P < 0.069$) in flood plains than in uplands, largely because American sweetgum was 11% more abundant in the floodplains. These differences in hardwood components of provinces and landforms are probably related to differences in geology, soils, and moisture conditions. Three species sampled only in the Fourche Mountains reflect the drier, rocky soils found in that region: post oak (*Q. stellata*), black hickory (*C. texana*), and eastern juniper (*Juniperus virginiana*). Within the Novaculite Uplift Province, hardwood components of the Zig Zag and Crystal mountain regions were not different ($P > 0.332$).

Of 31 species of hardwoods sampled, 26 species occurred in the Zig Zag Mountains, 20 in the Crystal Mountains, and 16 in the Fourche Mountains. Only white oak, northern red oak, mockernut hickory, American sweetgum, and blackgum tupelo were found in the flood plains and uplands of all 3 mountain regions. The number of tree species in sample stands correlated ($r = 0.699$, $P < 0.002$) with the relative density of hardwoods. The positive relationship between relative hardwood density and species richness, along with higher hardwood components in flood plain stands than in uplands, suggests that flood plain habitats were richer in species than upland habitats. To accurately compare species richness, each landform should have equal sample area, which was not the case in this study.

The relative density and basal area of nut-producing species were 17% to 36% higher ($P < 0.029$) in the Novaculite Uplift Province than in the Fourche Mountain Province (Table 1), but were not different ($P > 0.151$) between the Crystal and Zig Zag mountains within the Novaculite Uplift. The relative density of nut-producing trees did not differ ($P > 0.209$) between landforms. However, the relative basal area in nut-producing species was 11% higher ($P < 0.073$) in upland stands than in flood plain stands, principally because other hardwood species were 27% less abundant in uplands than in flood plains. Of 468 nut-producing trees sampled, 79% were oaks, 20% were hickories, and 1% were walnuts. The most common nut-producing species in flood plains were white oak (54%), mockernut hickory (15%), and northern red oak (9%); and similarly in uplands, they were white oak (47%), mockernut hickory (21%), and northern red oak (14%). Diameter class distribution of the oaks was comparable in flood plain and upland stands.

Density of live trees with dens (cavities) ranged from 0 to 29.8 trees/ha for individual stands along streams, but mean densities did not differ among mountain regions ($P > 0.884$) or between landforms ($P > 0.506$) (Table 2). The average ($\pm$ SE) for all stands was 12.9 $\pm$ 1.6 den trees/ha. All den trees ($N = 48$) were hardwoods. American sweetgum (40%), blackgum tupelo (21%), and white oak (10%) were the most common den tree species, and each of 10 other species comprised <5% of den trees sampled. The presence of dens in live hardwoods corre-

Table 2. Mean (±SE) density of live den[a] trees in forest habitats adjacent to perennial streams in the Ouachita Mountains, Arkansas, 1980.

Mountain regions and landforms	Den tree density (trees/ha)
Mountain region	
Zig Zag	14.4 ± 4.4
Crystal	12.1 ± 2.8
Fourche	12.1 ± 2.4
Landform	
Flood plain	14.6 ± 2.7
Upland	11.1 ± 1.7

[a]Cavity entrance ≥2.5 cm diameter.

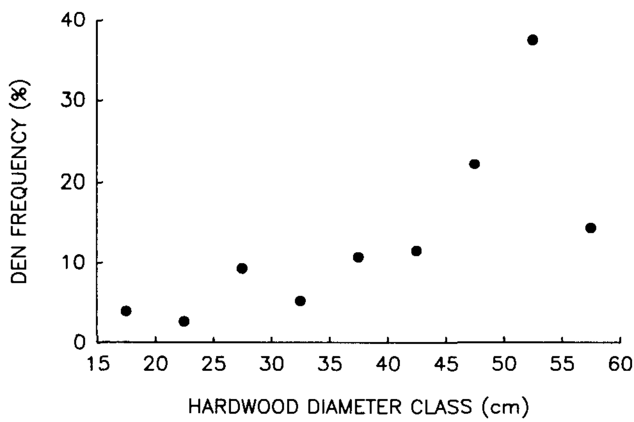

Figure 1. Relationship between the frequency of occurrence of dens (cavity entrance ≥2.5 cm diameter) and diameter of hardwoods in forest habitats adjacent to perennial streams in the Ouachita Mountains, Arkansas, 1980.

lated with tree diameter ($r = 0.774$, $P < 0.022$) (Fig. 1) and was associated with particular hardwood species. For example, 3.4% of trees 15 to 24.9 cm, 7.5% of trees 25 to 34.9 cm, 11.0% of trees 35 to 44.9 cm, and 25.0% of trees ≥45 cm had dens. Species with higher occurrences of dens were blackgum tupelo (20% with dens), American sycamore (*Platanus occidentalis*) (15%), and American sweetgum (12%). Den trees averaged 30.4 cm dbh and hardwoods without dens averaged 25.0 cm.

Discussion and Conclusions

In this study, stand density and stand basal area were similar among study areas and landforms, but the hardwood components of sampled stands were higher in flood plains than in uplands, and higher in the Crystal and Zig Zag mountains than in the Fourche. Similarly, in the Hilly Coastal Plain Province of Mississippi, Warren (1980) found that "merchantable timber and total cordwood were similar" in 2 physiographic regions, but that hardwood components and species composition were different. In the Interior Flatwoods Region, Warren found that stands in the "hills" (ridges) were 43% pine and 57% hardwood, whereas in the "bottoms" (draws) they were 24% pine and 76% hardwood.

The capability to produce hard mast was different among mountain regions, but was not consistently different between landforms in the Ouachitas. Relative basal area of nut-producing species was higher in uplands than in flood plains, yet relative density of nut-producers did not differ. Regardless, mast production in streamside habitats can be managed through selective logging to favor species, diameter class distribution, or crown development to maintain diversity and increase yields of hard mast.

The density of live den trees varied considerably but was not different among regions or between landforms in this study. The average of 12.9 den trees/ha in the Ouachitas is comparable to average densities of 9.6 and 15.8 den trees/ha for oak-pine forest in South Carolina and Florida, respectively (McComb et al. 1986). The average diameters of den trees (30.4 cm) and sound trees (25.0 cm) in the Ouachitas were slightly higher than averages for den trees (25.4–26.7 cm) and sound trees (20.8–21.3 cm) in South Carolina and Florida (McComb et al. 1986). McComb et al. sampled trees $\geq$12.5 cm dbh, whereas we sampled trees $\geq$15 cm dbh. However, the differential in average diameter of trees with and without dens, approximately 5 cm, was similar for all areas.

In Mississippi flatwoods, Warren and Hurst (1980) estimated squirrel populations at 4.1 squirrels/ha in streamside management zones (40–141 m wide), 3.6/ha in pine-hardwood stands adjacent to streamside zones, and 3.3/ha in upland pine-hardwood stands further away from streamside zones. They attributed the higher squirrel populations in streamside stands to higher mast production capability and more den trees. Their findings suggested a transition between riparian and upland forests in a coastal plain site. Whether or not this occurs in the Ouachita Mountains is unknown. If the upland habitats sampled in this study were transitional, differences in forests characteristics between streamside stands and stands further up side slopes than we measured may be more distinct. For example, den tree density was not different between riparian and adjacent upland habitats in the Ouachita Mountains, which contrasts with the finding of McComb et al. (1986) that den trees were 2 to 11 times more abundant along narrow stream margins than in the flatwoods and rolling uplands of Florida and South Carolina. Gysel (1961) and Carey (1983) also reported higher den tree densities in mesic than in xeric forest types, but Carey found that "random events appear to play an important role in determining cavity tree abundance," and that stand characteristics such as slope position and topographic features could not be used to accurately predict the abundance of den trees in Appalachian hardwood forests.

Southern forest managers leave streamside management zones primarily to protect water quality and to maintain some natural forest diversity within managed pine plantations. Streamside management practices should consider landowner objectives, differences in forest habitats related to regional physiography and landform, and variation in flood plain width. Much more information is needed about wildlife habitat characteristics and animal populations in riparian areas of southern pine forests, and about costs associated with various streamside management practices. Minimal, as well as optimal, streamside zone widths and streamside management practices need to be developed for cost-effective integration of wildlife management objectives into forest management programs. In the Ouachita Mountains, where flood plain width is variable, a forest management policy that promotes variable-width streamside zones seems appropriate. Streamside zones of a fixed width would include less desirable upland habitats (lower hardwood component) where flood plains are narrower than streamside management zones.

Because of wide variation in flood plain width, which resulted in unequal samples of flood plain and upland habitats among the physiographic regions, we could not test for differences in species richness or diversity. Thus, we recommend sampling areas of equivalent size for all landforms in all regions, with transects parallel to, or perpendicular to, streams and topography. The presence or absence of a riparian-upland transition community should also be assessed.

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