A COMPARISON OF VEGETATION WITHIN AND OUTSIDE RIPARIAN AREAS BORDERING EPHEMERAL STREAMS IN THE OUACHITA MOUNTAINS

David K. Radabaugh, Hal O. Liechty, and James M. Guldin[1]

Abstract—Ephemeral streams frequently occur in shortleaf pine (*Pinus echinata* Mill.) hardwood stands that grow on the upper and mid-slopes of the Ouachita Mountains in Arkansas. Stream management zones are established around these ephemeral streams in the Ouachita National Forest to minimize impacts of adjacent forest management activities. To better understand the vegetation communities in these riparian areas, we quantified composition, density and diversity of the woody vegetation within these riparian areas and upland areas outside these zones. Overstory density outside riparian areas was significantly greater than inside ($p < 0.001$) but seedling density was significantly higher inside than outside the riparian area ($p = 0.07$). The overstory was more diverse within the riparian areas than outside. However, midstory, sapling, nor seedling diversity significantly differed between the two areas. Pines dominated the overstory in riparian and nonriparian areas alike. The midstory, sapling, and seedling size classes contained a greater species richness and were not dominated by any one single species as was the overstory.

INTRODUCTION

Riparian areas are located directly adjacent to water and are a transition between upland and aquatic ecosystems (Svejcar 1997; Hansen and Law 1994). These riparian areas have many essential functions. They display high levels of diversity (Naiman and others 1998), are important in maintaining water quality (Anderson 1992), reduce flood occurrence (Stuart and others 1994), provide shade for streams thereby reducing water temperature, and provide shelter for birds and other animals (Anderson 1992). The extent of a riparian area surrounding rivers varies depending on the type of river system, vegetation, topography and soils in the landscape.

Ephemeral streams primarily flow during snowmelts and rainstorms, thereby producing temporally and seasonally diverse environmental conditions for plant growth and adaptation (Banner and MacKenzie 1998). Given the spatially and temporally diverse nature of ephemeral streams, vegetation bordering these streams could be unique because of the need for plants to survive in both seasonally hydric and xeric environments. Species diversity in these areas could also be high because diversity and richness is frequently found to be greatest in areas where the disturbances are ephemeral in frequency and variable in their size and intensity (Malanson 1993). Thus, ephemeral riparian systems have the potential to be important for enhancing landscape and species diversity.

Within the Ouachita Mountains there are many ephemeral streams. These streams likely comprise greater than 50 percent of stream channels within this region (Personal communication. 1999. Alan Clingenpeel, Ouachita National Forest). Within the Ouachita National Forest, stream management zones (SMZ) or buffers in upland pine-hardwood stands are used to protect ephemeral streams and sustain the functions of the riparian vegetation and soils bordering these streams (U.S. Department of Agriculture, Forest Service 1990). Guidelines require that SMZ of at least 10 m width be installed on each side of ephemeral stream channels that are scoured (U.S. Department of Agriculture, Forest Service 1990). If a steep slope borders the stream, the SMZ is to be extended to the top or break of the slope. Forest management activities such as tree removal are minimized in SMZ to reduce disturbance to these areas. SMZ along ephemeral streams account for approximately 8-14 percent of area within shortleaf pine-hardwood stands growing on southwestern facing slopes in the Ouachita Mountains (David K. Radabaugh. 1999. Unpublished data. On file with: School of Forest Resources, University of Arkansas at Monticello, Monticello, AR 71656).

Although the primary objective of installing SMZ along ephemeral streams in the Ouachita Mountains is to protect water quality, land managers expect that these SMZ will also increase landscape diversity and wildlife habitat. However, to our knowledge there have been few if any studies in this region to quantify whether these ephemeral SMZ accomplish any of these secondary objectives. It is not known whether or to what degree the vegetation within these riparian communities differs from the surrounding upland forest communities. Without a fundamental knowledge of the vegetation bordering ephemeral streams it is difficult, if not impossible, to determine their value for fulfilling stand and landscape management objectives or developing management plans to sustain the ecological functions of these areas.

Characterization of the woody vegetation is the initial step to fully understand and better manage riparian communities that border ephemeral streams. Therefore, the objectives of this study were (1) to quantify the woody vegetation composition and examine the vegetative community characteristics, such as diversity and density, within SMZ adjacent to ephemeral streams in pine-hardwood stands and (2) to compare the composition and characteristics of plant

[1] Graduate Student and Assistant Professor, School of Forest Resources, University of Arkansas at Monticello, Monticello, AR 71656; and Project Leader, USDA Forest Service, Southern Research Station, Monticello, AR 71656, respectively.

Citation for proceedings: Guldin, James M., tech. comp. 2004. Ouachita and Ozark Mountains symposium: ecosystem management research. Gen. Tech. Rep. SRS–74. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 321 p.

communities within these SMZ to plant communities outside riparian areas in pine-hardwood stands located in the Ouachita Mountains.

METHODS

Study Design and Location

Woody vegetation measurements utilized for this study were collected at two different times. The first measurements were collected in 1993, from 16 relatively undisturbed, mature shortleaf pine-hardwood stands occurring on generally south-facing slopes in the Ouachita Mountains. These 16 stands were a subset of the stands used for the Phase II Ouachita/ Ozark Ecosystem Management Study described by Baker (1994). Stands had a minimal size of 14 ha, were dominated by shortleaf pine that were at least 70 years old, occupied south or south-west slopes, and contained between 13.8 to 25.3 m^2 per ha of pine as well as between 4.6 to 11.5 m^2 per ha of hardwood basal area (Baker 1994). Overstory and midstory tree measurements utilized for our study were from two woody overstory and midstory plots established in the SMZ as well as from two of twelve overstory and midstory plots established outside the SMZ (Guldin and others 1994) in each of the stands. Plots outside the SMZ were selected such that they occurred on similar slope positions and as near as possible as those within the SMZ.

Saplings and seedlings were measured during 1999 in four of the original 16 stands. These four stands had been selected as controls, as part of the Phase II USDA Forest Service Ecosystem Management Study, and were the only stands of the original 16 that were not harvested. Three plots corresponding to lower-, mid-, and upper-slope positions were established in at least one SMZ in each of these four stands. The plots were 15 m wide while the length of the plot spanned the entire width of the SMZ. Thus plot length varied from location to location but averaged 32.6 m. The plots were placed at least 120 m apart and 75 m or more from the stand boundary or the upslope end of a SMZ. An additional 15 x 30 m plot was established adjacent to each of these plots but at a distance of at least 40 m outside the edge of the SMZ. The plots outside the SMZ were located at the same aspect and slope position to the corresponding plot located within the SMZ.

Overstory and Midstory Measurements

Trees with a diameter at breast height (d.b.h.) ≥ 24.4 cm were classified as overstory while trees with a d.b.h. ≥ 9.1 and < 24.4 cm were classified as midstory trees. Overstory trees were sampled using variable radius plots. Species and d.b.h. to the nearest 0.25 cm was recorded for each tree sampled. All midstory trees were tallied by 1 cm classes and species on a 0.04 ha fixed radius plot. A complete description of the midstory and overstory sampling and measurement methodologies can be found in Guldin and others (1994).

Sapling and Seedling Measurements

Woody stems > 3 cm in height with a d.b.h. ≤ 1.3 cm were categorized as seedlings. Seedling presence and coverage was quantified using 1 m^2 quadrats. A transect was established along the length of the plot such that it passed through the plot center. The quadrats were centered on the transect at each sampling location. Sampling locations were established at equal distances from each edge of the plot so that they mirrored each other along the length of the plot. The first quadrat in the SMZ plot was placed 2 m from the SMZ edge. The other quadrats were placed 5 m from the first. When the middle of the plot was less than 5 m away from a potential quadrat location, the quadrats were located half the distance from the last established quadrats and the center of the plot. Quadrats were evenly dispersed along the transect in plots located outside the SMZ. Density was determined by tallying the number of individuals of each specific species located within the quadrats.

Saplings were defined as woody species with a d.b.h. > 1.3 cm and dbh < 9.1 cm. Species and d.b.h. of each sapling in the 2 x 5 m plots that enclosed each of the 1 x 1 m seedling plot were recorded. D.b.h. was measured to the nearest 0.1 cm.

Data Analysis and Summaries

Density was determined for overstory, midstory, saplings and seedlings. Species diversity for each woody vegetation size class and plot was calculated using the Shannon-Weaver index (Shannon and Weaver 1949). Species richness values were also determined for each plot in each area. To determine the degree of similarity between riparian and nonriparian woody vegetation Sorensen index (Sorensen 1948) and Ellenberg index (Ellenberg 1956) were computed for each vegetation size class. Paired t-tests were used to test whether diversity, richness, and density significantly differed between nonriparian and riparian plots.

Importance values were used to evaluate the differences in species composition of the vegetation communities within and outside the riparian areas. Importance values of seedlings were calculated using relative density (stems per ha), relative dominance (percent cover) and relative frequency (individual species) (Krebs 1985). Importance values of the sapling, midstory and overstory were calculated using relative density (stems per ha), relative dominance (basal area per ha), and relative frequency (individual species) (Krebs 1985).

RESULTS AND DISCUSSION

Density

Overstory stems per ha and basal area per ha were significantly greater ($p < 0.01$) in the plots inside than outside the SMZ (table 1). On average the overstory in the nonriparian plots contained 34 percent more trees and 36 percent more basal area than overstory in the riparian plots (table 1). Differences in density of the overstory did not appear to be related to differences in growth or stand dynamics because average quadratic mean diameters did not differ between areas. It is more likely that the lower density in the riparian areas reflected a reduction in growing space due to the shallow, rocky soils on the steep slopes that often border these streams and area occuppied by the stream channels themselves. The shallow soil depths and rocky nature of the slopes bordering many of these streams would likely reduce tree survival and growth of trees in these areas. Crow and others (2000) indicated that reduced moisture holding capacity of sandy soils in riparian areas may cause trees to be scattered with low basal areas. Soils surrounding the ephemeral streams did not appear to be coarser than the areas

Table 1—Mean stem density (stems ha^{-1}), basal area (m^2 ha^{-1}) and probability level associated with paired T-test comparison of riparian and nonriparian plots

Size class	Riparian	Nonriparian	P-value
		Stem density	
Overstory	185	248	0.002
Midstory	491	480	0.790
Sapling	1516	1564	0.926
Seedling	6640	3733	0.072
		Basal area	
Overstory	16.7	22.3	< 0.001
Midstory	8.6	8.0	0.455
Saplings	2.0	2.6	0.498

outside the SMZ and thus the cause of the reduced density in the SMZ. Riparian plots generally had higher seedling densities than nonriparian plots. Differences were signficant at $p = 0.072$ (table 1). Midstory and sapling densities were similar in the two areas. The higher densities of the seedlings within the riparian plots may reflect the lower densities of the riparian overstory. The lower density of the overstory in the riparian plots most likely provides light conditions underneath the canopy that are more condusive to survival and regeneration of trees in the lower strata than does the higher overstory density in the nonriparian plots. On average, the riparian plots contained 78 percent more seedlings than the nonriparian plots.

Diversity and Similarity

The riparian overstory was significantly more diverse ($p < 0.01$) than the nonriparian overstory (table 2). Differences in diversity, in part, occurred because of the greater dominance of shortleaf pine in the nonriparian overstory. Pines composed 92 percent of all overstory stems in the nonriparian plots compared to 71 percent in the riparian plots. The higher diversity in the riparian plots also reflected greater species richness in these plots (table 2). Species richness of the overstory was significantly greater in riparian plots than in the nonriparian plots (table 2). Midstory, saplings and seedlings diversity nor species richness significantly differed between the two areas (table 2). However, richness and diversity values were consistently greater in the riparian areas regardless of size class.

It was apparent that diversity differed among size classes within these areas. Overstory and seedlings were the least diverse while the midstory size class was the most diverse. The large diversity values in the midstory in part reflects a greater diversity in the light environment of this strata. The midstory size class includes shade intolerant species as well as a number of mid-tolerant or shade tolerant species. The dominant overstory species such as shortleaf pine and post oak (*Quercus stellata* Wangenh.) are shade intolerant or in the case of white oak (*Q. alba* L.) mid-tolerant. Trees that dominate the midstory also included species such as blackgum (*Nyssa sylvatica* L.) and winged elm (*Ulmus alata* Michx.) that are shade tolerant. Sapling and seedling size classes are primarily dominated by shade tolerant species

Table 2—Mean Shannon-Weaver's index computed using stem density and basal area, mean richness, and probability level associated with paired T-test comparison for nonriparian and riparian plots

Size class	Riparian	Nonriparian	P-value
		SWI (Stem density)	
Overstory	0.65	0.27	< 0.001
Midstory	1.52	1.39	0.201
Sapling	1.21	1.10	0.645
Seedling	0.92	0.89	0.880
		SWI (basal area)	
Overstory	0.62	0.25	< 0.001
Midstory	1.46	1.31	0.157
Sapling	0.96	0.99	0.830
		Richness	
Overstory	4.25	2.69	0.006
Midstory	8.81	8.13	0.086
Sapling	4.25	4.00	0.377
Seedling	3.83	3.17	0.221

SWI = Shannon-Weaver's index.

while importance values of shade intolerant species were much lower than in overstory or midstory size classes (tables 3-6). Differences in diversity among woody vegetation size classes may also reflect the number and distribution of plots utilized for the overstory and midstory plots (24 pairs of plots in 12 stands) compared to the sapling and seedling plots (12 paired plots in 4 stands).

Overstory and midstory vegetation in the riparian areas were relatively similar to that in the nonriparian areas. Ellenberg's and Sorensen's indices indicated that the

Table 3—Riparian and nonriparian overstory importance values

Species	Riparian	Nonriparian
Carya texana Buckl.	1.6	0.7
C. tomentosa (Poir.) Nutt.	3.0	0.7
Fraxinus pennsylvanica (Borkh.) Sarg.	1.1	
Liquidambar styraciflua L.	5.6	0.7
Nyssa sylvatica Marsh.	1.7	1.3
Pinus echinata Mill.	59.3	78.7
P. taeda L.	1.1	
Quercus alba L.	9.3	7.1
Q. falcata Michx. var *falcata*	2.3	0.8
Q. marilandica Muenchh.		0.6
Q. rubra L.	1.5	0.6
Q. stellata Wangenh.	8.9	6.2
Q. velutina Lam.	1.8	2.6
Ulmus alata Michx.	1.8	
U. americana L.	0.6	
U. rubra Muhl.	0.6	

Table 4—Riparian and nonriparian midstory importance values

Species	Riparian	Nonriparian
Acer rubrum L.	4.7	0.3
Amelanchier arborea (Michx. f.) Fern.	0.5	0.1
Carya texana Buckl.	8.4	3.6
C. tomentosa (Poir.) Nutt.	7.4	3.6
Cornus florida L.	1.5	4.3
Hardwood misc.	1.3	
Juniperus virginiana L.	0.9	1.3
Liquidambar styraciflua L.	5.2	2.4
Nyssa sylvatica Marsh.	5.2	3.0
Ostrya virginiana (Mill.) K.Koch	1.1	
Pinus echinata Mill.	18.0	28.6
Prunus serotina Ehrh.	0.5	0.1
Quercus alba L.	11.7	16.0
Q. falcata Michx. var *falcata*	2.1	3.2
Q. marilandica Muenchh.	0.3	6.2
Q. stellata Wangenh.	16.7	9.2
Q. rubra L.	1.8	0.4
Q. velutina Lam.	2.7	10.0
Ulmus alata Michx.	9.1	7.5
U. americana L.	0.3	
U. rubra Muhl.	0.7	0.2

Table 5—Riparian and nonriparian sapling importance values

Species	Riparian	Nonriparian
Acer rubrum L.	9.2	10.2
Carya texana Buckl.	2.6	7.0
C. tomentosa (Poir.) Nutt.	1.3	4.2
Chionanthus virginicus L.	1.4	
Cornus florida L.	11.4	12.9
Crataegus marshallii Eggl.	1.5	
Diospyros virginiana L.	1.0	1.2
Fraxinus pennsylvanica (Borkh.) Sarg.	1.6	
Juniperus virginiana L.	1.8	1.6
Liquidambar styraciflua L.	10.8	3.4
Ostrya virginiana (Mill.) K.Koch	19.5	11.5
Nyssa sylvatica Marsh.	12.8	11.2
Pinus echinata Mill.	2.2	4.3
P. taeda L.	1.6	
Prunus serotina Ehrh.	1.6	1.2
Quercus alba L.	4.1	9.1
Q. marilandica Muenchh.	1.0	2.5
Q. stellata Wangenh.	1.2	7.5
Rhamnus caroliniana Walt.		1.8
Ulmus alata Michx.	12.1	5.9
Vaccinium arboreum Marsh.	1.0	4.3
Vitis rotundifolia Michx.	0.8	

overstory was respectively 84.8 percent and 66.6 percent similar while the midstory was 74.4 percent and 71.8 percent similar. The high degree of similarity in these two areas could be attributed to the incised nature of the ephemermal stream corridors. The borders of the SMZ in these upland pine-hardwood stands contain short but steep slopes. These slopes are relative dry and most likely similar to those in the upland areas. Distribution of plant communities on either side of streams usually reflects the gradient of environmental factors such as water availability which dominates these areas (Hancock and others 1996). However, these slopes increase drainage as well as elevate trees above standing water during storm events. These factors create a drier environment more suitable to upland species such as shortleaf pine, black hickory (*Carya texana* Buckl.), mockernut hickory [*C. tomentosa* (Poir.) Nutt.], post oak, white oak, black oak (*Q. velutina* Lam.), and blackjack oak (*Q. marilandica* Muenchh) than species typically found in riparian landscapes. This suggests that more hydric conditions exist only in close proximity to the stream channel and for only short periods of time. Thus stream effects on at least these two size classes of vegetation are spatially and temporally limited in these stream corridors.

Table 6—Riparian and nonriparian sapling importance values

Species	Riparian	Nonriparian
Acer rubrum L.	3.5	15.0
Carpinus caroliniana		0.9
Carya texana Buckl.	0.9	5.6
C. tomentosa (Poir.) Nutt.	1.1	
Cercis canadensis L.		0.9
Cornus florida L.	14.9	26.1
Crataegus marshallii Eggl.	0.6	
Fraxinus pennsylvanica (Borkh.) Sarg.	3.7	
Hardwood misc.	2.3	
Juniperus virginiana L.	0.9	0.9
Liquidambar styraciflua L.	1.0	
Nyssa sylvatica Marsh.	14.9	7.6
Ostrya virginiana (Mill.) K. Koch	24.9	4.1
Prunus serotina Ehrh.	1.7	
Quercus alba L.	13.1	8.1
Q. marilandica Muenchh.	0.6	4.3
Q. phellos L.	1.0	0.9
Q. rubra L.	0.9	1.5
Q. stellata Wangenh.	5.7	8.1
Q. velutina Lam.	6.3	3.4
Rhamnus caroliniana Walt.	7.5	5.5
Rhus aromatica Ait	1.7	
Ulmus alata Michx.	0.3	3.2

Similarity indices for saplings or seedlings size classes were much lower than those calculated for the overstory or midstory size classes. Similarities of 27.1 percent and 18.5 percent were calculated using Sorensen's index for the saplings and seedlings respectively. Ellenberg's index indicated a 32.5 percent similarity between riparian and nonriparian saplings. Reduction in vegetation similarity of the seedling and sapling size classes compared to that of the midstory and overstory may again reflect the differences in the number of plots utilized for index calculation of each group.

However, several species in the seedling and sapling size classes occur on the riparian plots that do not occur in the nonriparian plots and one or two species occur in the non-riparian plots that do not occur in the riparian plots. Many of the saplings and seedlings occuring in these areas are considered late successional species within these ecosystems. Late successional species are typically resource specialists (Odum 1997). Compared to early successional species in the larger size class, these late successional species may better reflect subtle differences in environmental conditions within or outside the influence of these streams, thus creating the observed differences in similarity among size classes.

Composition

Shortleaf pines dominated the overstory with importance values of 59.3 percent and 78.7 percent for the riparian and nonriparian areas respectively (table 3). These two areas are primarily composed of species that are shade intolerant, favor relative dry habitats, and are intolerant of inudation (Hook 1984). No one species dominated either the riparian or nonriparian midstory. The importance value of any one species never exceeded 29 percent (table 4). Shortleaf pines and oaks (post, white and black) were major components of both riparian and nonriparian areas. Black oak and blackjack oak are two species that were prevalent in the nonriparian midstory. The midstories of both areas were comprised of intolerant to intermediate shade tolerant species but some shade tolerant species such as flowering dogwood (*Cornus florida* L.) and ironwood (*Ostrya virginiana* Mill.) also occurred. The sapling and seedling size classes were equally dominated by six to seven species (table 5). White oak was the only species that had importance values greater than 10 percent within the seedling or sapling size classes as well as in the midstory and overstory size classes. Species such as flowering dogwood, ironwood, blackgum, and red maple (*Acer rubrum* L.) which were only minor components in the overstory and midstory were major components of the woody vegetation communities in these smaller size classes (table 5). Species which are shade intolerant generally had low importance values while more shade tolerant species had high importance values in the sapling and seedling size classes (tables 5 and 6). These changes in composition reflected the lower light levels within these forest strata.

CONCLUSION

Woody vegetation within SMZ bordering ephemeral streams within shortleaf pine-hardwood stands generally was found to be significantly more diverse and have a greater species richness than woody vegetation growing outside the influence of these streams. Differences in diversity and richness between riparian and nonriparian areas were generally greater in the larger than smaller size classes. The density of the overstory woody vegetation was greater outside than inside these SMZ but did not significantly differ in the smaller size classes. The riparian vegetation communities in these SMZ appear to contribute to the overall diversity of the landscape. However, due to the relatively small size of these streams and their relatively minor impact on moisture regimes, vegetation communities are much more similar to upland communities than would be expected for riparian communities growing along perrenial streams with larger floodplains.

LITERATURE CITED

Anderson, S. 1992. Water quality series: riparian forest buffers. Cooperative Extension Service. Division of Agriculture Sciences and Natural Resources. Oklahoma State University. 6 p.

Baker, J.B. 1994. An overview of stand-level ecosystem management research on the Ouachita/Ozark National Forests. In: Baker, J.B., comp. Proceedings of the symposium on ecosystem management research in the Ouachita Mountains: pretreatment conditions and preliminary findings. Gen. Tech. Rep. SO-112. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 29-49.

Banner, A.; MacKenzie, W. 1998. Riparian areas: providing landscape habitat diversity part 5 of 7. British Columbia Ministry of Forests Research Program

Crow, T.R.; Baker, M.E.; Barnes, B.V. 2000. Diversity in riparian landscapes. In: Ed. Verry, E.S., Hornbeck, J.W. and C.A. Dolloff. Riparian management in forests. C.A. Lewis Publishers. 402 p.

Ellenberg, H. 1956. Aufgaten und methoden der vegetationskunde. Stuttgart:Eugen Ulmer.

Guldin, J.G.; Baker, J.B.; Shelton, M.G. 1994. Midstory and overstory plants in mature pine-hardwood stands on south-facing slopes of the Ouachita/Ozark National Forests. In: Baker, J.B., comp. Proceedings of the symposium on ecosystem management research in the Ouachita Mountains: pretreatment conditions and preliminary findings. Gen. Tech. Rep. SO-112. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 18-28.

Hancock, C.N.; Ladd, P.G.; Froend, R.H. 1996. Biodiversity and management of riparian vegetation in Western Australia. Forest Ecology and Management 85:239-250.

Hansen, W.F.; Law, D.L. 1994. Riparian management on the National Forests in South Carolina. In: Proceedings of conference on riparian ecosystems in the humid U.S.; functions, values and management. USDA Forest Service, Cooperative Forestry Atlanta, Ga. 56-64.

Hook, D.D. 1984. Waterlogging tolerance of lowland tree species of the South. Southern Journal of Applied Forestry 8:136-149.

Krebs, C.J. 1985. Ecology: the experimental analysis of distribution and abundance. (Third Edition). Harper & Row Publishers Inc. New York, NY. 800 p.

Malanson, G.P. 1993. Riparian landscapes. Cambridge University Press. New York, NY. 296 p.

Naiman, R.J.; Fetherston, K.L.; McKay, S.J.; Chen, J. 1998. Riparian forests. In: Ed. Naiman, R.J. and Bilby, River ecology and management. R.E.Springer-Verlag. New York, NY. 705 p.

Odum, E.P. 1997. Ecology: a bridge between science and society. Sinauer Associates, Inc. Massachusetts. 331 p.

Shannon, C.E.; Weaver, W. 1949. The mathematical theory of communication. Urbana: University of Illinois Press.

Sorensen, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. Det Kong. Danske Vidensk. Selsk. Siol. Skr. (Copenhagen) 5:1-34.

Stuart, G.; Dolloff, A.C.; Corbett, E.S. 1994. Riparian area functions and values – a forest perspective. In: Proceedings of conference on riparian ecosystems in the humid U.S.; functions, values and management. U.S. Department of Agriculture, Forest Service, Cooperative Forestry. Atlanta, GA. 81-86.

Svejcar, T. 1997. Riparian zones: (1) what are they and how do they work? Rangelands 19:4-7.

USDA Forest Service. 1990. Amended land and resource management plan. Ouachita National Forest. Vol. 1. For. Serv., Ouachita Nat. For., Hot Springs, AR.