THE SPATIAL DISTRIBUTION OF DEAD TREES ACROSS ARKANSAS TIMBERLANDS[1]

Martin A. Spetich and James M. Guldin[2]

Abstract—Dead trees are an important part of the forest ecosystem and their attributes have been studied at the stand scale. However, their distribution over a large region has rarely been examined. In this study, the distribution and dynamics of sound wood in dead trees and the ratio of dead to live trees across the Arkansas landscape were analyzed using U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis data. These data showed that deadwood volumes followed patterns of potential timberland productivity. Values were lowest in the northwestern portion of the State and increased to the south and east. For potential timberland productivity in the range of 20-49 ft^3 per acre per year, mean deadwood volume was 52 ft^3 per acre. Where potential site productivity was high (range = 165-224 ft^3 per acre per year), mean deadwood volume was 177 ft^3 per acre. The ratio of the number of dead trees to number of live trees was not statistically significant among potential site productivity classes. Across all sites the ratio of dead to live trees was 0.089 (95 percent confidence interval = ± 0.009). Because this ratio appears to be relatively consistent over a wide range of forest conditions, it may have value as a forest health monitoring tool.

INTRODUCTION

Dead trees serve as habitat for wildlife and provide structural diversity. According to a study in southern hardwood and pine forests (Lanham and Guynn 1996), 45 bird species use standing dead trees. In the Southeastern U.S., at least 23 mammal species use standing dead trees (Loeb 1996). Forest Inventory and Analysis (FIA) surveys rated the greater density of dead trees in bottomland hardwood community types compared with pine in Arkansas (Rudis, in press), Louisiana (Rudis 1988a), and east Texas (Rudis 1988b). Reptiles and amphibians are associated with coarse woody debris, and their diversity may be linked with the quality and quantity of coarse woody debris (Whiles and Grubaugh 1996). Despite the importance of dead trees, little is known about their statewide distribution and dynamics.

An increase in deadwood volume across a gradient of increasing forest productivity (productivity for all trees $ 5 in. d.b.h. to a 4-in. top) has been documented for the four-State region of Indiana, Illinois, Missouri, and Iowa (Spetich and others 1999). However, the ratio of the number of standing dead trees to standing live trees remained relatively consistent across that gradient. These patterns have not been established for Arkansas forests.

Findings for Indiana, Illinois, Missouri, and Iowa have implications for forest health monitoring. Any quantifiable consistencies in number, volume, or the ratio of dead to live trees could be used as part of monitoring efforts to identify spatial and temporal forest health trends. Observed values that fall outside normal ranges could be used as indicators of change in forest tree health. Thus, a quick examination of inventory data could help identify potential health problems in a timely manner.

This study examines deadwood abundance and its relationship to potential timberland productivity in Arkansas. The four objectives in this study follow: (1) illustrate the spatial distribution of potential timberland productivity across the Arkansas landscape using a variation of the Delaunay triangulation method; (2) quantify the net volume and spatial distribution of dead trees across the State; (3) determine what trends, if any, exist between deadwood and potential forest productivity; and (4) examine similarities and/or differences of these results with other studies.

METHODS

The 1995 statewide forest inventory database for Arkansas was used in this analysis (London 1997). Data used in this study were restricted to trees $ 5 in. d.b.h. in stands of sawtimber size and of natural origin as defined in the Eastwide Forest Inventory Data Base: Users Manual (Hansen and others 1992). We limited data to stands of natural origin, thereby excluding planted stands. Planted stands in Arkansas are typically managed in ways that are not conductive to natural snag development. The resulting sample included 1,402 forest inventory plots from across the State. Mean forest conditions were computed for all plots in a county. Countywide means were used to quantify the statewide distribution in dead tree volume, potential forest site productivity, and the relationship of dead to live trees.

Mean values for forests in each county were plotted across the State using the mean latitude and longitude values for all plots within each county. Statewide contour maps of potential forest site productivity, dead tree volume, and the

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[2] Research Forester and Project Leader/Research Forest Ecologist, USDA Forest Service, Southern Research Station, Hot Springs, AR 71902, respectively.

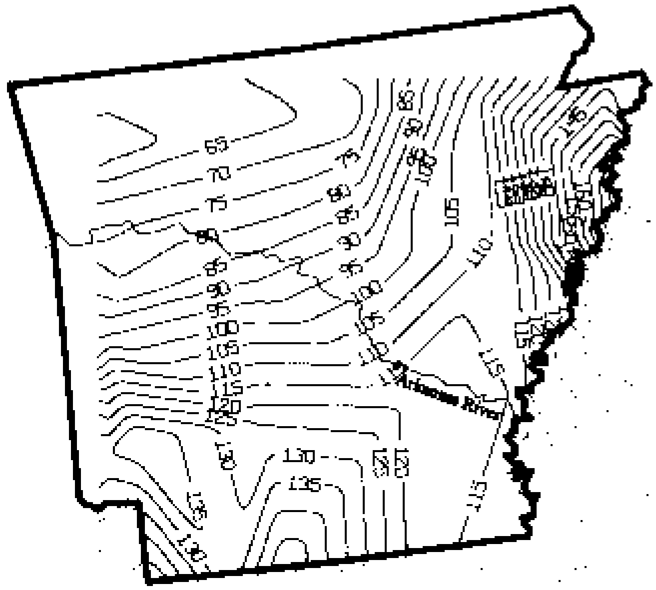

Figure 1—Patterns of potential productivity of live commercial tree species for forests of sawtimber size and of natural origin. Isolines were calculated from site productivity (ft^3 per acre per year) for each county [Source - FIA data (London 1997)].

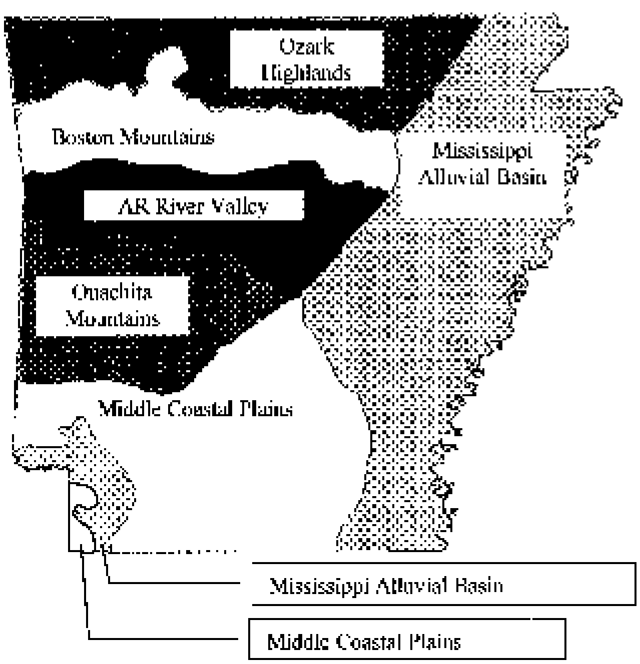

Figure 2—Ecological sections of Arkansas as defined by Keys and others (1995).

ratio of the number of all dead to live trees were created using commercially available software (RockWare Utilities 1995).

Additionally, means of deadwood volume and the ratio of dead trees to live trees were calculated for each of six

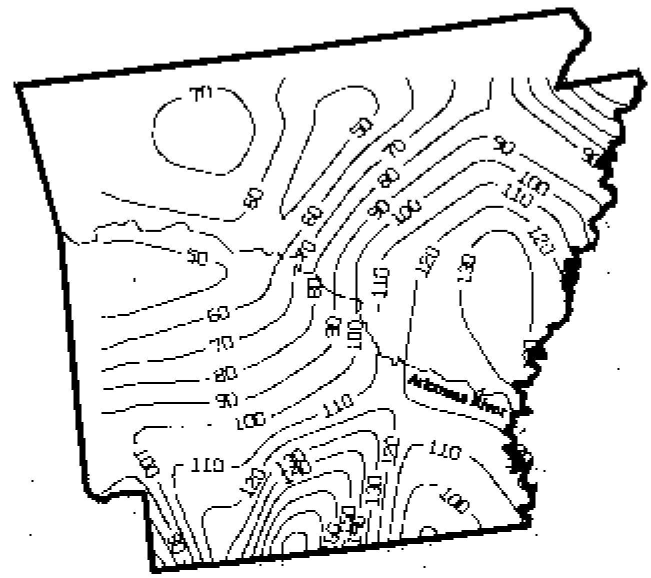

Figure 3—Dead tree volume (ft^3 per acre) for trees $ 5 in. d.b.h. in stands of sawtimber size and of natural origin.

forest site productivity classes. Kruskal-Wallis one-way analysis of variance on ranks test was used to test the hypothesis that dead tree abundance does not differ among productivity classes.

RESULTS

Potential wood productivity followed a gradient across Arkansas (fig. 1). Lowest productivity values (< 65 ft^3 per acre per year) were located in the northwest and increased to the south and east. With the exception of the Arkansas River Valley, calculated productivity values correspond with the expected relative productivity of the ecological regions in the State, (Keys and others 1995) (figs. 1 and 2). Other factors may also influence this trend.

With the exception of the Arkansas River Valley and parts of northwestern Arkansas, total volume of dead trees in these forests increased with increasing site productivity (fig. 3). Mean deadwood volume was as low as < 50 ft^3 per acre in northwest Arkansas and increased to $ 160 ft^3 per acre in south-central Arkansas.

Mean deadwood volumes were grouped by each of the six potential wood productivity categories. Deadwood volume differed significantly among several of the six potential wood productivity groupings (fig. 4). Deadwood volume clearly increased with increasing potential productivity (fig. 4).

The mean ratio of the number of dead trees divided by the number of live trees (fig. 5) ranged from 0.06 to 0.12 over most of the State (up to 0.21 in the northeast corner and

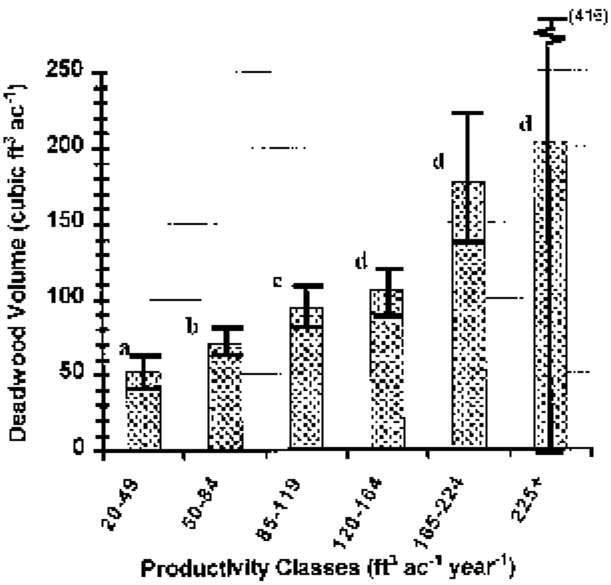

Figure 4—Relationship of potential timberland productivity classes to mean dead tree volume. Site productivity classes of values included (ft^3 per acre per year) are indicated by the range. Mean dead tree volumes are among all plots within that range. Bars with the same superscript do not differ significantly at the 0.05 level (based on Kruskal-Wallis one-way analysis of variance on ranks). Cross bars represent the 95 percent confidence interval (CI) for snag volume within each productivity range. The CIs for ranges 165-224 and 225+ are wider because sample sizes were smaller (84 and 16 plots respectively).

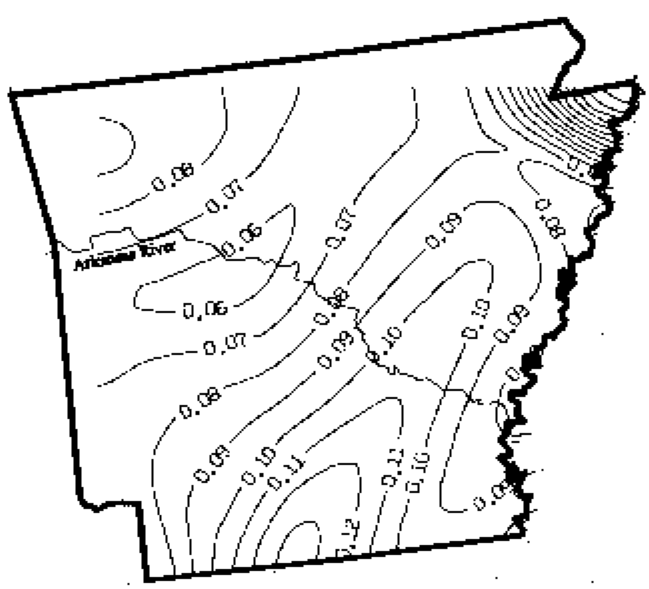

Figure 5—Ratio of dead to live trees for trees $ 5 in. d.b.h. in stands of sawtimber size and of natural origin. Isolines were calculated from mean ratio for all qualifying plots within each county.

ranging from 0 to 0.24 for county means). This is not as clearly related with site productivity (fig. 1). Visually, this ratio appears to increase with increasing productivity in the south-central portion of the State. However, the ratio did not differ significantly among the six site productivity classes statewide.

DISCUSSION

In a study of deadwood character of upland forests, Spetich and others (1999) reported a trend in forest productivity for the Midwest. They theorized that similar gradients exist throughout the country. Their regional productivity gradient illustrated what had only been an intuitive concept based on field and experimental experiences. This study is further proof that these productivity gradients exist across other forests of the United States. These trends in forest productivity should be particularly useful in developing hypotheses of trends in forest character because of the integrating effect of productivity. Productivity is a fundamental integrator of the effects of soil quality, disturbance, climate, potential evapotransporation, topography, geology, organisms and all other factors that impact forest tree growth and the overall character of the forest ecosystem. Therefore, trends in regional site productivity should continue to be a useful tool in the prediction and examination of change in forest character over a region.

That dead tree volume increased with increasing potential productivity is not surprising. Forests with high productivity values should accumulate large amounts of biomass, which in turn, should lead to large dead tree volumes. The amount of coarse-woody-debris base energy has been described as a functional component of forest productivity (Huston 1996). In comparing dead tree volume (fig. 3) with the productivity trend (fig. 1) dead tree volume does not increase with increasing site productivity in the northeastern portion of the State. The most obvious factor that would potentially influence this trend is the region's proximity to Memphis, TN. Low dead tree volume may be related to the cutover character and high value of bottomland hardwoods in proximity to this urban center, or firewood use and other demands. This low deadwood volume is also notable, because when all high productivity plots (> 120 ft^3 per acre per year) are compared (fig. 4), volume of sound wood in dead trees is significantly greater than for the three lowest productivity ranges (all < 119 ft^3 per acre per year). Even a cursory examination of the productivity map illustrates potential site productivity values > 160 ft^3 per acre per year near the Memphis area, but dead tree volume ranges from 90 to 100 ft^3 per acre.

The two 50 ft^3 per acre lines are notable in that they also do not follow productivity trends well. Lower-than-expected values of dead wood volume are difficult to interpret. One plausible explanation is that the active management tactics in the area preclude development of deadwood, either through management that keeps trees alive longer or through closer utilization of trees prior to mortality. Other explanations may be equally plausible.

The ratio of dead to live trees in northern Arkansas is comparable to values reported in a study of undisturbed second-growth sites in southern Missouri (Spetich and others 1999). In that study the mean snag-to-live-tree ratio among eight Missouri Ecosystem Project forests was 0.08. Figure 5 shows the same ratio for Northwestern Arkansas and within 2 percent for most of the remaining area of northern Arkansas. This ratio of dead snags to live trees may also be related to forest type. At $P<0.05$ the hardwood forest type differed significantly from the pine forest type. However, the oak-pine forest did not differ significantly from either the hardwood or pine forest types. It should also be noted that the Arkansas study includes all trees that died since the last inventory and, therefore, is likely to include some trees that have fallen to the ground.

The consistency of the ratio of dead to live trees may be useful in monitoring forest tree health. Forest managers could use this information to screen inventory data for dead/live tree ratios that indicate a potential forest tree health problem. Statewide, the mean dead/live ratio was 0.089 (95 percent confidence interval = ±0.009). On similar sites with large inventories, dead/live ratios significantly > 0.1 may indicate potential forest tree health problems, which could prompt further investigation.

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