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Precommercial Thinning of Water Tupelo Stands on the Mobile-Tensaw River Delta: Third-Year Results

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Abstract

Three 4-year-old stands were selected for precommercial thinning. Treatment consisted of two components: (1) thinning water tupelo (*Nyssa aquatica* L.) stump sprouts and dense patches of water tupelo seedlings and (2) cutting all stems of Carolina ash (*Fraxinus caroliniana* Mill.) and black willow (*Salix nigra* Marsh.) (cleaning). This approach provided a 2 by 2 factorial with two replications in each stand. Thinning increased average diameter growth of water tupelo stump sprouts, with the greatest increase in one stand that had the highest density of stumps and apparently the highest productivity; cleaning did not increase diameter growth. Thinning decreased stand basal area growth; cleaning did not affect basal area growth. Mortality of water tupelo stump sprouts was negligible. Cleaning may increase the number of water tupelo seedlings, although the evidence from this study is not compelling. Precommercial thinning will probably provide a favorable response in stands with high density of stumps and high productivity.

Keywords: Cleaning, coppice, diameter growth, mortality, precommercial thinning, water tupelo, wetlands.

Introduction

Water tupelo (*Nyssa aquatica* L.) stands tend to be more dense than other bottomland hardwood stands (Goelz 1995, Putnam and others 1960). Young, postclearcut stands are also dense, with many sprouts arising from each stump. Most of these sprouts will die before they are harvested, thus their growth is lost to mortality. Carolina ash (*Fraxinus caroliniana* Mill.) or black willow (*Salix nigra* Marsh.), often abundant in these young stands, are not merchantable on these sites.

Mature water tupelo stands in the Mobile-Tensaw River Delta are often harvested with helicopter systems, a method too expensive to use for thinning. Ground conditions often preclude using rubber-tired or tracked equipment for thinning. As commercial thinning may not be practical in these stands, interest has arisen in conducting precommercial thinning to achieve a merchantable size (currently, 3-inch [in.] top diameter) at an earlier age, reducing rotation length as well as minimizing unsalvageable losses of growth to mortality.

Previous studies have indicated that thinning is not particularly beneficial for water tupelo stands. Kennedy (1983) found that thinning mature water tupelo stands in the Atchafalaya Basin of Louisiana did not increase diameter growth. In McGarity's (1979) study of 60-year-old muck swamp forests, thinning increased growth of individual trees, but control plots had the greatest volume growth.

Although mortality of individual sprouts is expected as each stump undergoes self-thinning, previous studies have indicated that mortality is high for entire stumps of water tupelo. DeBell (1971) reported high survival for water tupelo stump sprouts 1 year after harvesting; however, at age 4, 45 percent of the stumps with sprouts had died. Kennedy (1982) reported that because mortality of young water tupelo sprout clumps was high, tupelo coppice would not comprise an important component of the mature stand. After 6 years, only 9 percent of the stumps cut in May and 18 percent of the stumps cut in November had live sprouts.

The high density of stems in the 3- to 4-year-old stands in the Mobile-Tensaw River Delta could decrease rapidly if patterns of mortality are similar to those found in the Atchafalaya Basin. This study is intended to determine (1) whether diameter and height growth rates of water tupelo stump sprouts respond to thinning; (2) whether stump sprout thinning will improve survival of the remaining sprouts; and (3) whether cutting all Carolina ash and black willow (cleaning) will improve growth and survival of tupelo stump sprouts and seedlings.

Initial results from this study (Goelz and others 1993) indicate that thinning increases annual diameter growth by 27 to 37 percent over unthinned plots, although cleaning does not improve growth. The treatments had negligible influence on the number of water tupelo seedlings, although flooding that extended into June during the first growing season following treatment probably caused a 30-percent reduction in seedling numbers. Unlike previous observations, mortality of tupelo stump sprouts was negligible.

Methods

Three locations were selected on Scott Paper Company land on the delta of the Mobile and Tensaw Rivers in Alabama. The native water tupelo stands on these locations were clearcut in 1986-87. Four seasons of growth occurred before this study began; each clearcut was 40 to 60 acres (ac). Treatments were applied in the autumn of 1990. All stems over 2 in. in diameter at breast height were felled when the stands were clearcut. The locations are good for water tupelo and are densely stocked to water tupelo, Carolina ash, baldcypress (*Taxodium distichum* [L.] Rich.), and black willow with other species present. Before treatment, the locations had 5,000 to 10,000 stems per acre with 300 to 3,500 water tupelo seedlings per acre. Sprout-origin stems were larger and appeared to dominate the locations, although seedlings were abundant in patches where sprouts were absent.

A 2- by 2-factorial design with two randomly selected replications at each location was used. The first factor consists of two treatments—thinning or not thinning water tupelo. Thinning comprises two components:

1. All water tupelo stumps were thinned to one or two best sprouts where "best" was defined as the largest well-formed sprout that originated low on the stump. When two well-spaced sprouts of good form and low origin were present, both were left.

2. Water tupelo seedlings were thinned with a machete wherever they occurred in a dense patch (more than 20 per 100 square feet [ft^2] in patches of 100 ft^2 or larger). The tallest water tupelo seedlings were left at a density of approximately one per 36 ft^2 (or a nominal 6- by 6-ft spacing).

The second factor consists of two treatments—cleaning or not cleaning the Carolina ash and black willow. All ash and willow were cut as close to the ground as possible with a chainsaw. These factors provide four treatment combinations: (1) no thinning, no cleaning (control); (2) no thinning, cleaning; (3) thinning, no cleaning; and (4) thinning and cleaning.

Eight 0.786-ac treatment plots were placed in each location. As the soils near the riverbank are much different from the rest of the stand, all treatment plots were at least 12 chains from the river. Three potential treatment plots were discarded as they represented intersections of pull-boat channels and were poorly stocked. Pull-boat channels are remnants from previous harvests when logs on "pull-boats" were winched through the harvested area to the riverbank. The eight plots were otherwise adjacent to each other on a square grid two plots wide by four plots long. When potential treatment plots were discarded, a new plot was placed adjacent to the other plots in the opposite direction from the riverbank.

The measurement plot (0.304 ac) was in the center of each treatment plot. Small stems were counted by species and origin (sprout or seedling). Stems >2.5 in. in diameter at breast height were permanently numbered and the following measurements were taken—diameter at breast height, species, origin, number of sprouts on stump, and crown class (Kraft's tree class) (Daniel and others 1979). Total height was measured on 25 randomly selected trees per plot, unless <25 stems were present ≥2.5 in. in diameter at breast height. These trees were remeasured 1 and 3 years after the study began.

Analyses were by analysis of variance or covariance analysis. The design is a 2 by 2 factorial with two levels for thinning, two levels for cleaning, and three blocks (referred to as locations) with two replications per block. Effect of locations was considered fixed. For individual tree characteristics, such as diameter and height growth, measurement plot averages were used. For height growth, only data were used from water tupelo trees that were dominant or codominant at both measurements. Significance tests were conducted at an α level of 0.05.

Results and Discussion

Average Diameter Growth of Water Tupelo

Plot average diameter growth from 1990-93 is presented in figure 1. The initial average plot diameter was not a significant covariate and was not included. Thinning and location and the thinning by location interaction were significant. Cleaning and the thinning by cleaning interaction

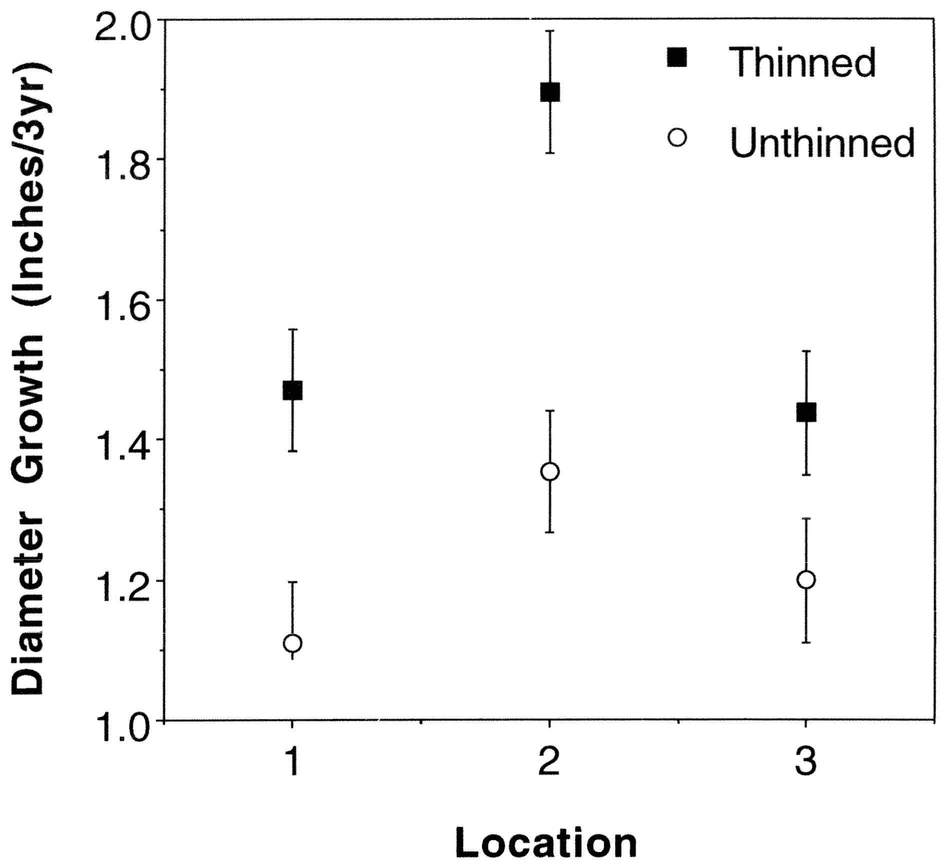

Figure 1—Plot-average diameter growth for thinned and unthinned plots for three locations. Means represent averages across cleaning treatments. Error bars represent the mean plus or minus twice the pooled standard error.

terms were not significant, thus each point in figure 1 represents averages of plots that are cleaned and not cleaned. Locations 1 and 3 were similar in regard to diameter growth on thinned and unthinned plots. Location 2 had greatest diameter growth and response to thinning. The greater magnitude of response to thinning may have occurred because this location had the greatest density of water tupelo stumps (Goelz and others 1993), making initial competition greater. As diameter growth in unthinned plots for location 2 was greater than for the other two locations, productivity of this location may be higher, and thinning response is generally greatest for sites of highest productivity.

Average Height Growth of Dominant and Codominant Water Tupelo

Treatments did not significantly affect plot average height growth of dominant and codominant water tupelo trees from 1990-93, although location effect was significant. Average height growth for locations 1, 2, and 3 was 5.8, 8.2, and 6.0 ft, respectively, which further substantiates the argument that location 2 had inherently greater productivity. The reason for the higher productivity is unknown. One possibility is that the stand harvested at location 2 was probably younger than those at locations 1 and 3, and the smaller stumps have more vigorous sprouts. Evidence for this possibility is personal

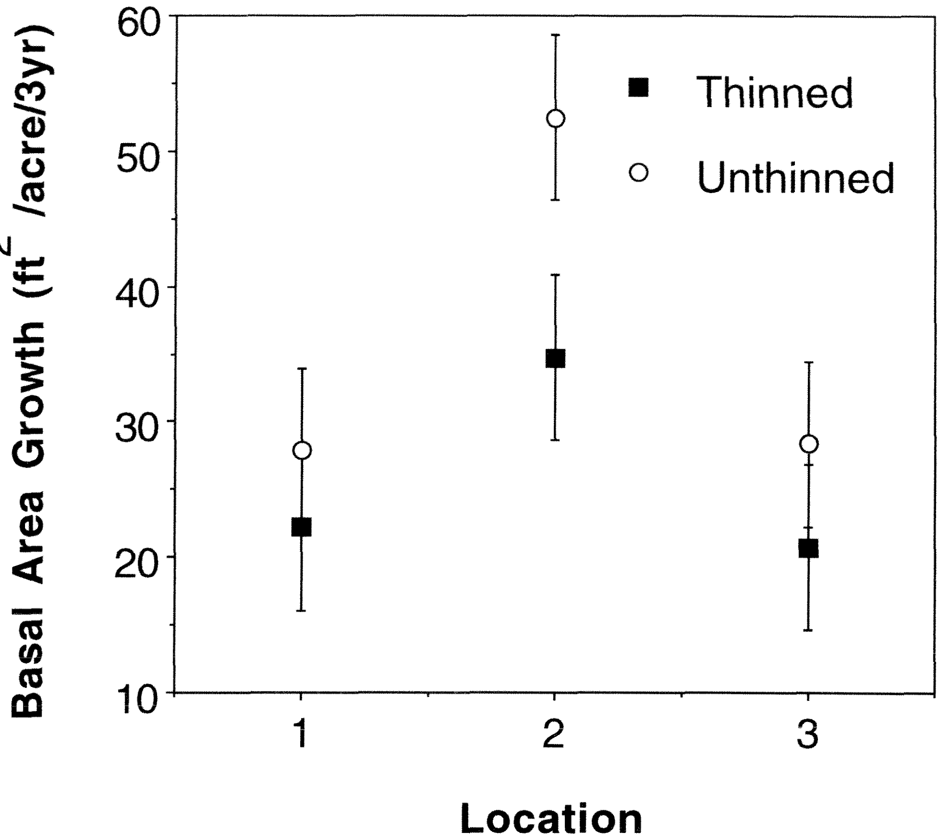

Figure 2—Basal area growth for thinned and unthinned plots for three locations. Means represent averages across cleaning treatments. Error bars represent the mean plus or minus twice the pooled standard error.

observation of the size of the stumps. Soils and flooding regimes may also affect productivity. Although the effects were not significant at α of 0.05, thinning and cleaning, alone or in combination, had a negative effect on height growth.

Basal Area Growth

Thinning and locations significantly affected plot basal area growth (fig. 2). Thinning decreased basal area growth on all locations. The cleaning and all interaction terms were not significant. Although the reduction of basal area growth appears considerable, much of the basal area growth on the unthinned plots may be lost to future mortality when sprouts within stumps undergo natural thinning, while the fewer stems on the thinned plots may survive until final rotation.

Change in Quadratic Mean Diameter

Change in quadratic mean diameter is determined by growth of initially measured trees and the number and size of ingrowth trees. Thinning, cleaning, locations, and thinning X location interaction terms significantly affect change in quadratic mean diameter (fig. 3). The thinning by cleaning interaction term was not significant. Thinning increases growth in quadratic mean diameter, and the effect of thinning is greatest for location 2. Cleaning decreased growth in quadratic mean diameter; cleaning decreased average diameter growth and basal area growth, but the effect was not significant for those variables. Thus, we discount the effect here; this result may be a type one error.

Quadratic mean diameter can be considered analogous to stand maturity. A stand with a greater quadratic mean diameter is, therefore, closer to rotation age. For locations 1 and 3, thinning had a modest effect on quadratic mean diameter. However, the effect of thinning was much greater for location 2. The increase in quadratic mean diameter in 3 years for the thinned plots on location 2 may be similar to the increase unthinned plots at the same location will attain in 6 years. Thus, the thinned plots may be maturing almost twice as fast as the unthinned plots. If this difference is

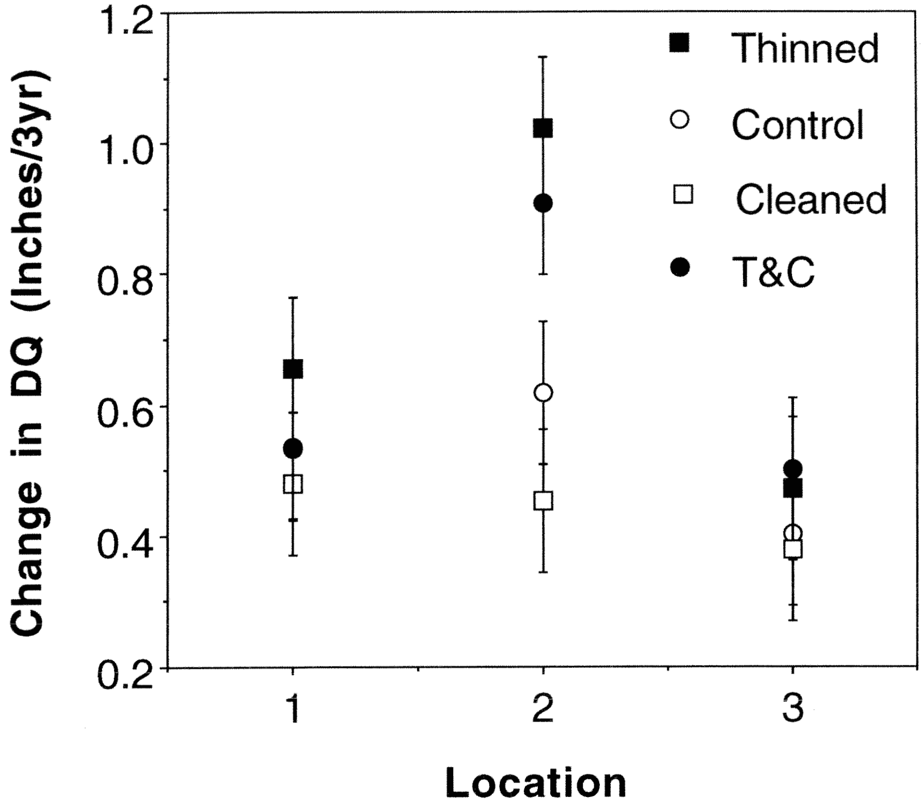

Figure 3—Change in quadratic mean diameter (DQ) for four treatments and three locations. Error bars represent the mean plus or minus twice the pooled standard error. Control at location 1 is hidden by thinned and cleaned.

maintained for several years, the reduction in rotation age may make precommercial thinning economically viable on sites similar to location 2.

Mortality

Only 8 out of more than 1,000 trees permanently numbered after treatment have died from 1990-93. The mortality of seven trees was attributed to animal damage rather than density-dependent mortality or disintegration of the supporting stump. This very low mortality contrasts studies of water tupelo coppice in other areas where few stumps maintained living sprouts (DeBell 1971, Kennedy 1982). The Mobile-Tensaw River Delta has not been greatly affected by major hydrological alteration, although the areas studied by DeBell (1971) and Kennedy (1982) have been. Thus, stump mortality may remain inconsequential in this relatively undisturbed wetland. In the near future, density-dependent natural thinning of the stump sprouts will occur. As more sprouts die, treatments will likely have an effect on sprout mortality as treatments did affect diameter growth and thus vigor.

Change in Numbers of Water Tupelo Seedlings

Equation 1 represents a conceptual form to predict number of water tupelo seedlings.

$$N_{1993} = A + B(N_{1990}) \quad (1)$$

where

N = the number of water tupelo seedlings in 1993 or 1990, and
A and B = linear functions of dummy variables representing treatments and locations that were significant.

Thus, B can be considered survival while A represents new regeneration. However, because B was not constrained to be between 0 and 1, it is not entirely survival. If the number of new seedlings in 1993 was related to the number of existing seedlings in 1990, then this component would be subsumed into B. As we consider that component to be small relative to survival, B can often be considered to be survival. A negative value for B would probably indicate that the number of tupelo seedlings is wildly fluctuating from year to year. A value for B >1 would indicate that survival is probably high, and that the number of new seedlings was positively related to the initial number of seedlings. The final equations for A and B follow:

$$A = 536(TC) - 595(L_1TC) - 489(L_2TC)$$
$$B = (0.984 + 0.327(C)) \qquad (2)$$

where

T = a dummy variable that is 1 when the plot has been thinned, and 0 when not thinned;
C = a dummy variable that is 1 when the plot has been cleaned, and 0 when not cleaned;
L_1 = a dummy variable for location 1; and
L_2 = a dummy variable for location 2.

The adjusted R^2 was 0.95 and the standard error of the estimate is 121 trees per plot. "A" corrects for an anomaly—a plot on location 3 that had been thinned and cleaned had a very large number of seedlings. Thus the importance of A may be discounted.

The equation for B indicates that for thinned and control plots the number of seedlings in 1993 almost equaled the number of seedlings in 1990 ("survival" = 0.984). For plots that had been cleaned, the "survival" term is >1, probably indicating that the causes of high initial seedling numbers also caused higher numbers of new regeneration. Thus "survival" for all seedlings was less than the 0.984 parameter value would indicate. Although the equation indicates that cleaning increases the number of tupelo seedlings, a long, late flood in 1991 may have affected the reliability of these results. The flood reduced seedling numbers by approximately 30 percent between 1990 and 1991, and the increase of tupelo seedlings from 1991 to 1993 represent a recovery from these losses. Because these numbers fluctuate drastically, random chance may cause a perceived treatment effect. For these reasons, making any inferences about the treatment effect on tupelo seedling numbers is unwarranted.

Conclusions

These third-year results indicate that cleaning has little or no beneficial effects on the water tupelo stands selected for this study. The response to thinning seems to depend on stand and site characteristics. The response was greatest for location 2, which seemed to have the greatest site quality and which had few large gaps between sprout clumps and, thus, a high density of stumps. However, the magnitude of the effects might change as the stands develop and mortality of the sprouts become more common as natural thinning occurs within stumps.

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