LEAF BIOMASS AND ACORN PRODUCTION IN A THINNED 30-YEAR-OLD CHERRYBARK OAK PLANTATION

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Abstract—Objectives of this study were to determine the effects of two levels of thinning on leaf biomass and acorn production of cherrybark oak (*Quercus pagoda* Raf.). To evaluate the effects of thinning 2 years after treatment, treatment plots were selected and blocked on the basis of initial stocking levels. Two levels of stocking and a control were established for each of five repetitions. Collection traps were randomly distributed on each plot to collect litter and acorns. The contents of the traps were collected weekly throughout the fall and winter of 2001. ANOVA was used to detect significant differences among thinning treatments regarding leaf biomass and acorn production. Two years after thinning, both leaf area and acorn production were affected by thinning level. Results, although preliminary, suggest enhanced leaf area and changes in acorn production. Level of thinning did have different effects over the short term.

INTRODUCTION

There were 5 million hectares of forested land in Louisiana in 1991. This accounted for 52.5 percent of the total land area of the State. Of the forested land, 62 percent was owned by nonindustrial private landowners, 29 percent belonged to the forest products industry, and 9 percent was publicly owned. Bottomland hardwoods made up 34 percent of this land (Vissage and others 1992). Good hardwood management can therefore have significant impact on both economic and habitat-related factors in Louisiana.

One of the more important bottomland hardwood species in the lower Mississippi Valley is cherrybark oak (*Quercus pagoda* RAF). It is plentiful in this region where it grows quickly, generally producing a clear bole and superior quality wood. These qualities have led to its being rated the best red oak in the region; it is used for furniture and trim (Harlow and others 1996).

Knowledge of the effects of thinning on acorn production could be useful on several fronts. Cherrybark oak acorns are important both as a source for regeneration and as food for wildlife (Auchmoody and others 1993); the acorns provide vitamins, fats, and carbohydrates for deer, squirrels, mice, ducks, and turkeys (Kea 1999). Acorns can also be harvested and used by nurseries to grow seedlings. Thinning is a commonly used stand management tool. A stand is typically thinned to a density that will meet landowner objectives, which can include increasing future timber value, improving stand and tree quality, producing current income, and enhancing wildlife habitat (Goodrum and others 1971). Management for wildlife includes ensuring that proper habitat is available and that food is readily obtainable. However, there is not much information available regarding the effects that thinning may have on bottomland hardwood plantations (Meadows and Goelz 2001). Similarly, there is little data about the effect thinning may have on acorn production (Healy 1997).

Biomass allocation has a great effect on the growth and physiology of a tree (Martin and others 1998). Since stem biomass and biomass allocation are dependent on solar energy capture and conversion, biomass production is closely related to leaf area. Understanding the nature of thinning effects on leaf biomass over time will be crucial in understanding the relationship between changes in stand density, stand productivity, and acorn biomass production.

MATERIALS AND METHODS

Study Site

This study took place on the Red River Wildlife Management Area (RRWMA) in Concordia Parish, LA. The portion of the RRWMA used for this study was one of a series of bottomland hardwood plantations located near the Mississippi River. The two growing seasons before this study were much drier than normal, with approximately 122 cm of precipitation compared with the average of 165 cm (Louisiana Office of State Climatology 2000, 2001). Precipitation during the study year was near normal, but nearly 51 cm of that came with tropical storm Allison that impacted the area from June 5-11, 2001. We did not see substantial storm damage at the site, but rainfall was high during that period. The soil on the site is of the Commerce-Bruin soil association. Cherrybark oak site index on the area averaged 33.5 m at base age 50. A 142.5-ha tract in the area north of State Highway LA910 was planted between 1969 and 1972. Various hardwood species were planted in single species blocks repeated throughout the area. Cherrybark oak accounted for approximately 43 percent of the planted area. Average planting density was 166 trees per ha.

Plot Establishment

Fifteen plots were established in 1998 in this plantation for an ongoing thinning study. The rectangular plots measured 20.4 by 81.6 m and were surrounded by a buffer strip 20.4 m wide. Diameters of trees greater than 12.88 cm at breast height (d.b.h.) were measured. Measurements were

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used to determine initial stocking, which was based on Goelz's (1995) stocking guide for southern bottomland hardwoods. Five blocks, with three plots per block, were created based on initial stocking. One of three different thinning treatments was randomly assigned a plot within each block. The treatments were:

Treatment 1: Thin to a 70- to 75-percent stocking level

Treatment 2: Thin to a 50- to 55-percent stocking level

Treatment 3: Uncut control.

Once the plots were established, trees to be removed were selected based on d.b.h., crown class, vigor, and overall stocking. The Meadows and others (2001) crown classification system was used to evaluate crown condition, crown class, and vigor. Plots were thinned in the winter between 30 September 1998 and 03 February 1999. Thinning was a mixture between high and low thinning, but dominant and co-dominant trees were favored as leave trees.

Litter Trap Construction, Placement, and Collection

Leaf and acorn collection traps (hereafter referred to as traps) were constructed of shade cloth, plastic tubing, and PVC pipe. Circular traps, used to determine tree-level effects, were 1.0 m tall and 0.5 m^2 in area. Shade cloth sewn into a funnel shape was attached to plastic tubing formed into a circle, then attached to legs made of PVC pipe. A 5-gallon bucket (In a minimal number of cases, large pecan pots were used in place of 5-gallon buckets. The pots had holes in the bottom sides that were plugged with cotton; however, the cotton came out in some instances. Although we were careful to collect acorns that might have spilled, we could not determine if mice might have entered the holes and taken acorns. Mice feces were not found in the pots during the collections.) placed under each trap was used to collect acorns and leaves. Traps were stabilized by pushing the PVC legs into the ground. Holes were drilled into the buckets to allow rainwater to escape.

To test the effects of tree size and thinning level on the production of leaf biomass and acorns, a random selection of 48 trees was made in each of the three treatments for a total of 144 trees. A cardinal direction was randomly chosen, and the distance from the trunk of each sample tree to the edge of the crown was measured. A single trap was placed at a point halfway between the tree bole and the edge of the crown (Perry and Thill 1999).

Rectangular traps were also placed in the measurement plots and were used to estimate production of leaf biomass and acorn production for the entire plot. Elongated traps were made with PVC frames and had shade cloth attached to the frames with wire ties. Elongated traps were 3.04 m long, 0.609 m wide, and 1.85 m^2 in area. Twelve traps were placed on each plot to represent a 1-percent sample of the plot area (168 total rectangular traps). A randomly chosen row and distance into the plot were chosen as the placement point for a rectangular trap, and a random distance from the tree boles within a row was also chosen for the placement between rows. This sampling scheme was designed to effectively sample the entire area, not just areas under tree crowns. The traps were emptied once a week during the period of acorn and litter fall (approximately mid-October to December). When the litter and acorn fall decreased, traps were emptied every 2 weeks, with the final collection completed the first week of February.

Analysis

All leaf litter and acorns were transported to the lab. Litter was sorted and all non-cherrybark litter was removed. Cherrybark oak leaf litter and acorns were oven-dried and weighed. All materials were dried until stable ovendried weights were achieved. Both leaf litter biomass and acorn biomass results were analyzed using ANOVA and Tukey's Studentized Range tests (SAS 1991). A significance level of 0.05 was chosen as adequate to show significant differences in this study.

RESULTS

Leaf Biomass

When analyzed at the individual tree level (circular traps), trees in the light-thinned treatment produced the greatest amount of leaf biomass, 22.7 g per m^2 of trap area, whereas trees in both the unthinned control treatment and the heavy-thin treatment produced only 17.5 g per m^2 and 15.6 g per m^2, respectively (fig. 1). There were significant differences ($\alpha = 0.05$) in leaf biomass produced between the control treatment and the light-thin and between the light and heavy-thin treatment. There were no significant differences between the leaf biomass collected in the control plots and the heavy-thin treatment plots.

On a whole-plot basis (rectangular traps), the light-thin treatment also produced the greatest amount of leaf biomass, 284.3 kg per ha, followed by the control, 243.2 kg per ha, and the heavy-thin, 211.0 kg per ha (fig. 2). Only

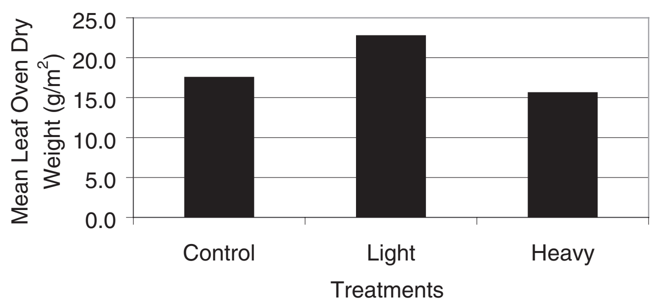

Figure 1—Mean leaf biomass per unit trap area collected midway between tree bole and canopy edge.

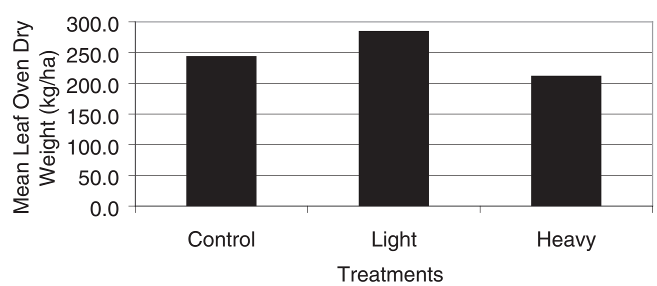

Figure 2—Mean leaf biomass collected per unit plot area.

contrasts between the light-thin and heavy-thin treatments produced significant differences in leaf biomass. No significant differences existed between the control and light-thin, or the control and heavy-thin.

Acorn Biomass

For purposes of this paper, all acorn biomass, complete acorns, acorn caps, and acorn pieces were weighed together. Means of 3.0, 2.2, and 1.6 g per m^2 of acorn biomass were collected on the control, light-thin, and heavy-thin treatments, respectively (fig. 3). Significant differences (α = 0.05) were found between the control and the heavy-thin treatment. There were no significant differences between the control and the light-thin treatment or the light-thin and heavy-thin treatments.

Means of 14.1, 8.1, and 8.1 kg per ha of acorn biomass were collected in the rectangular traps in the light-thin treatment, control, and heavy-thin treatments, respectively (fig. 4). No significant differences were found between any of the treatments.

DISCUSSION

Tree Level Measurements

Light thinning appeared to have the greatest early effect on leaf biomass production at the individual tree level. There were significant differences between the light-thin treatment and both the heavy-thin and control treatments. The lack of response on the heavy-thin could be due to reductions in relative tree size on heavy-thinned plots or could be the result of slow crown expansion caused by an initial shock from the heavy-thin treatments (Johnson and others 2002). The crowns of the light-thin treatment could be increasing at a slightly greater rate than those of the heavy-thin treatment. Greater crown expansion would result in a greater leaf area, which would promote greater biomass production by allowing for greater rates of photosynthesis (Johnson and others 2002).

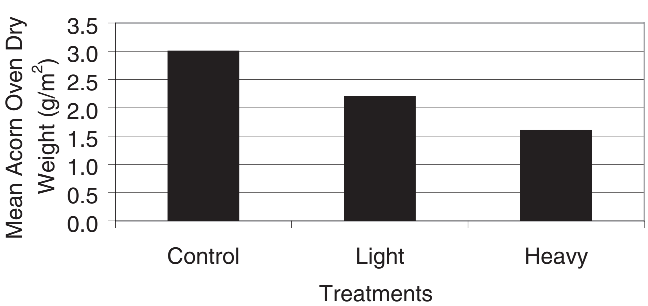

Figure 3—Mean acorn biomass per unit trap area collected midway between tree bole and canopy edge.

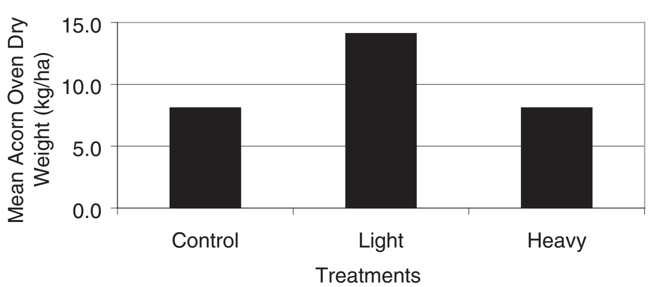

Figure 4—Mean acorn biomass collected per unit plot area.

On an individual tree level, both the light-thin and the control treatment produced significantly more acorn biomass than the heavy-thin treatment. In contrast, Healy and others (1999) found that trees in thinned plots produced more acorns than those in unthinned plots. We found variation in acorn production among individual trees to be high. Healy (1997) also found variation in individual trees to be greater than the effect of thinning. Continuing study of the results over time may lead to firmer conclusions.

Plot Level Measurements

Thinning also affected leaf biomass production at the plot level. Two years after treatment, leaf biomass production in the light-thin plots was 34 percent greater than that in the heavy-thinned plots, but there was no significant difference in leaf biomass production between the light-thin and the control or the heavy-thin and the control. Light thinning seemed to stimulate leaf biomass production at the plot level as well as at the individual tree level. This is most likely the result of crown expansion into the newly opened gaps in the canopy. This growth in turn increases leaf area, which increases tree-level photosynthetic capacity (Johnson and others 2002). The heavy-thin treatment removed considerable basal area, more trees, and more leaf area from the plots. Time needed to recover lost leaf area will likely take longer in the heavy-thin treatment. Since heavy-thinned plot leaf biomass production was not significantly different from leaf biomass on the unthinned control plots, it appeared that leaf biomass production may have been stimulated by the heavy thinning as well. At the time of the study, the crowns in the light and heavy-thin treatments may still have been expanding at the same rate. This would cause the light-thin to produce more biomass because there are more trees in the light-thin treatments than the heavy-thin. Further analysis is warranted.

At the plot level, there was no significant difference in acorn production. This may be the result of several factors. It may be too soon to see the effects of thinning on acorn production. The acorn crop produced the year of this study was relatively small and may have been a product of the previous 2 low-precipitation years plus the effects of tropical storm Allison that hit the area in early June. Predation may also have affected the amount of acorns collected in the traps.

Further Research

Initially, it appeared that a light-thin treatment would increase the leaf biomass and acorns produced in a stand within 2 years after a thinning operation. A heavy-thin might appear to have a negative impact on both leaf and acorn production; however, there was no significant reduction of leaf biomass at the plot or the tree level, nor was there a reduction in acorn production at the plot level when compared to the unthinned control. The heavy-thin treatment and control appeared to produce leaf biomass and acorns in the same amount, despite the heavy-thin plots having fewer and somewhat smaller trees. This indicated greater production per tree on the heavy-thinned plots than on the controls. The longer term effects of thinning may, indeed, show a large enhancement in leaf and acorn biomass with heavier thinning levels on these good sites. The next few years of data collection and analysis will be useful in revealing the response to the heavier thinning treatment.

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