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Development of water oak stump sprouts under a partial overstory

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Application. A partial overstory did not influence the number of stumps that sprouted or the number of sprouts per clump. Sprout clump survival and growth of dominant sprouts can be maximized under heavy partial cuttings. Additional overstory removal or sprout clump thinning may be necessary to maintain vigor of stump sprouts beneath partial overstories.

Abstract. A 28-year-old water oak (Quercus *nigra* L.) plantation was thinned from below to either 254 or 462 stems per hectare to determine the influence of a partial canopy on oak stump sprout development. Sprout clump survival, number of living sprouts in a clump, and height and DBH of the dominant sprout in a clump were measured in years l-5 and 7 after harvest. By year 7, sprout clump survival under the heavily thinned canopy was 23% higher than under the lightly thinned canopy. Within-clump sprout mortality was not influenced by overstory thinning level, but by year 2 height and diameter increment were 15% and 22% greater, respectively, under the heavy overstory removal. Positive height and diameter growth of dominant sprouts continued under both canopy conditions through year 7, but early benefits of the heavy overstory removal on sprout growth diminished. Additional overstory removal or sprout clump thinning would be necessary to sustain sprout clump survival and sprout growth over extended periods.

Introduction

Oaks (Quercus spp.) are a principal component in bottomland hardwood forests of the southern and southeastern United States, where they are highly valued economically and ecologically. Desirable timber and wildlife habitat qualities are exemplified in bottomland species such as water oak (Q. *nigra* L.), cherrybark oak (Q. *pagoda* Raf.), swamp chestnut oak (Q. *michauxii* Nutt.), and Nuttall oak (Q. *nuttallii* Palm.). As a result, these and other bottomland oak species are favored in natural stand regeneration and afforestation efforts. Unfortunately, securing natural regeneration for bottomland oaks is difficult under currently practiced regeneration methods (Johnson and Deen 1993), and is a common problem among other North American oaks (Smith 1993).

Sources of oak natural regeneration include seedlings, seedling sprouts and stump sprouts (Johnson 1993), with seedling sprouts and stump sprouts considered to be the most reliable sources in bottomland hardwood forests (Johnson and Deen 1993). Successful establishment of oak stump sprouts is facilitated by rapid early shoot growth, which enables the sprout to compete with other vigorous vegetation (Zahner and Myers 1984). In addition to being an important component of the regeneration pool, stump sprouts can rapidly provide cover and browse for wildlife, and add vertical structure to single-storied canopies typical of plantations.

Several factors are known to influence sprouting of oak stumps including harvest season, stump size and age, and species (Roth and Hepting 1943; Longhurst 1956; Johnson 1975; Kays et al. 1988). These factors are correlated with dormant bud frequency on root collars, carbohydrate reserves in root systems, or water and nutrient uptake capacity of the root system, and therefore can be used to predict much of the initial sprout response from a stump (Johnson 1993). Environmental factors such as site quality can also affect stump sprout development of oaks (Johnson 1975; Tworkoski et al. 1990). However, how oak stump sprouts develop beneath partial canopies is not well known (McGee and Bivens 1984; Johnson 1993). Light availability beneath a partial canopy would possibly limit growth of bottomland oak stump sprouts, because most bottomland oak species are intolerant to moderately intolerant of shade (Putnam et al. 1960). This study was implemented to 1) describe sprouting ability of stumps and development of water oak sprouts under a partial overstory, and 2) determine if degree of overstory thinning influenced water oak stump sprout development.

Methods

The study was installed in a 28-year-old water oak plantation established on an old-field site in Franklin Parish, Louisiana (32°6′N, 91°38′W). Stand characteristics for the plantation are summarized in Table 1. Soil was described as Calhoun-Calloway and Calhoun-Loring complexes (Krinard and Johnson 1988). These soils are loessial in origin, have silt loam or silty clay loam surface horizons, and have fragipans about 50 centimeters (cm) below the surface. Water oak site index of these soil complexes is estimated to be 26 meters (m) at 50 years (Krinard and Johnson 1988). Mean annual temperature at the site is 18.5°C, and mean annual precipitation is 128 cm.

Eight, 0.6-ha treatment plots were delineated in the plantation and randomly assigned either a heavy or light thinning level. In the winter of 1987-88, heavy thinning from below reduced stand density to 254 dominant or codominant stems per ha, and light thinning from below reduced density to

Table 1. Stand characteristics of a water oak plantation 1 year before, 1 year after, and 7 years after receiving a light or heavy overstory thinning.

	Pre-thinning	Year 1 Post-thinning		Year 7 Post-thinning	
		Light	***Heavy***	***Light***	***Heavy***
Density (stems/ha)	879[1]	462	254	432	242
Average DBH (cm)	16.7	17.7	19.3	22.1	24.9
Basal Area (m^2/ha)	19.7	11.9	7.8	17.2	11.9

[1] The plantation was originally established on about a 9 x 6 spacing, 1990 stems/ha.

462 dominant or codominant stems per ha (Table 1) (Meadows and Goelz 1993). Thus, heavy thinning removed 60% of the basal area (BA), whereas light thinning removed 40% of the BA (Table 1). Three, 0.04-ha measurement plots were systematically established in each treatment plot. All stumps in the measurement plots were tagged and measured 1-5 and 7 years after treatment for the number of living sprouts in a clump, height (nearest 2.5 cm) of the dominant sprout in a clump, and DBH (nearest 2.5 millimeter) of the dominant sprout in a clump. A total of 378 stumps were tagged and measured in this study.

The study was a completely randomized design and analysis of variance was performed by year on treatment plot means for sprout clump survival, sprouts per clump, sprout height and sprout DBH. An alpha level of 0.05 was used to determine significant treatment effects. Simple linear regression was used to explore relationships between initial tree DBH and sprout clump survival, sprouts per clump, sprout height and sprout DBH.

Results and Discussion

All stumps sprouted the year following harvest (Figure la). Sprout clump survival sharply decreased by year 2, then continued on a gradual decline through year 5 with no significant effect of thinning level on survival. However, in year 7 stump survival under the heavy thinning regime averaged 76%, 23% higher than survival of stumps in lightly thinned plots (Figure 1 a). Mortality of sprout-producing oak stumps is expected over time even in open environments, but appears to be greatest the first few years following harvest (Johnson 1977), and may be negligible after sprouts establish dominance

(Johnson 1975). However, where stump sprouts result from an intermediate stand practice, resources supporting stump survival would probably become limiting as crown closure progressed. This effect is evident in this study from the greater mortality observed under the lightly thinned canopy.

Profuse stump sprouting in both treatments was observed 1 year after harvest as stumps supported an average of 15 sprouts (Figure lb). In this year, over 50% of all stumps produced 11 or more sprouts and 30 or more sprouts were produced by 17% of the stumps (Figure 2). Also, initial sprouting frequency was not affected by level of overstory removal (Figure lb). A high rate of sprout mortality was observed within clumps through year 4 reducing the number of sprouts on a stump by more than half. Mortality rate within sprout clumps stabilized and 7 years after harvest live stumps supported about four sprouts (Figure lb). Frequency distribution of sprouts in a clump had greatly shifted by year 7 as 92% of all live stumps supported 10 or fewer sprouts (Figure 2). Interestingly, self-thinning within the sprout clumps was not influenced by overstory treatment (Figure lb). Apparently, within-clump sprout mortality was more directly determined by intra-clump sprout competition, rather than resource availability to the whole stump.

In agreement with other research on oak stump sprouts (Cobb et al. 1985), greatest height growth increment occurred the first season after harvest leading to an average height of 2.3 m among dominant sprouts (Figure lc). By year 2, stump sprouts in the heavily thinned plots grew 15% taller than sprouts under the lightly thinned overstory. This difference was maintained five years after partial overstory removal (Figure lc). A similar response was observed for diameter increment and by year 2 dominant sprouts in the heavily thinned plots were 22% larger than sprouts in the lightly thinned plots (Figure 1d). Positive height and diameter growth of dominant sprouts continued through the study period, but early benefits of the heavy overstory removal on stem growth diminished by year 7 (Figures lc, 1d). At this time, dominant sprouts averaged 4.5 m tall with a DBH of 2.7 cm regardless of overstory thinning level. Failure to find statistical differences between treatments at year 7 appears to be due to increased variation about treatment means (Figures lc, 1d). This increased variation over time may be due to the heterogeneous progression of canopy closure in this thinned stand. For sprouts which developed beneath the light overstory, evidence that canopy closure may have reduced growth is noted by a decrease in average height increment from 0.51 m per year between years 1 and 5 to 0.23 m per year between years 5 and 7. Likewise, diameter increment of these same sprouts decreased from an average of 0.52 cm per year between years 0 and 5 to 0.27 cm per year between years 5 and 7. Similar decreases in height and diameter increment were observed for sprouts in the lightly thinned plots.

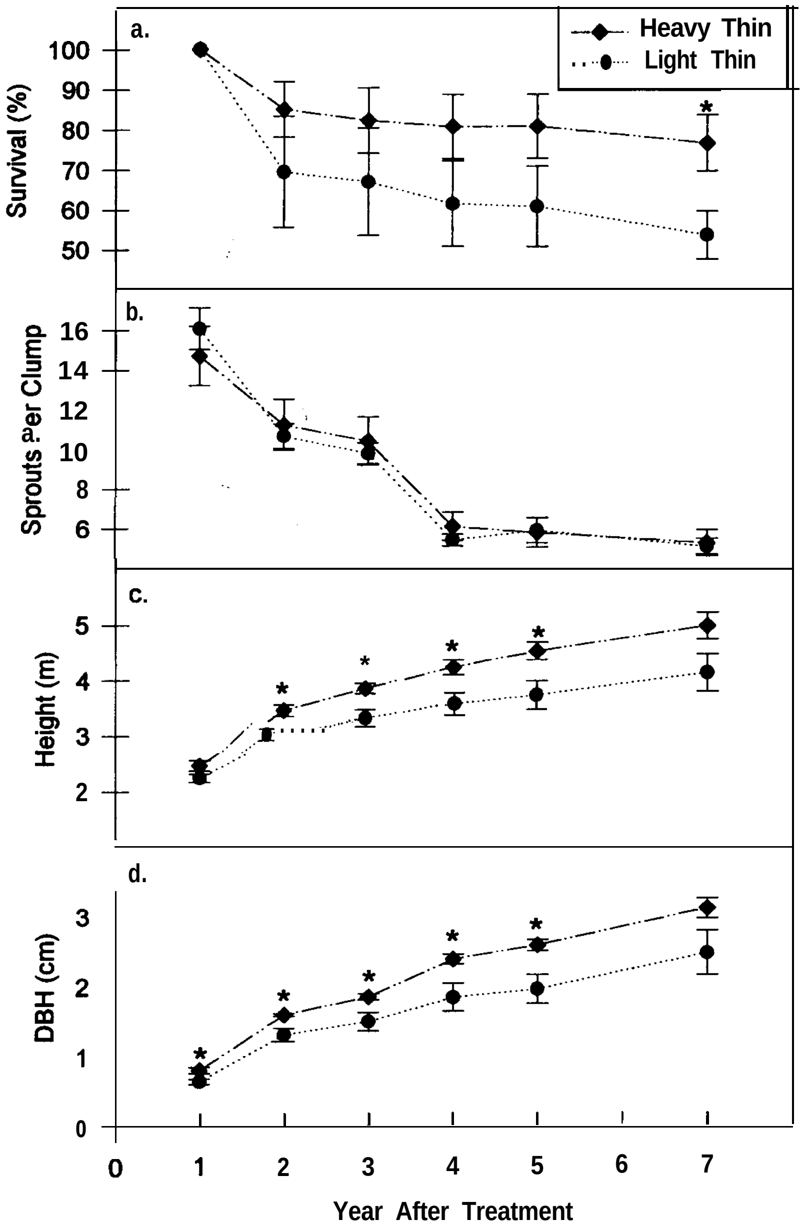

Figure I. a. Average sprout clump survival, b. sprouts per clump, c. height of dominant sprout, and d. DBH of dominant sprout for water oak coppice in a plantation thinned to two different densities. Bars are ± 1 standard error and significant difference between treatment levels are noted by an asterisk above the error bar (α = 0.05).

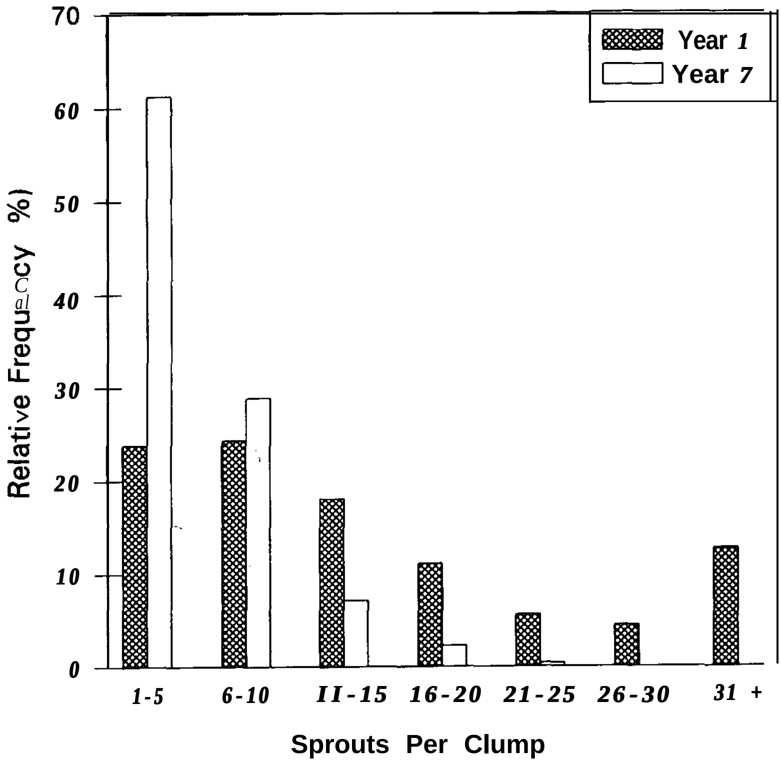

Figure 2. Frequency distribution of sprouts per clump for water oak coppice 1 and 7 years after thinning a plantation.

Regression analyses revealed no direct relationship between initial tree DBH and sprout clump survival, sprouts per clump, or height and DBH of dominant sprouts. Other reports on different oak species are contrary to these findings (Johnson 1975, 1979; Kays et al. 1988). For example, Kays et al. (1988) found that a growing season harvest greatly reduced stump sprouting on white oak (*Q. alba* L.) stems greater than 30 cm DBH. Our results may be explained by the single age and small degree of variation in tree DBH among the harvested trees.

Research documenting sprouting ability and development of oak stump sprouts beneath partial canopies is limited. Our results impart a few important implications for managing coppice regeneration beneath a partial overstory. First, sprout clump survival and sprout height and diameter growth diminished as canopy closure advanced. Additional overstory removals may be necessary to maintain sprout clump survival and growth over extended periods, especially for shade intolerant species such as water oak. Also, sprout clump thinning possibly could extend survival and maintain growth of sprouts. Sprout clump thinning was used to successfully increase survival and stem volume of open-grown oak coppice (Johnson and Rogers 1984; Lamson 1988; Lowell et al. 1989). Secondly, the heavier overstory removal prolonged sprout clump survival and increased growth of dominant sprouts. Thus, the period between the initial harvest and additional treatments to sustain coppice regeneration will be determined by the amount of overstory originally removed. Finally, the partial overstory did not influence the number of sprouts produced or supported by water oak stumps. Managing coppice beneath a partial overstory does not reduce opportunities to select superior sprouts or control sprout distribution around a stump with clump thinnings.

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