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COMPOSITION AND HEIGHT GROWTH OF NATURAL REGENERATION IN A MESIC, OAK-DOMINATED FOREST FOLLOWING A SHELTERWOOD HARVEST

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INTRODUCTION

A characteristic of many Indiana forest stands located on mesic sites is a well-developed, even-aged canopy dominated by oak species (white oak, *Quercus alba,* in particular). The natural development of regeneration beneath these oak stands includes very little white oak; certainly not enough to maintain white oak as a major component in the future stand (Merritt, 1979). In fact, a subcanopy of relatively shade tolerant species may develop and effectively prevent newly established oak seedlings or sprouts from gaining dominance or co-dominance after disturbance or removal of the main canopy (McGee, 1986). Efforts to naturally regenerate oak have been focused on drier sites with little subcanopy development, where competition for light may not be as severe as on more mesic sites (Sander, *et al.,* 1983).

The literature suggests that a shelterwood system may be employed to promote acorn production, germination, establishment, and growth of white oak seedlings. Sander (1977) states that an adequate number of white oak seedlings or sprouts 4.5 feet tall or taller at the time of overstory removal will provide rapid growing white oak sprouts that will be able to compete with other quick growing species. Sander also cautions that overstory removal with no treatment to the subcanopy may result in vigorous resprouting of the subcanopy trees which may overtop the white oak seedlings. The objective of this paper is to examine the effects of subcanopy removal treatments on the growth of white oak seedlings and sprouts as well as other species over the 1988 growing season.

METHODS

The study area is a thirty acre forest stand at Miller-Purdue Agricultural Center, located in eastern Grant County, Indiana, approximately two miles east of Upland. This site is located in the Bluffton Till Plain Section of the Central Till Plain Natural Region as described by Homoya, *et al.* (1985). The soil association at this site is the Glynwood-Pewamo-Morley Association, characterized by nearly level, deep, moderately well to poorly drained, moderately fine textured soils formed in glacial till. The two soil types found at the study site are Blount silt loam, which is somewhat poorly drained, and Morley silt loam, which is well drained.

The overstory is composed primarily of white oak and northern red oak (*Q. rubra*). The subcanopy is composed of sugar maple (*Acer saccharum*), American elm (*Ulmus americana*), red elm (*U. rubra*), white ash (*Fraxinus americana*), black

cherry (*Prunus serotina*), American basswood (*Tilia americana*), bitternut hickory (*Carya cordiformis*), and shagbark hickory (*C. ovata*).

A February 1987 shelterwood harvest in the southern one-third of the stand removed approximately forty percent of the overstory. Forty-eight 20 m x 30 m plots were located in the shelterwood area, and fifteen of the interior plots were selected for this study. Either the west half or the east half of each plot was randomly assigned to examine natural regeneration, and the other half was used for a planting study. Each natural regeneration half-plot (referred to hereafter as experimental unit) was randomly assigned one of the following three treatments: 1) control (the subcanopy was left intact); 2) subcanopy removal (all trees taller than 4.5 feet were cut off at the base or girdled); and 3) subcanopy removal plus herbicide (the same treatment as in number 2 above with an 18% glyphosate solution applied to the cut stumps or to the girdle cuts).

In each experimental unit, twelve plot centers were systematically located five meters apart, two and one-half meters from each edge. The plot center marked the center of each of the twelve 5 m x 5 m plots in each experimental unit. In total, there are 180 5 m x 5 m plots with 60 in each treatment. The nearest seedling or sprout to the plot center less than 4.5 feet tall of each tree species was tagged after the subcanopy removal treatments, and the height and current season's growth measured. The number of current season's flushes, and the total number of flushes were counted for each individual.

RESULTS AND DISCUSSION

The occurrence of each species throughout the 180 5 m x 5 m plots is reported in Table 1. Eight other tree species were recorded, but the frequency of occurrence of each of these was less than six plots each. Only the ten most frequently occurring species were used in the following statistical analysis. White oak is the second most frequently occurring species, but of the ten species, white oak is the shortest (Figure 1) as well as the slowest growing species (Figure 2).

The mean current season's growth for each species by treatment in Figure 2 shows varying responses to the removal treatments. Curiously, the growth of white oak seedlings and sprouts is significantly greater ($P > .05$, SNK Mean

TABLE 1. Frequency of occurence of seedlings and sprouts of each species in a February, 1987 shelterwood harvest at Miller-Purdue Agricultural Center (1988). There are 180 total plots.

Species	Number of Plots
Sugar maple	157
White oak	137
White ash	124
Bitternut Hickory	100
Red elm	95
American elm	72
Northern red oak	61
Shagbark hickory	58
Black cherry	54
America basswood	53
Misc. species[1]	21

[1]Black walnut, bur oak, chinkapin oak, hackberry, sassafras, redbud, and white mulberry.

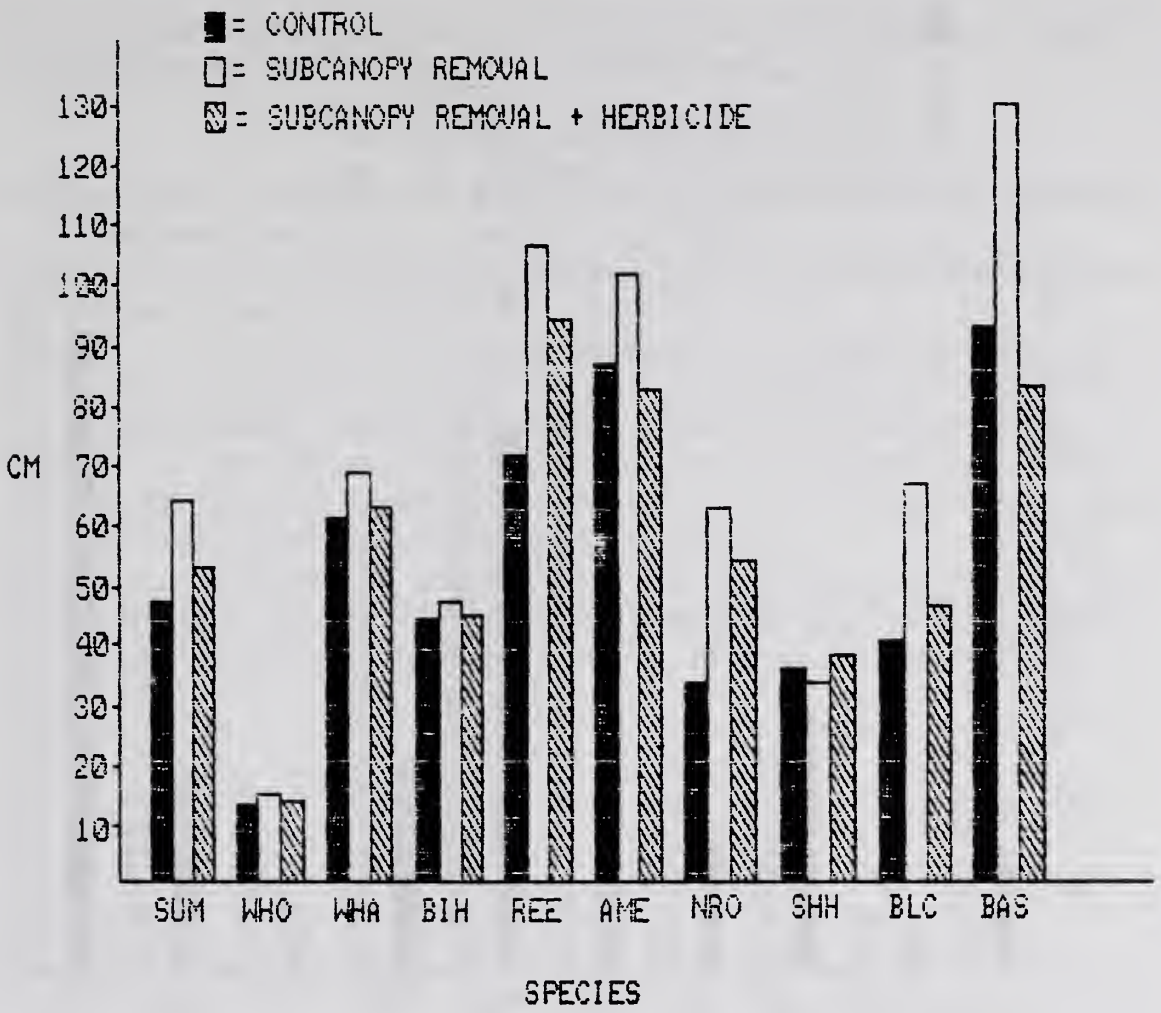

FIGURE 1. Mean total height of seedlings and sprouts for each species by treatment in February, 1987 harvest area at Miller-Purdue Agricultural Center (1988).

Separation Test) in the removal treatment than in the herbicide treatment. There was no significant difference at the 0.5 level between the control and the removal treatments. Red elm and black cherry also grew significantly more in the removal treatment than in the herbicide treatment. Sugar maple grew significantly more in the removal treatment than in the control treatment, as might be expected. American elm, red oak, and American basswood show no significant differences in growth, probably due to substantial unequal distribution between treatments.

Some of the variation in mean height growth between the treatments for each of the species is related to the proportion of true seedlings to sprouts in each treatment. Mean height growth for sprouts is significantly greater ($P < .05$) than mean height growth of true seedlings for all species except basswood (only one true seedling was found). Sugar maple, white oak, red elm, and black cherry all have proportionately more sprouts in both removal treatments and thus greater growth. However, only sugar maple shows a significant increase in growth between the removal treatment and the control.

While the mean height growth varies by treatment for each species, it is evident that white oak seedlings have the shortest mean height and the lowest mean height growth. The remaining nine most frequently occurring species' had significantly greater mean height and mean height growth than that of white oak.

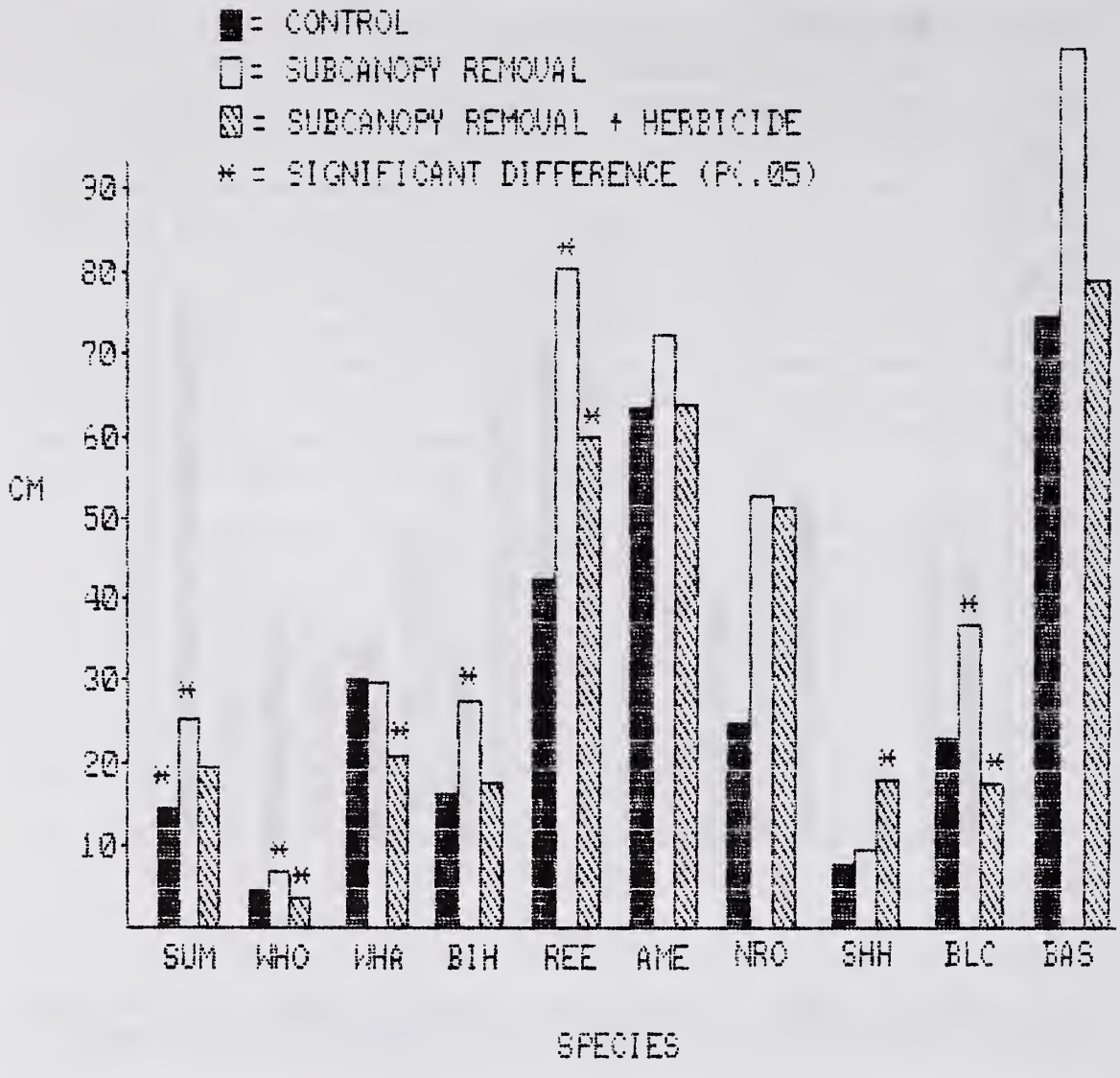

FIGURE 2. Mean height growth of seedlings and sprouts for each species by treatment in a February, 1987 shelterwood harvest area at Miller-Purdue Agricultural Center (1988).

True white oak seedlings have the youngest mean age, a little over two years (flushes). Sugar maple and white ash have the oldest mean age, just over seven years (flushes) for both species. While the sprouts of white oak may be older than the mean true seedling age, they are not as old as the other species' sprouts and do not grow as fast. No white oak saplings were found in the subcanopy in any of the experimental units, but all of the other nine species had substantial numbers of saplings and pole-sized trees removed in the subcanopy treatments. Sprouts from these cut trees are the sprouts with which white oak is competing. The herbicide treatment may have slowed the height growth for most species (Figure 2), but the mean height growth for white oak is still less than that of the other nine species.

The white oak individuals sampled are being overtopped and may never reach the 4.5 feet Sander (1977) recommends before overstory removal without additional cultural treatment to the competing understory vegetation. Removing and chemically treating the subcanopy well before the shelterwood harvest may reduce or eliminate the vigorous sprouting of the subcanopy trees. When the shelterwood

harvest is completed, the white oak seedlings and sprouts will then be competing with vegetation of similar size.

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