TREE REGENERATION FOLLOWING GROUP SELECTION HARVESTING IN SOUTHERN INDIANA

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Abstract: An increased interest in the use of group selection harvesting in the Central Hardwood forests has emphasized the lack of scientific information about species response under this uneven-aged management system. Tree regeneration response following group selection harvesting was studied on thirty-six group selection openings on the Naval Surface Warfare Center, Crane Division in southern Indiana. The objectives were to determine whether aspect, age, species group, size of the opening, or their interactions had any influence on the number of stems or average height of the tree regeneration. Two different aspects, three postharvest age classes, and three opening sizes were examined. Yellow-poplar and dogwood were the most abundant stems $\geq$ 2.5 cm dbh, and dogwood and cherry-ash-walnut were the most abundant stems $<$ 2.5 cm dbh. Stem density ($<$ 2.5 cm dbh) was influenced by age, aspect, and the age/species group and aspect/species group interactions. The north aspect and the oldest openings contained the highest number of stems per hectare for stems $<$ 2.5 cm dbh. Age, species group, and their interaction influenced average height for stems $\geq$ 2.5 cm dbh.

INTRODUCTION

Recently there has been an increased interest in the use of group selection for the regeneration of Central Hardwood forests. Since the mid 1960s clearcutting was one of the most commonly used methods to regenerate Central Hardwood forests on national forest lands. Its use was encouraged by research completed by Roach and others (1968), and by Sander and Clark (1971). Therefore, research conducted by the USDA Forest Service and other researchers has centered around the use of clearcutting with limited research effort given to uneven-aged management.

The renewed emphasis in uneven-aged management has underscored the need for information on uneven-aged silvicultural systems. There is little scientific information about Central Hardwood regeneration under uneven-aged management which addresses the effect of opening size, parent stand composition, variation within an opening, temporal change, or aspect on regeneration.

The group selection method was developed to combine the benefits of single-tree selection and even-aged management (Marquis 1978). A benefit of single-tree management is the retention of a fairly continuous canopy providing a more natural appearing forest stand. Even-aged management provides for the regeneration of shade intolerant tree species. Thus, group selection should provide for the regeneration of intolerant and intermediate trees while retaining a mostly continuous forest canopy.

The suggested size of the group opening varies from the removal of a few trees to many trees. There has been much discussion on the maximum and minimum size. Marquis (1989) suggests an opening of a tenth to a quarter acre in size with a maximum of a half acre. An opening from a half acre to one acre in size is recommended to regenerate intolerant species (Law and Lorimer 1989, Sander and Clark 1971). Openings of up to two acres have been mentioned as group selection (Mills and others 1987) but if the openings are larger than an acre Marquis (1989) and Marquis and Johnson (1989) suggest they be termed patch clearcuts.

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Light reaching the group selection openings can be managed (Fischer 1981) by controlling the shape and placement of the opening on the landscape. Thus, the regeneration of intolerant species can be encouraged by the proper shape and location of the group selection openings.

This paper will report how the quantity and height of the four most prevalent species groups; oak-hickory, yellow-poplar, dogwood, and beech-sugar maple, are influenced by the age, size, and aspect of the group selection openings.

METHODS

This research was conducted on the Naval Surface Warfare Center-Crane Division, (NSWC), located in south central Indiana. NSWC contains over 62,000 acres of which more than 48,000 are forested. Uneven-aged management has been the regeneration system used at NSWC since timber management began there in the early 1960s.

Nearly the entire NSWC is unglaciated and lies within the Crawford Upland Section of the Shawnee Hills Natural Region as described by Homoya and others (1985). It is characterized by rugged hills with sandstone cliffs and rockhouses. The forest vegetation consists of oak-hickory on the upper slopes with a mesic component in the coves and bottoms. Soils in the study area were of the Wellston association characterized as deep and moderately deep, gently sloping to very steep, well drained soils formed in loess and material weathered from sandstone, siltstone, and shale on uplands (USDA Soil Conservation Service 1988). The group selection openings ranged in elevation from 170 m to 260 m.

The overstory composition surrounding nineteen of the group selection openings was classified as oak-hickory by the NSWC stand inventories. The oak-hickory stands averaged 75% oak-hickory while no other species group contributed over 10%. Seventeen of the group selection openings were surrounded by stands of mixed hardwood. The mixed hardwood stands contained 44% oak-hickory, 21% beech-sugar maple, 11% yellow-poplar, and no other species group contributing more than 10%.

All timber sale contracts from NSWC for the period 1971 to 1985 were examined for potential group selection sample sites. The group selection harvests were then divided into three age classes depending on the time of harvest: 6-10 years from harvest (1981-1985), 11-15 years from harvest (1976-1980), and 16-20 years from harvest (1971-1975). After year 20, timber stand improvement work was begun on these stands thus influencing the composition of the groups. Stands harvested less than 6 years ago were not examined because the group openings were still changing rapidly and species dominance had generally not become well established.

Each timber sale area was located on aerial photos and examined stereoscopically to locate as many group selection openings as possible. Group openings in bottomlands or on ridge tops were not sampled. The openings were divided into groups of north and south aspect, using the aerial photos and topographic maps. The divisions, north aspect 315°-135° and south aspect 136°-314°, were based on previous work in southern Indiana by Hannah (1968) and by Van Kley (1993). Once all timber sale contracts were examined, six openings from each of the three age classes for each of the two aspects were randomly selected from the pool of openings for sampling. Thus, there were 12 openings per age class or 18 openings per aspect for a total of 36 openings.

All selected openings were examined in the field to verify: (1) that the aspect was appropriately identified, (2) that the opening was fairly distinct and discernible, (3) that the surrounding stand was mature upland central hardwoods, and (4) that the opening was not in an area of reverting field. Each group opening failing to meet conditions (2) through (4) was dropped, and a new one was randomly selected.

Woody plant species were sampled on transects extending from the center to the edge of each opening. One-meter-wide transects were used for stems less than 2.5 cm diameter at breast height (dbh, 1.37 m above ground), and 2-meter-wide transects were used for all stems greater than or equal to 2.5 cm dbh. Transects extended upslope, downslope, and in both directions across the slope, beginning 1 meter from the center of the opening and ending at the edge of the opening as defined by the trunks of the mature trees surrounding the opening. The ending of transects at the base of the trees bordering the opening follows Runkle's (1982) method of measuring extended canopy gaps. Each transect was subdivided into 1-meter lengths for sampling woody species by location along the transect. Field data collection was completed during the summer of 1991.

Height (in 25-cm categories) and distance from the plot center (in 1-m increments) were measured by species for each stem less than 2.5 cm dbh. Dbh (to the nearest 0.1 cm), height (nearest 1 m), crown class (in relationship to the regeneration), and distance from the plot center (1 m) were recorded by species for woody stems greater than or equal to 2.5 cm dbh.

Aspect was determined in the field, and area of each opening was calculated using the length of each transect to determine the area of an ellipse. The group openings ranged in size from .07 ha to .23 ha with an average size of .12 ha. For analysis the openings were divided into three size classes; less than 0.1 ha with 12 openings, 0.1 ha to 0.14 ha with 15 openings, and greater than 0.14 ha with 9 openings. Also for analysis, the species were put into the following eight groups: (1) oak-hickory, (2) yellow-poplar, (3) dogwood, (4) beech-sugar maple, (5) shrubs and small trees, (6) cherry-ash-walnut, (7) sassafras, and (8) miscellaneous species. Only the first four species groups are discussed in this paper.

Analysis of variance was used to determine whether the variables aspect, age, size of opening, species group, or their interaction had any effect on the average number of stems per hectare or average height. When an effect was found to be significant, the Student-Newman-Keuls multiple range test was used to determine differences between the means.

RESULTS

Number Of Trees

DBH ≥ 2.5 cm. Species group was the only variable which influenced the number of stems per hectare ≥ 2.5 cm dbh. Aspect, size of the opening, and age had no influence. Yellow-poplar was the most abundant species group, followed by dogwood, beech-maple, and finally oak-hickory. This ranking was consistent for all age classes, group opening size classes, and both aspects (Figure 1a-c). While this ranking was constant, it was seldom significant. Yellow-poplar was significantly more abundant than beech-maple and oak-hickory in the 11-15 year age class. Abundance was not significantly different among species groups for the youngest and oldest openings. Beech-maple was the only group to show a significant change in number of stems between age classes. The oldest age class contained significantly more stems than the two youngest age classes.

There was no significant difference between individual species groups among opening sizes or aspects. Yellow-poplar and dogwood were significantly more abundant than beech-maple and oak-hickory in the smallest openings and yellow-poplar was significantly more abundant than beech-maple and oak-hickory in the middle size openings (Figure 1b). In the largest openings there was no significant difference between species groups.

Yellow-poplar was significantly more abundant than oak-hickory on the north aspect (Figure 1c). There were significantly more yellow-poplar and dogwood than oak-hickory, and significantly more yellow-poplar than beech-maple in openings with a southern aspect.

DBH 〈 2.5 cm. The number of smaller stems, 〈 2.5 cm dbh, was influenced by the age, aspect of the openings, and by the species groups. The size of the openings did not influence the number of stems. The two oldest age openings had more stems than the youngest. In the youngest openings, there were significantly more dogwood stems than the other three species groups (Figure 2). In the middle age openings, there were significantly more dogwood stems than yellow-poplar. In the oldest openings sampled, there were significantly more dogwood and beech-maple than oak-hickory and yellow-poplar.

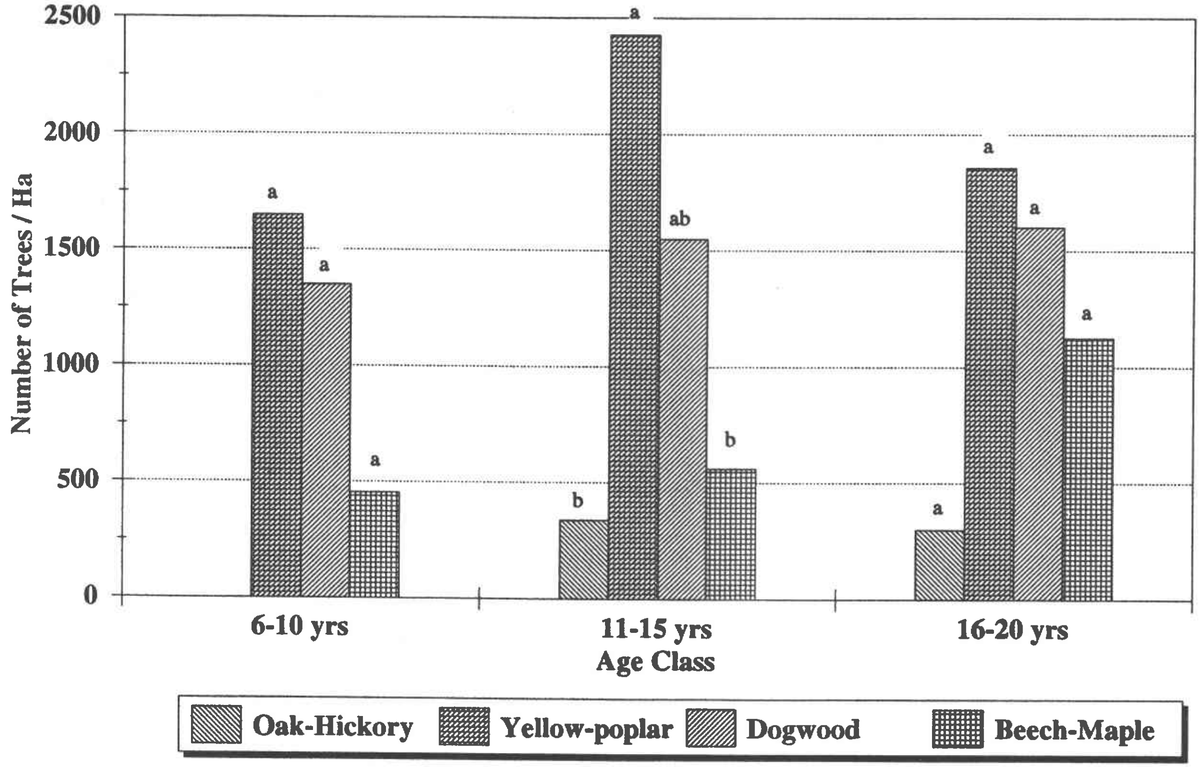

Figure 1a. Number of trees greater than or equal to 2.5 cm dbh by species group and age class. Species groups within an age class with the same letter are not significantly different at the 0.05 level.

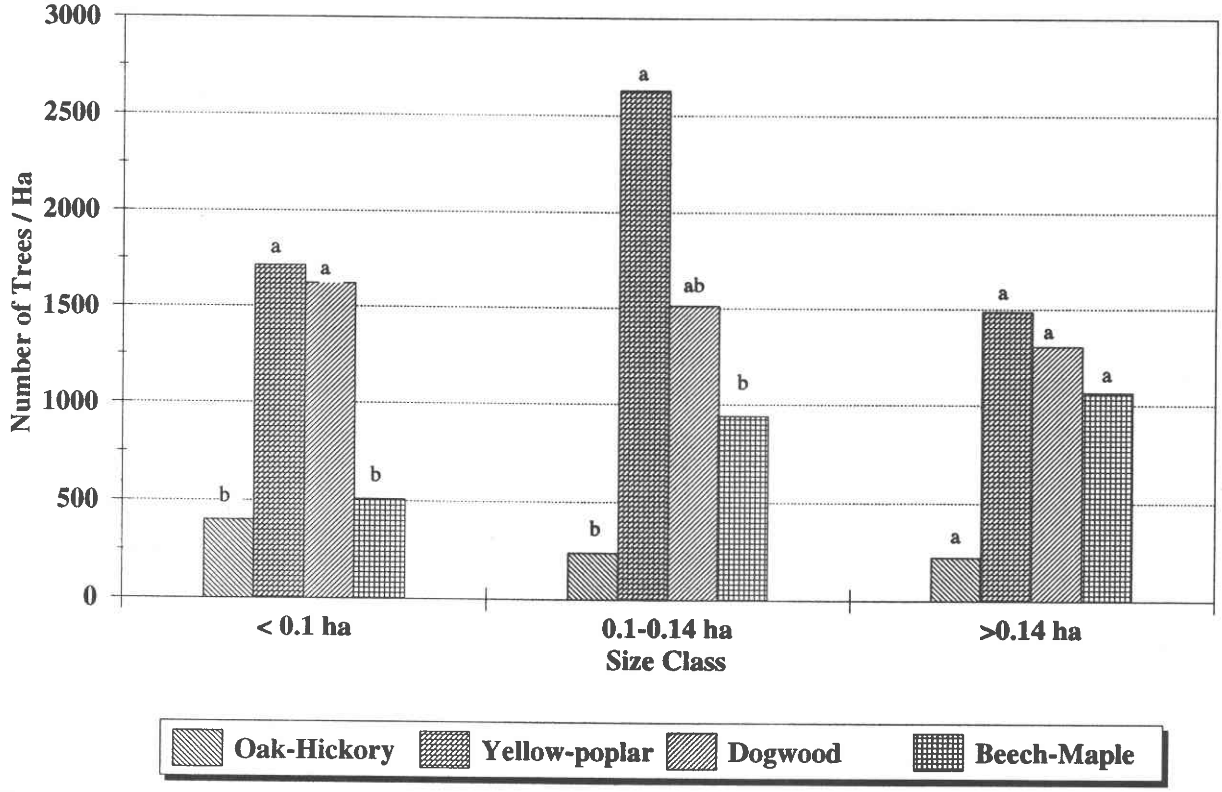

Figure 1b. Number of trees greater than or equal to 2.5 cm dbh by species group and size class. Species groups within a size class with the same letter are not significantly different at the 0.05 level.

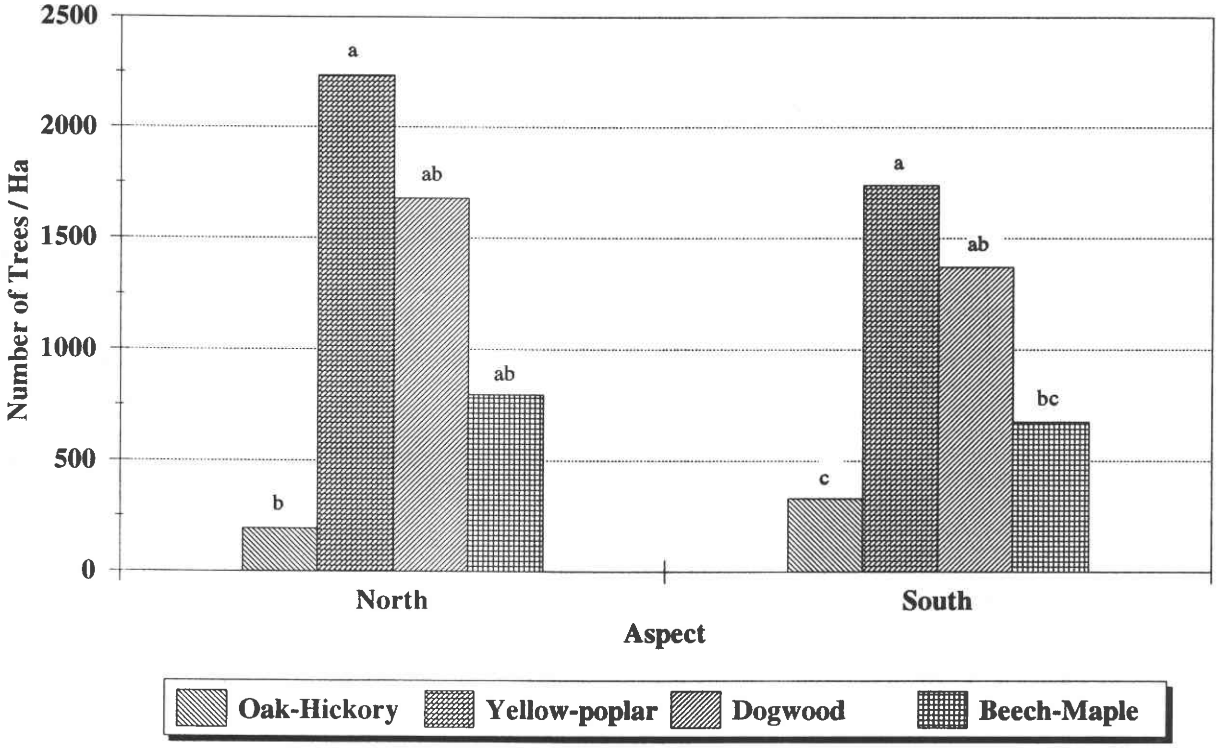

Figure 1c. Number of stems greater than or equal to 2.5 cm dbh by species group and aspect. Species groups within each aspect with the same letter are not significantly different at the 0.05 level.

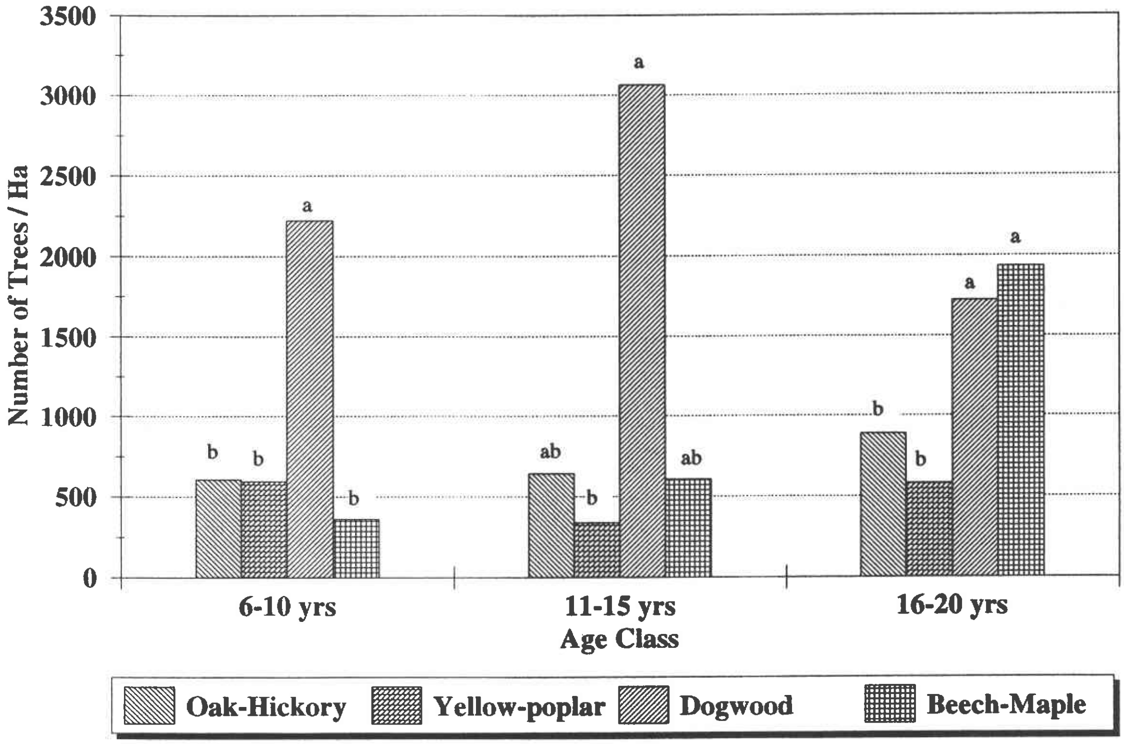

Figure 2. Number of trees less than 2.5 cm dbh by species group and age class. Species groups within an age class with the same letter are not significantly different at the 0.05 level.

Average Height

DBH ≥ 2.5 cm. Height of stems ≥ 2.5 cm dbh was significantly influenced by age of the opening and species groups, but not by size or aspect of the opening. Yellow-poplar was the only species group to show a significant increase in height between age classes. Beech-maple and dogwood showed a slight decrease in height from the middle to the oldest age class. Oak-hickory showed a nonsignificant increase in height from the youngest to the oldest openings.

In the youngest age class, beech-maple, dogwood, and yellow-poplar were significantly taller than oak-hickory; also, beech-maple was significantly taller than dogwood (Figure 3a). Beech-maple and yellow-poplar were significantly taller than the other two species groups in the middle age class. By the oldest age class, yellow-poplar was significantly taller than the other groups with beech-maple and oak-hickory significantly taller than dogwood.

Yellow-poplar and beech-maple showed a positive height increase with increasing opening size (Figure 3b). However, only the increase from the middle size openings to the largest openings was significant for yellow-poplar. Oak-hickory and dogwood showed a negative response to increased opening size. Yellow-poplar and beech-maple were significantly taller than oak-hickory and dogwood only in the largest openings.

DBH ⟨ 2.5 cm. Stems ⟨ 2.5 cm dbh decreased in height from youngest to oldest stands. This trend was significant. The other significant variable was species group. Neither aspect nor size of opening had a significant affect on the average height of the regeneration. This decrease in height was most likely due to the taller stems growing into the larger size class and to mortality.

Yellow-poplar was significantly taller than the other species groups for the two youngest age classes but by the oldest age class it was the shortest (Figure 4). Dogwood remained the only group taller than 1 meter, by the oldest age class.

DISCUSSION

The oak-hickory type is the most widespread and currently covers the greatest area in the Central Hardwood forests (Sander and Fischer 1989). The perpetuation of this type is of great concern to many people. In this study area the parent stands were dominated by the oak-hickory group. As indicated by trees ≥ 2.5 cm dbh, the future stands will not be dominated by the oak-hickory group which contained the fewest number of stems. It would appear that the future stand will be comprised of a diversity of species with yellow-poplar being the most dominant. The stems ⟨ 2.5 cm dbh confirm this trend with the oak-hickory group not among the most common.

These results differed from those reported by Runkle (1981) and Barden (1981), who reported that species replaced themselves in larger canopy gaps. However, their research was conducted in forest stands where tolerant species dominated the forest canopy and tolerant species replaced tolerant species. In stands with less tolerant oak-hickory overstories, Standiford and Fischer (1980) reported a decrease from 80% oak before harvest to 7% oak 12 to 15 years after harvest. Fischer (1987) and George and Fischer (1991) showed a similar trend for clearcuts on the Hoosier National Forest. They found that the oak-hickory group declined in numbers from the original parent stand.

One unknown in the study was the quantity and type of advanced regeneration present before harvest. Many of the group selection openings studied might have been located in areas that contained little advance regeneration, accounting for the low percentage of oak-hickory. Sander (1978) and Sander and others (1983) suggested that successful oak regeneration following harvest depends primarily on the amount and size of oak present as advance regeneration prior to harvest.

If oak advance regeneration is not present in sufficient quantities, steps must be taken to increase the quantity. Loftis (1985, 1988) recommended the use of herbicide to remove undesirable stems, allowing for the increase in size and number of desirable stems. Johnson and others (1986) suggested, in conjunction with a shelterwood silvicultural system, the planting of oak seedlings 3 years before harvest to increase the number of oaks.

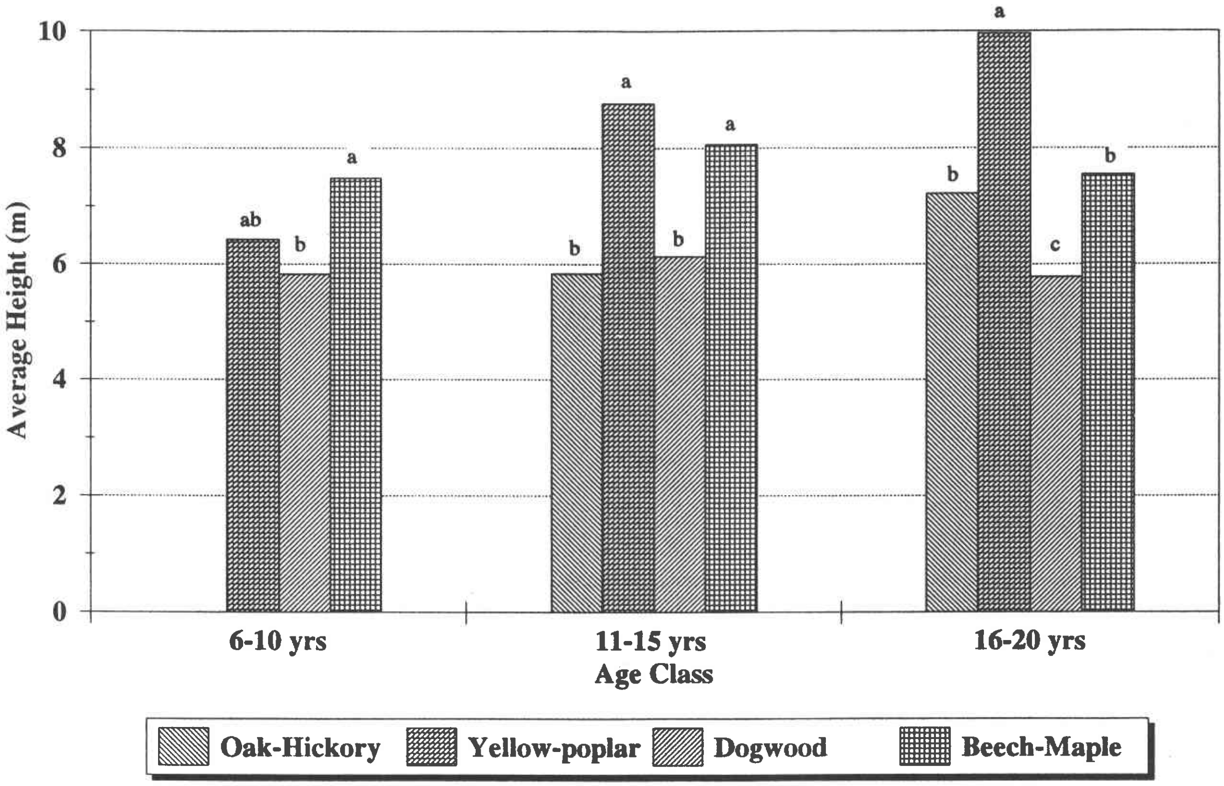

Figure 3a. Average height of trees greater than or equal to 2.5 cm dbh by species group and age class. Species groups within an age class with the same letter are not significantly different at the 0.05 level.

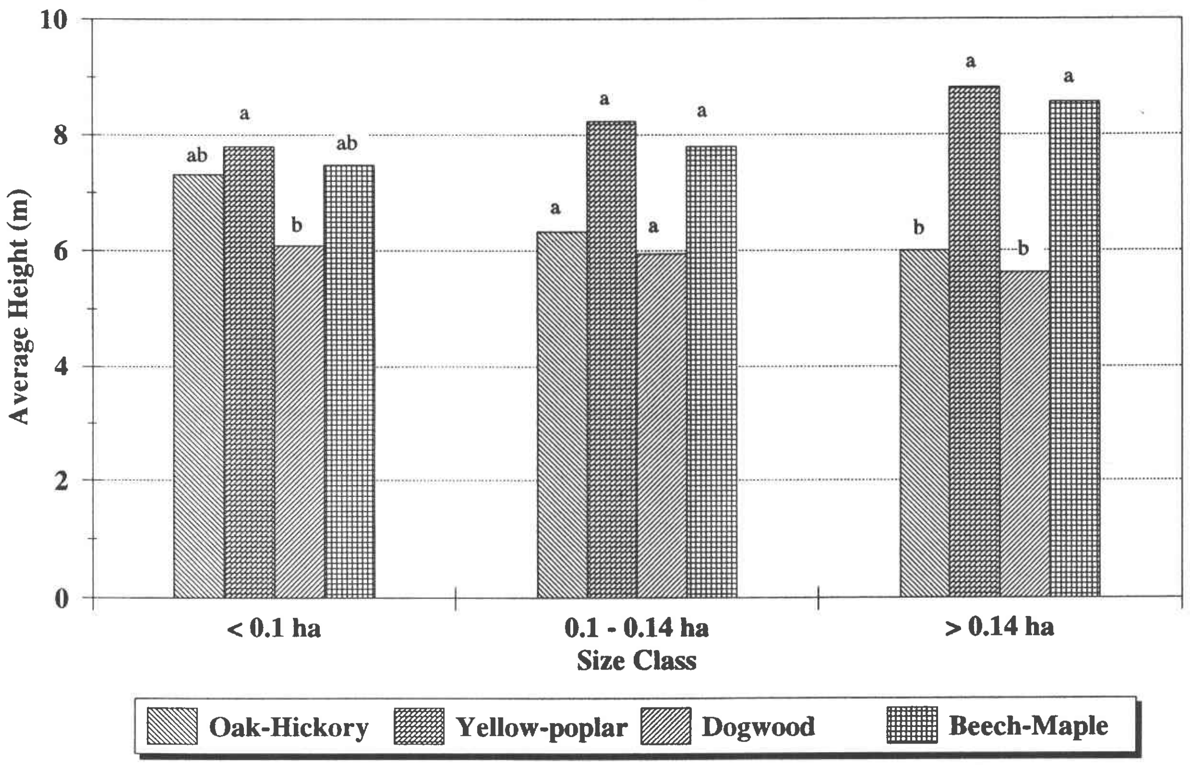

Figure 3b. Average height of trees greater than or equal to 2.5 cm dbh by species group and size class. Species groups within a size class with the same letter are not significantly different at the 0.05 level.

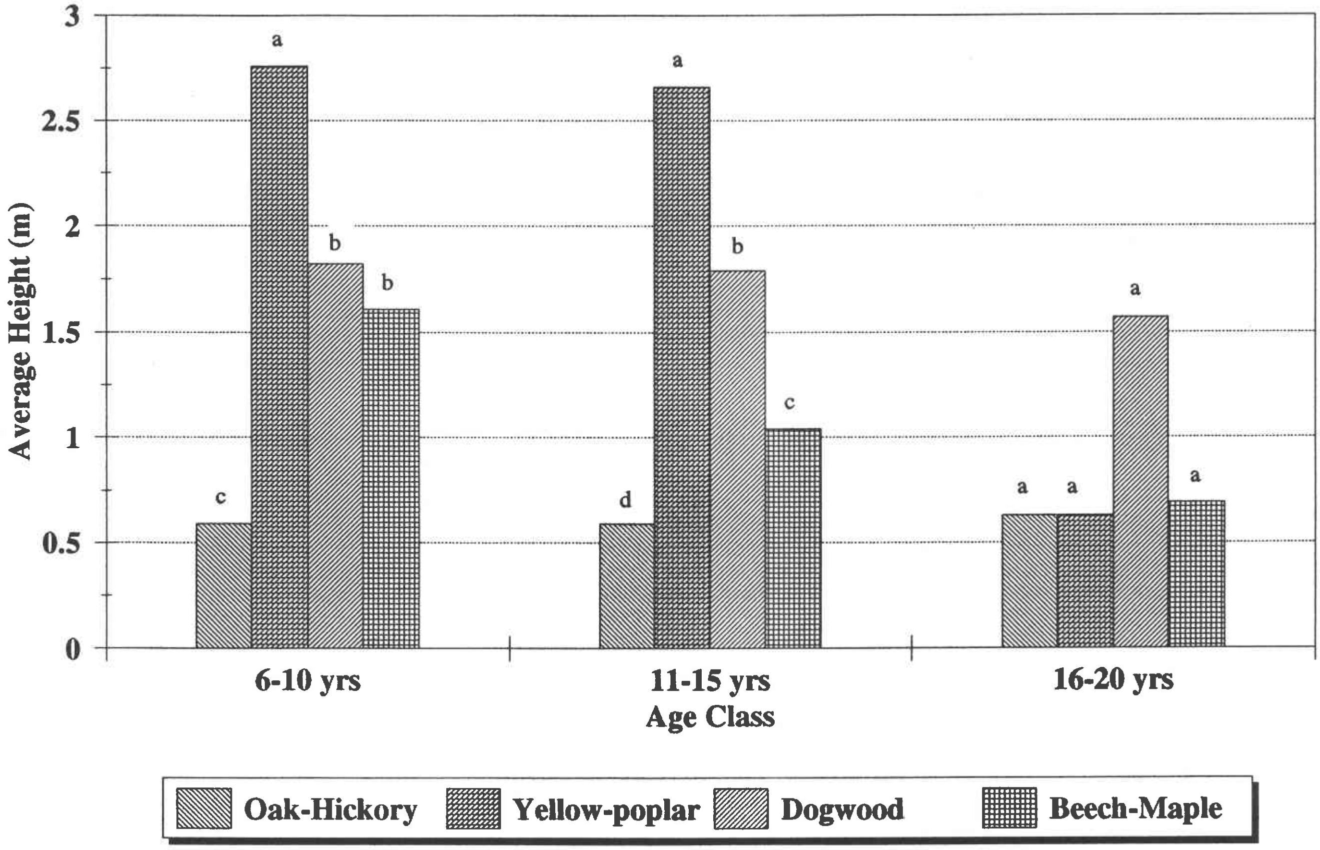

Figure 4. Average height of trees less than 2.5 cm dbh by species group and age class. Species groups within an age class with the same letter are not significantly different at the 0.05 level.

As applied, the group selection openings gave no evidence of promoting oak regeneration success. Additional investigation to monitor group selection openings with known levels of advance oak reproduction would be beneficial.

CONCLUSION

This study was an initial examination of tree regeneration following group selection harvesting in openings of three age classes. The progression of tree regeneration through time was not directly examined in this study; it was inferred from an examination of thirty-six group selection openings observed at different times since harvest. Whether or not the regeneration in the youngest group selection openings will contain the same mix of tree regeneration as the oldest group selection openings in another decade cannot be known with certainty, but it seems a likely course of development.

A better study could be conducted if it were established prior to harvesting. This would allow for the measurement of the advanced regeneration and the overstory composition. The regeneration within the openings could then be followed over time to obtain a more accurate picture of the progression of tree regeneration. Establishing the study prior to harvest would also permit the control of opening size, shape, and placement. Unfortunately this was not possible for this study.

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