GRASS OR FERN COMPETITION REDUCE GROWTH AND SURVIVAL OF PLANTED TREE SEEDLINGS

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Abstract: Bareroot seedlings of northern red oak, white ash, yellow-poplar and white pine were planted into herbaceous communities at three forested sites in central Pennsylvania that were clearcut 0 to 1 year earlier. Seedlings were grown 4 years in the presence and absence of either an established grass or hay-scented fern community. Survival and height growth were measured annually at the end of each growing season. Fourth year results showed significant decreases in the average survival of northern red oak, white ash and yellow-poplar seedlings grown in the presence of grass or hay-scented fern. Survival of the white pine was not affected by the presence or absence of either herbaceous community. Tree heights were also affected by herbaceous competition. After four growing seasons, the average heights of all tree species were significantly greater in areas maintained free of grasses or hay-scented fern. Average height responses due to release from herbaceous competition were greatest for white ash and yellow-poplar with average increases of up to 150% after four growing seasons. White pine showed the least response to control of herbaceous vegetation with average height increases of < 30%. The results of this study demonstrate the importance of controlling herbaceous vegetation when artificially regenerating hardwoods on forested sites that have been clearcut.

INTRODUCTION

A recent statewide inventory of Pennsylvania's forests, has raised concerns about the likelihood of these forests to successfully regenerate following a natural disturbance or harvest cut (Williams and others 1995). The inventory revealed that a large majority of the sampled forest stands with 40% to 75% overstory stocking did not have adequate amounts of advance tree-seedling regeneration for new stand establishment. Such findings emphasize the continuing need to develop effective means of regenerating hardwood stands.

Past efforts to obtain successful regeneration of harvested Allegheny hardwood and mixed oaks stands in Pennsylvania have focused on enhancing natural regeneration. Use of electric fences to reduce deer browsing, chemical control of competing woody and herbaceous understory vegetation, partial overstory removals prior to the final harvest cut, and fertilization following harvesting are some of the methods that have been explored. While increasing the likelihood of obtaining successful regeneration, these measures have not consistently provided sufficient numbers of seedlings to ensure adequate distribution of seedling stocking or desirable species compositions in all stands. This suggests the possible need for artifical regeneration.

Studies by Johnson (1976, 1981, 1984) with northern red oak and Francis and Bivens (1985) with yellow-poplar and black cherry have demonstrated the potential for hardwood plantings in forested stands. Unfortunately, previous plantings of hardwoods have not routinely resulted in acceptable survival and growth when compared to naturally regenerated hardwoods or conifers. The "failure" of these plantings has frequently been attributed to stresses from excessive undesireable vegetation (Sander 1971, Russell 1984, von Althen 1977, Loftis 1979, Johnson 1981, McGee 1981). Competition from herbaceous vegetation has traditionally been a problem in old field plantings of hardwoods. The same may be true for forest plantings as many of the harvested sites in the Northeast are rapidly invaded by persistent herbaceous vegetation (Williams and others 1995).

To assess the potential importance of this problem, a study was conducted to examine the effect of herbaceous vegetation on the survival and growth of barerooted seedlings planted in oak stands of Pennsylvania. Four species,

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northern red oak (*Quercus rubra* L.), white ash (*Fraxinus americana* L.), yellow-poplar (*Liriodendron tulipifera* L.), and white pine (*Pinus strobus* L.) were grown in the presence and absence of two herbaceous communities, hay-scented fern (*Dennstaedtia punctilobula* L.), and poverty oat grass (*Danthonia spicata* (L.) Beauv.). Results of the study after two growing seasons were reported earlier (Bowersox and McCormick 1987). The purpose of this paper is to provide an update of the results after four growing seasons.

METHODS

The study consisted of two experiments, one initiated in the spring of 1984 and the other in the spring of 1985. Both experiments were conducted at two forest sites, Laurel Run and Sand Knob, located in central Pennsylvania near State College, PA, on lands managed by the Pennsylvania Bureau of Forestry. The sites previously contained 100-year-old, even-aged oak stands that were partially harvested in the early 1970s and then clearcut and fenced to reduce deer browsing in the 1983-1984 dormant season. A five strand electric fence was used to minimize deer browsing. Effectiveness of the fence decreased after 2 years of operation (George and others 1991). Following the partial cutting in the early 1970s, the sites became dominated by grass and fern communities. The grass communities were primarily poverty grass, but also contained lesser proportions of *Rubus* L., goldenrod (*Solidago* L.), fireweed (*Erechitites hieracifolia* (L.) Raf.), whorled loosestrife (*Lysimachia quadrifolia* (L.) Ell.), and sheep sorrell (*Rumex acetosella* L.). The fern communities were dominated by hay-scented fern. Soils at the sites had similar surface texture and chemical properties (extremely acidic—pH 4.6—and low fertility), but differed in drainage. The soil at Laurel Run was a poorly drained Andover loam (Typic Fragiaquults) whereas the soil at Sand Knob was a well-drained Hazelton sandy loam (Typic Dystrochrepts).

The experiments used a split-plot, randomized complete block design with four replications per site in 1984 and 1985. The main plots (160 m^2) initially contained either grass or fern communities. Each main plot was divided equally with one-half the area retained in either grass or ferns and the other one-half treated with glyphosate (1.7 kg ai/ha) to create grass-free or fern-free conditions. The glyphosate was applied in August 1983 (prior to harvest) for the 1984 planting and in August 1984 (first growing season after harvest) for the 1985 planting. In each weed and weed-free subplot, 20 bareroot seedlings each of northern red oak (1-0), white ash (1-0), yellow-poplar (1-0), and white pine (2-0) were planted at a 1x1 m spacing (2 rows of 10 trees) in early May. All seedlings were from seeds collected in Pennsylvania and grown in the state operated nursery. All hardwood seedling shoots were top-clipped to a 10 cm length prior to planting. The roots were pruned to fit into a 10 cm wide and 25 cm deep hole created by a KBC planting bar. The white pine seedlings averaged about 10 cm in stem length. Over all treatment combinations and replications, a total of 640 seedlings per species were planted in 1984 and in 1985. Annually in June-July the Grass-free and Fern-free treatment areas were hand-weeded around individual seedlings and the remaining vegetation controlled by spraying with glyphosate (1.7 kg ai/ha) to maintain weed free conditions.

Survival and total height values were measured at the end of the growing season for 4 years in 1984 and 1985 plantings. Species specific data were analyzed by analysis of variance with year, location, replication, herbaceous community as main effect factors and herbaceous conditions as a split-plot factor. All treatment effects were tested at the $p < 0.05$ level. Mean separations were performed using Duncan's Multiple Range Test. Only data from unbrowsed (deer) seedlings were used in the height growth analyses. This resulted in sample sizes for year four in the combined 1984 and 1985 height analyses of 380, 757, 568, and 676 for northern red oak, white ash, yellow-poplar, and white pine, respectively.

RESULTS AND DISCUSSION

Survival

Site was not a significant factor affecting survival, however, there were significant differences in survival associated with year of planting and treatment (Fern, Grass, Fern-free, and Grass-free). In general, survival was equally good for all Grass-free and Fern-free treatments in both the 1984 and 1985 plantings. Average survival 4 years after planting ranged from a low of 76% for 1985 planted yellow-poplar to 98% for 1984 and 1985 planted ash (Figure 1).

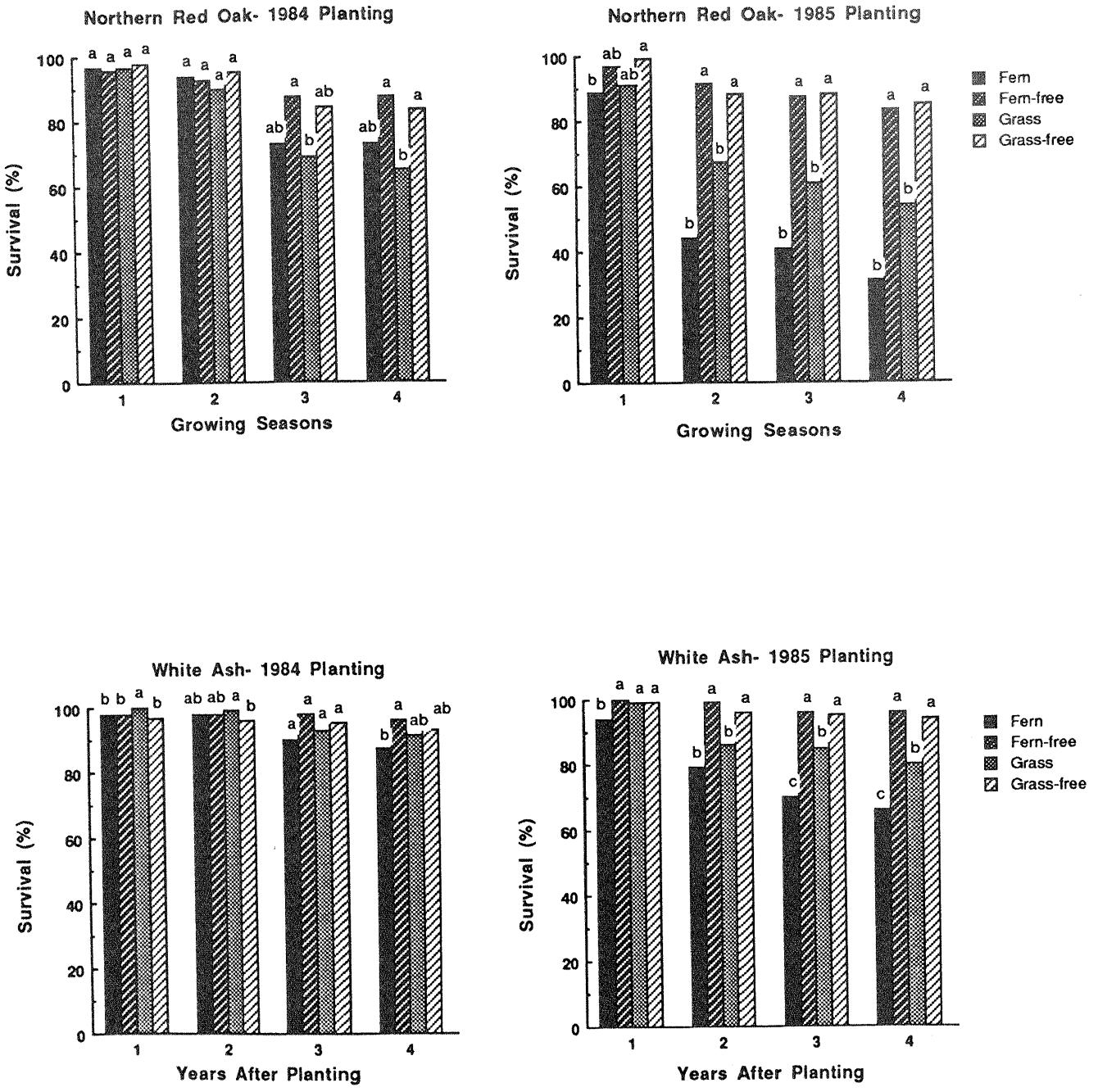

Figure 1. Average survival for 1 through 4 years after planting for the Fern, Fern-free, Grass, and Grass-free treatments, by planting years and species. Treatment survival averages (N=160) with the same letter within year after planting, planting year, and species were not significantly different at $p<0.05$.

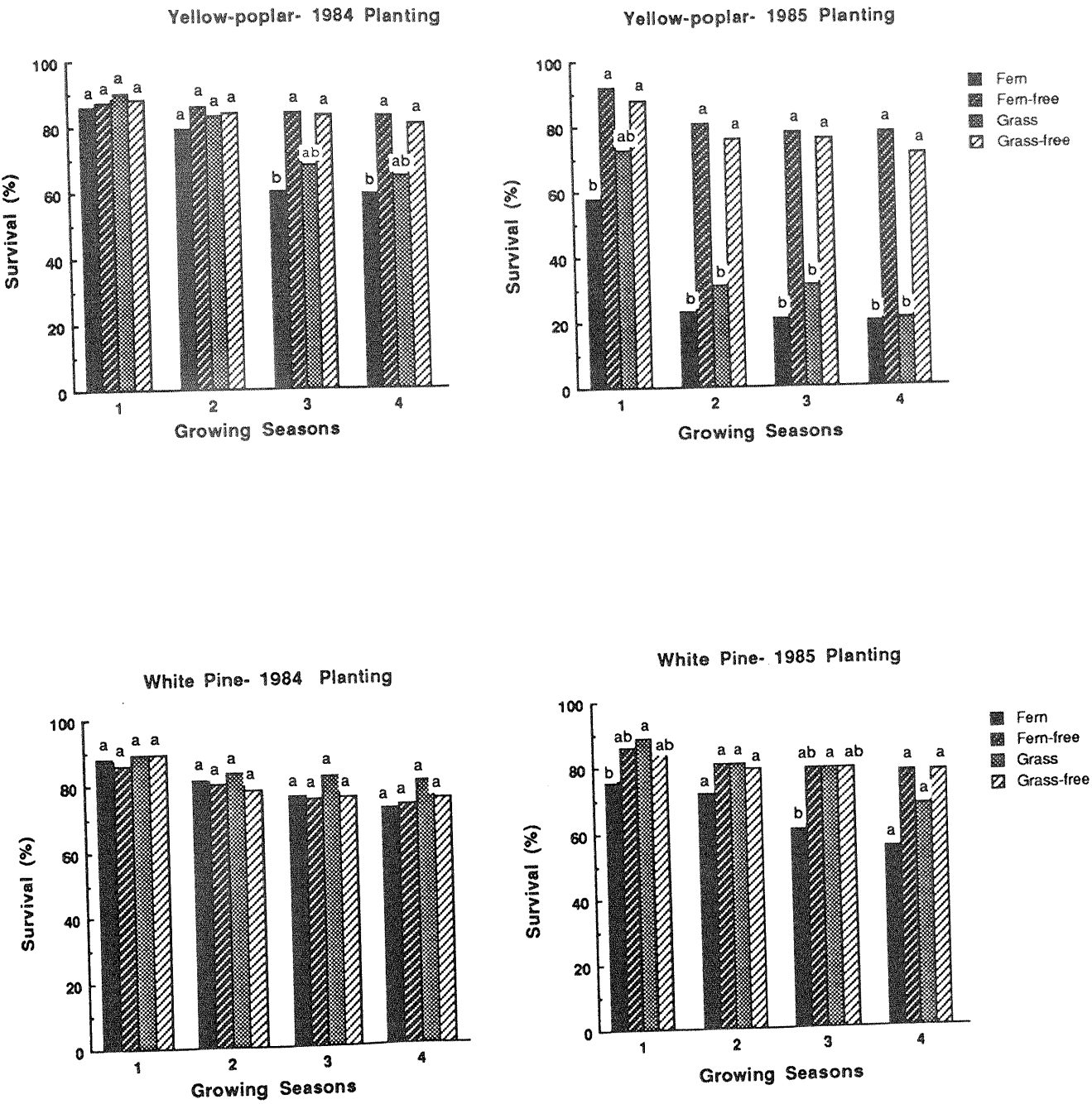

Figure 1 (cont.). Average survival for 1 through 4 years after planting for the Fern, Fern-free, Grass, and Grass-free treatments, by planting years and species. Treatment survival averages (N=160) with the same letter within year after planting, planting year, and species were not significantly different at $p<0.05$.

In contrast, seedling survival under weedy conditions tended to be lower—especially for the hardwoods. In the 1985 plantings, all of the hardwood species had significantly lower survival rates in the Grass and Fern treatments than in the Grass-free and Fern-free treatments after four growing seasons. Four year survival rates for the hardwoods in the 1985 plantings weedy treatments ranged from a low of about 20% for yellow-poplar (both Grass and Fern) to a high of about 70% for white ash (Grass). Survival of the white pine was not significantly affected by treatment. Similar response occurred in the 1984 plantings although hardwood survival rates of the in the Grass-free and Fern-free treatments were on average higher than in the 1985 planting. Rates of survival for the hardwoods tended to be lower in Fern treatments than in the Grass treatment, however, with the exception of white ash survival in 1985, the differences were not significantly different.

In both the 1984 and 1985 plantings, most of the seedling mortality in the Grass or Fern treatments occurred in the same calendar year (1986). This corresponded to the third year after planting for the 1984 planting and the second year after planting for the 1985 growing season. We are not certain what causes the increased level of mortality in 1986. Initially it was thought that this mortality may have been related to moisture stress. A check of precipitation data for 1985 and 1986 growing season, however, showed normal seasonal levels of precipitation. Other factors that could have accounted for the mortality include small mammal damage, deer browsing, or accumulated stresses associated with increased levels of competition from a maturing grass or fern communities.

Height Growth

Neither site nor year of planting significantly affected height growth of the planted seedlings. However, significant differences in height growth did occur among treatments. Starting in the second year after planting and continuing through the fourth year after planting, the average heights of all species were significantly greater in the Fern-free or Grass-free treatments than in the Fern or Grass treatments (Figure 2). The relative magnitude of the height differences between the weed and weed free treatments varied among species. White ash and yellow-poplar showed the greatest response to release from herbaceous competition. After four growing seasons, the average height of yellow-poplar trees in the Fern-free treatment was 1.9 times greater than in the Fern treatment and 1.6 times greater in the Grass-free than in the Grass treatment. Similarily, 4 years after planting, average height of white ash trees were 2.6 and 1.8 times greater in the Fern-free and Grass-free treatments, respectively, than their weedy counterparts. Height differences between the weed and weed free treatments were smaller for northern red oak and white pine. Average heights of the northern red oak and white pine in the Grass-free treatment after 4 years were only about 1.2 times greater than in the Grass treatment.

Type of herbaceous vegetation also had an effect on height growth of some species. After 4 years, the average heights of white ash and yellow-poplar in the Fern treatment were significantly different from the Grass treatment. These differences began to appear as early as 2 years after planting, and by the fourth year the average heights of white ash and yellow-poplar in the Fern treatments were about 20% less than the Grass treatments.. The average heights of the northern red oak and white pine were not significantly different between the Fern and Grass treatments. In contrast, the average height of northern red oak, white ash and white pine in the Fern-free treatment were greater than in the Grass-free treatment.

Results of this study indicate that planting can be a viable option for establishing northern red oak, white ash, yellow-poplar and white pine seedlings in clearcuts within the mixed oak forests of Pennsylvania. Overall, the fourth year survival and height values were acceptable for 1-0 bareroot northern red oak, white ash and yellow-poplar and 2-0 white pine seedlings. Average survival across all treatments was lowest for yellow-poplar (60%), moderate for northern red oak (70%) and white pine (72%), and highest for white ash (88%). Average height across all treatments was 1.1, 1.2, 2.0 and 3.0 m for white pine, northern red oak, white ash and yellow-poplar, respectively. Although these survival and height values may be acceptable, this study clearly indicates that the presence of herbaceous plants typical of disturbed mixed oak stands in Pennsylvania can have a detrimental effect on survival and growth of planted seedlings. This was especially true for hardwood species like northern red oak, white ash and yellow-poplar whose fourth year survival and height values were reduced when planted in either hay-scented fern or grass communities.

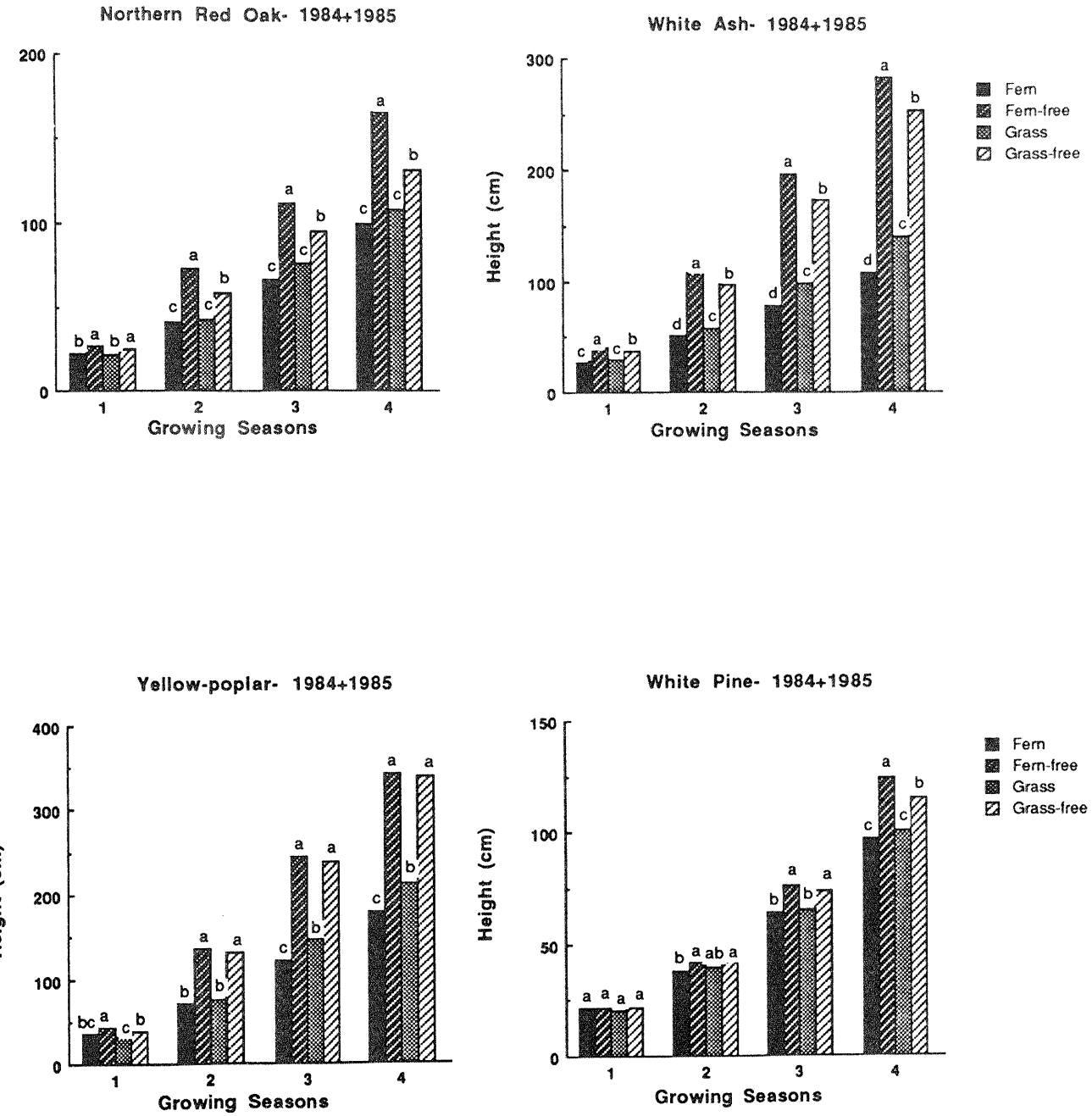

Figure 2. Average height for 1 through 4 years after planting for Fern, Fern-free, Grass, and Grass-free treatments by species. Combined 1984 and 1985 planting treatment values within a species and years after planting with the same letter were not significatly different at $p < 0.05$. Sample size was 380, 757, 568, and 676 for northern red oak, white ash, yellow-poplar, and white pine respectively.

Overall, northern red oak seedlings growing in the presence of either hay-scented fern or grass communities had a fourth year average survival of 56% and height of 1.1 m. When these herbaceous plants were treated with glyphosate and maintained weed-free, northern red oak fourth year survival averaged 85% and the height averaged 1.5 m. White ash fourth year survival was very good in both the weed-free (95%) and weed (81%) conditions but height was substantially different between the two herbaceous conditions. Growing in the presence of fern or grass, the white ash averaged 1.2 m in height after four growing seasons; whereas in the freedom of these herbaceous plants, white ash averaged 2.7 m in height. Yellow-poplar had the greatest responses to the control of ferns and grasses. In the presence of the two weedy conditions, yellow-poplar had an average survival of 41% and height of 2.0 m 4 years after planting. In the absence of these herbaceous plants, the 4 years after planting survival averaged 78% and height averaged 3.4 m. White pine was the least responsive to the control of the two herbaceous plants. Compared to the weedy condition, the weed-free treatments increased the average survival from 68% to 76% and height increased from 1.0 m to 1.2 m, respectively, 4 years after planting.

We believe that this study demonstrates that northern red oak, white ash, yellow-poplar, and white pine can be successfully planted into mixed oak stands of Pennsylvania. However, for the planted seedlings to have desirable survival and height growth in clearcut site dominated by herbaceous vegetation, some method of vegetation control must be used.

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