Survival and Growth of Planted Northern Red Oak in Northern West Virginia[1]

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Abstract: The survival and growth of northern red oak (*Quercus rubra* L.) seedlings planted beneath a shelterwood in northern West Virginia were evaluated one year after planting. The use of 1.5 m (5 ft) tall TUBEX tree shelters on planted seedlings was also examined. The study was conducted on both excellent and good sites (site indices of 27 m (89 ft) and 22 m (74 ft) for northern red oak, respectively). The overstories on both sites were dominated by yellow-poplar (*Liriodendron tulipifera* L.), white oak (*Quercus alba* L.), and northern red oak. A replicated four-level split-plot experimental design was used. Treatments consisted of: site quality, shelterwood cutting, understory herbicide treatment, and tree shelters. Overstories and understories were manipulated in late winter, and 2-0 northern red oak nursery stock was planted and the tree shelters were installed the following spring. The tree shelters significantly increased seedling height growth but not survival. After one growing season, the survival of planted seedlings was 88%. Sheltered trees grew significantly more in height (21 cm) and were more vigorous than the unsheltered seedlings (11 cm). These initial results suggest that when using the shelterwood method, tree shelters will increase the growth of planted northern red oak seedlings.

INTRODUCTION

Northern red oak (*Quercus rubra* L.) is an important species in the Appalachian hardwood forest. However, it often fails to regenerate even where it predominates in the overstory.

The shelterwood method has been used successfully for about 80 years in many forest regions (Hannah 1988). Hill and Dickman (1988) found that shelterwood cutting can be used to regenerate northern red oak. However, they pointed out the difficulty of keeping oak reproduction competitive in young stands. Loftis (1983 and 1990) similarly advocated using the shelterwood method and controlling undesirable understory stems for regenerating northern red oak. Beck (1988) also reported that understory treatment combined with shelterwood cutting was successful in regenerating upland hardwoods. Graney (1988) likewise indicated that the shelterwood method coupled with understory treatment can encourage the development of desirable reproduction. He found that there was more oak reproduction where shelterwood cutting with understory treatment was used than where understory treatment was not used.

Planting has been used to supplement natural oak regeneration in areas where it is scarce. Tworkoski and others (1986) feel that underplanting is a viable tool if it is done before harvesting.

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An earlier paper by Tworkoski and others (1982) concluded that a combination of shelterwood cutting and underplanting can regenerate northern red oak and white oak. Pubanz and others (1989) found that planted oak seedlings had better survival, growth, and vigor after the overstory was reduced and the understory was removed.

Lorimer (1989) suggested using the shelterwood method combined with intensive understory management for regenerating oaks naturally. However, on good sites he further pointed out that successful oak regeneration might be increased by planting. Johnson (1984) found that acceptable success rates could be obtained in stands where the overstory was thinned and the understory was removed. He defined a success probability as the "probability of a tree attaining some minimum acceptable rate of growth," which he believed was a better measure of planting success than the mean heights of survivors. Johnson and others (1986) also developed a prescription for planting northern red oak. In contrast, Wright and others (1984) found that planted northern red oak survival was acceptable but that the planted trees were unable to remain competitive under a thinned upland hardwood stand in Indiana.

Tuley (1985) demonstrated that tree shelters could increase the growth of oak seedlings as much as 5.2 times over that of unsheltered trees after three years. Similarly, Potter (1988) showed that early height growth could be increased 7- or 8-fold. Potter believed the main reason for this increased growth was the reduction of air movement inside the shelter. The humidity inside the tube was increased, and the possibility of moisture stress was decreased. Since tree taper is also decreased due to the reduced air movement, the saplings had a more columnar form. Minter and others (1992) found that carbon dioxide levels are also higher in shelters, which in turn increases seeding growth rate. Tree shelters also protect trees against many types of animal damage including deer browsing.

The objective of this study is to examine the effects of site quality, shelterwood cutting, understory herbicide treatment, and tree shelters on the survival and growth of planted northern red oak seedlings.

STUDY AREA AND METHODS

This study was conducted on the West Virginia University Forest in northern West Virginia near Morgantown. The study was established in May and June of 1990 and designed as a four-level split-plot experiment. The levels consisted of: site quality, shelterwood cutting, understory herbicide treatment, and planting 2-0 northern red oak nursery stock with and without tree shelters. The entire experimental area was about 5 ha (12.5 ac) in size, with the pairs of 0.4 ha-plots separated by buffer strips.

Stands representing two levels of site quality were selected for study: (1) northwest aspects with an average site index for northern red oak (at 50 years) of 22 m (74 ft), and (2) northeast aspects with an average site index of 27 m (89 ft). There were three pairs of plots on the excellent sites and two pairs on the good sites. The overstories on both sites were yellow-poplar (*Liriodendron tulipifera* L.), white oak, and northern red oak (SAF forest cover type 59). Soils were mapped as Dekalb stony sandy loam with slopes ranging from 20 to 40 percent (Baur 1959).

Shelterwood cutting was randomly applied to one plot in each pair during the spring of 1991. The overstory was reduced to 85% crown cover based on spherical densiometer measurements.

The understory herbicide treatment was randomly applied to half of each plot (a sub-plot) after cutting. This treatment consisted of cutting all non-oak stems less than 4.1 cm dbh (diameter at breast height) and applying a herbicide to the cut stems to control sprouting.

In March of 1991, 2-0 northern red oak nursery stock was planted. Seedlings were obtained from the state nursery at Point Pleasant near Parkersburg, WV. Half of the total of forty 0.04 ha sub-sub-plots were planted at a 3- by 3-m spacing. A total of 500 seedlings were planted among the various treatment combinations on the two sites. The seedlings were pruned 20 cm above and below the root collar to increase their root to shoot ratios. About half of the planted trees were protected by tree shelters. The tree shelters were TUBEX brand and 1.5 m (5 ft) tall. The shelters were pushed down into the ground around the seedlings and fastened to treated wood stakes.

Planted seedlings were measured at the end of the first field growing season. Measurements included: total height, length of last internode, number of leaves (as an indicator of vigor), and a measure of form class. Form class "1" represented flat-topped reproduction, class "3" reproduction had a strong central leader, and class "2" was intermediate in form. Because all stems were top-pruned, analyses were based on the length of the last internode instead of total height. Analysis of variance was based on the split-plot design. However, initial seedling diameter was used as a covariate because plots differed significantly in initial mean diameter. An alpha level of 0.05 was used for all statistical tests for significant differences.

RESULTS AND DISCUSSION

First-growing season survival of planted northern red oak seedlings was not affected by any treatment (including tree shelters) or by site quality. Survival rates for the individual sub-sub-plots in this experiment were all very high and averaged 88 %.

Northern red oak seedlings without tree shelters grew significantly more on good sites than on excellent sites (Figure 1). This may be the result of greater deer browsing on the better sites where deer densities probably were higher. Height growth of sheltered seedlings did not differ by site quality.

Because there were no significant effects due to overstory or understory treatments on both sites, the height growth data were pooled for further analysis. For all sites combined, tree shelters had a positive effect on the growth of planted northern red oak seedlings (Table 1). Sheltered seedlings grew significantly more than unsheltered seedlings (21 versus 11 cm).

Tree shelters also significantly affected the average numbers of leaves on planted northern red oak seedlings (Table 1). Sheltered seedlings produced more leaves than unsheltered seedlings (9.2 versus 6.8). Therefore, sheltered seedlings tended to be more vigorous after the first growing season than unsheltered trees.

Deer also may have affected the form of seedlings on the different sites. Although more seedlings on the good sites had a strong central leader than on the excellent sites, this difference may have been the result of deer browsing.

Seedling form was affected by the tree shelters (Figure 2). Seedlings with tree shelters tended to have stronger central leaders. On the other hand, those without tree shelters were more intermediate in their form.

CONCLUSIONS

Artificial regeneration of northern red oak may be a promising tool in the central Appalachians. Planting northern red oak is a way of supplementing inadequate natural reproduction. During the first field growing season, the seedlings in this study grew well and survival rates were high.

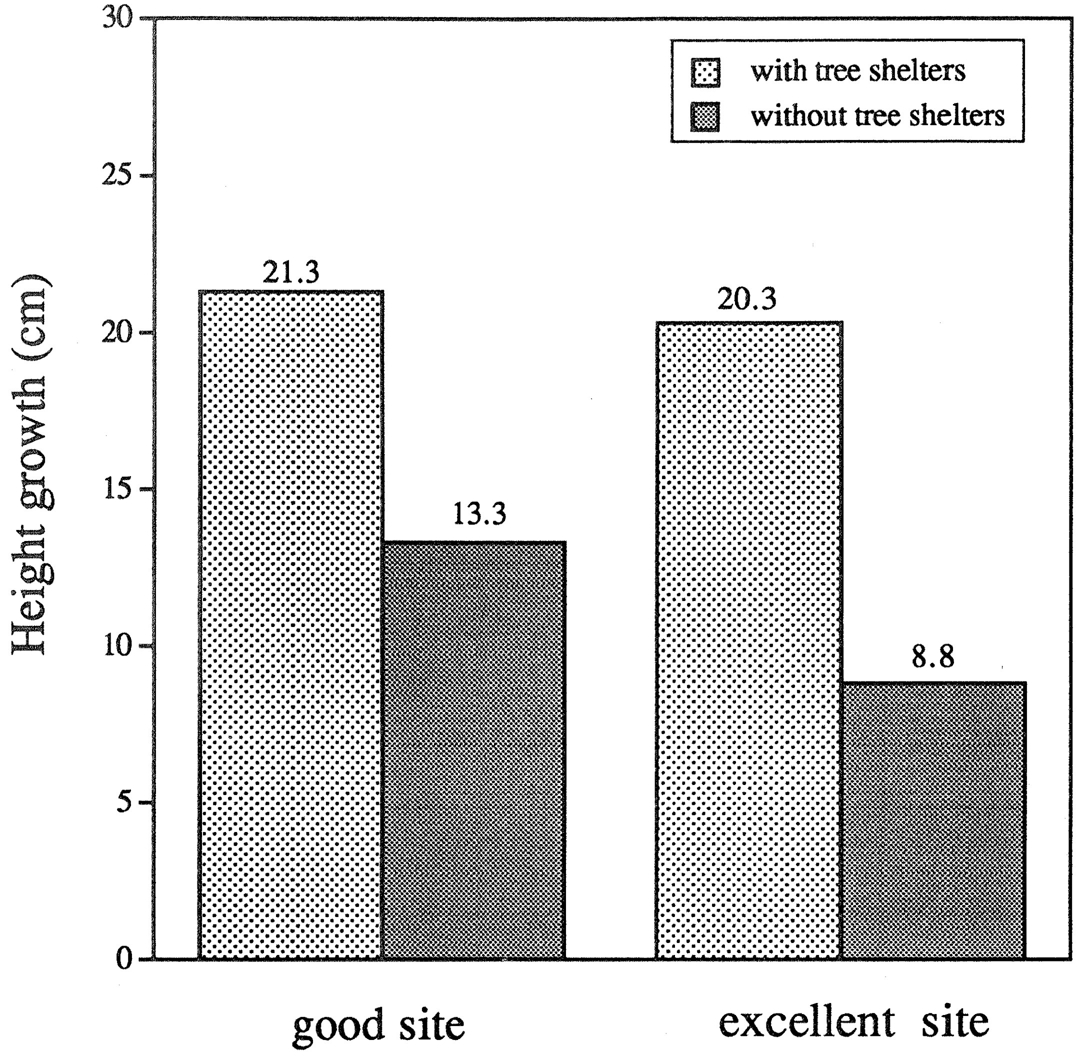

Figure 1.—Planted northern red oak seedlings without tree shelters grew significantly more ($p < 0.05$) on good sites than on excellent sites. There was no significant difference ($p > 0.05$) in growth rate between sites for seedlings with shelters.

Table 1.—Tree shelters significantly increased ($p < 0.05$) the height growth and average number of leaves of planted northern red oak seedlings

	With tree shelters	**Without tree shelters**
Height growth (cm)	20.8	11.1
Average number of leaves	9.2	6.8

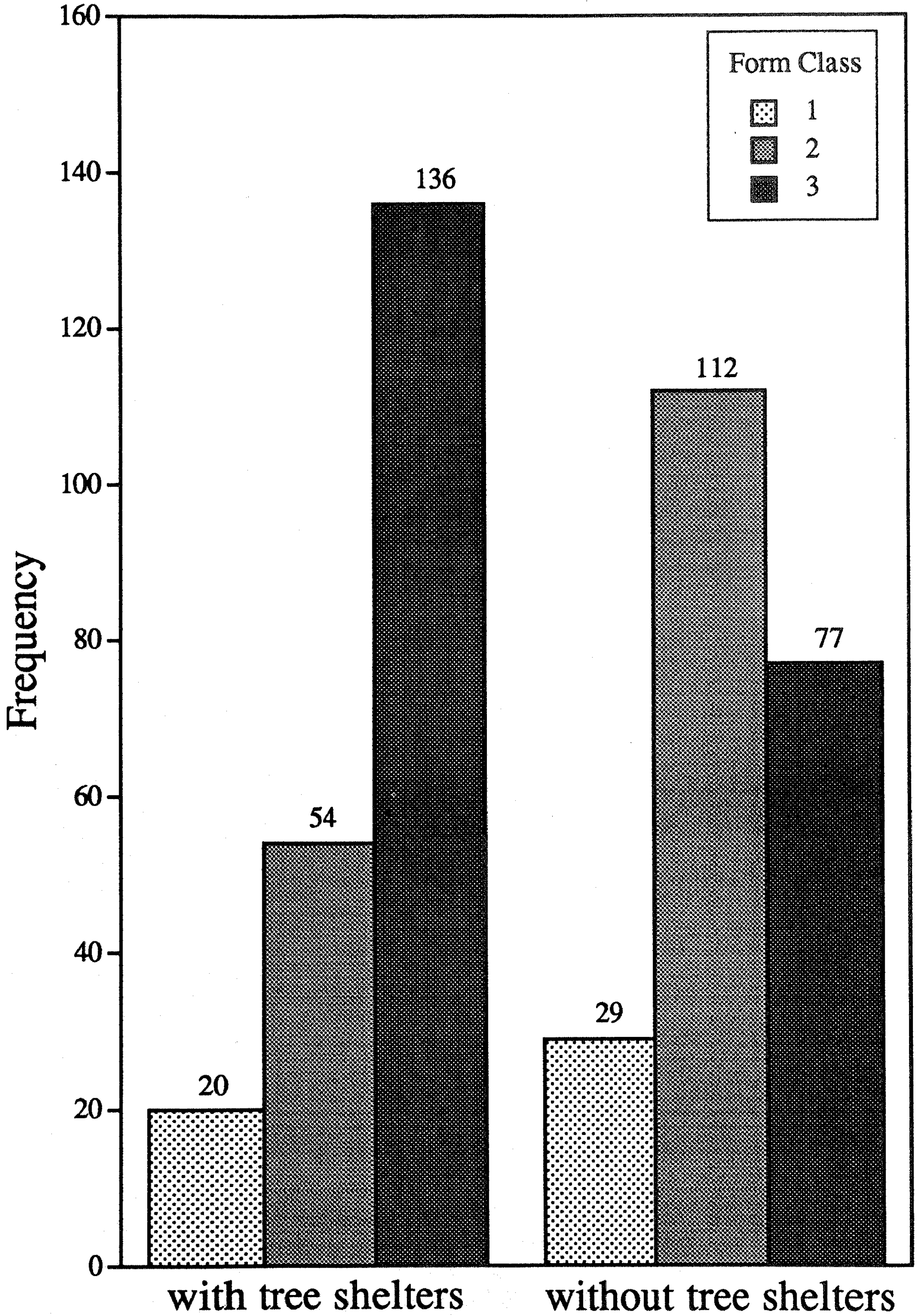

Figure 2.—Frequency of occurrence of the three form classes for planted northern red oak seedlings with and without tree shelters.

However, seedlings planted under a shelterwood did not grow any faster than those planted in uncut stands. Understory herbicide treatment also did not have any significant effects on growth. However, these trends may change.

Tree shelters, nevertheless, had a positive effect on the growth and vigor of northern red oak seedlings during the first growing season. It appears that tree shelters may continue to effect increases in the growth rate of oak seedlings in this area, as they have in other regions. This experiment has shown that tree shelters can promote the early growth of planted northern red oak seedlings. However, the high cost of the shelters may limit their use in extensive forest management applications. Cost analysis studies could ascertain if large-scale planting of northern red oak and using tree shelters on them is economically feasible.

LITERATURE CITED

Baur, A.J. 1959. Soil survey - Preston County, West Virginia. USDA Soil Conservation Service. 50 pp.

Beck, D.E. 1988. Clearcutting and other regeneration options for upland hardwoods. pp. 44-54 in Proc. Sixteenth Annual Symp. of the Hardwood Research Council. Cashiers, NC.

Graney, D.L. 1988. Growth of oak, ash, and cherry reproduction following overstory thinning and understory control in upland hardwood stands of northern Arkansas. pp. 245-252 in Proc. Fifth Biennial Southern Silvicultural Research Conf. Miller, J. H. (ed.) Memphis, TN. Gen. Tech. Rep. SO-74.

Hannah, P.R. 1988. The shelterwood method in northeastern forest types: A literature review. North. J. Appl. For. 5: 70-77.

Hill, J.P., and Dickman, D.I. 1988. A comparison of three methods for naturally reproducing oak in southern Michigan. North. J. Appl. For. 5: 113-117.

Johnson, P.S. 1984. Responses of planted northern red oak to three overstory treatments. Can. J. For. Res. 14: 536-542.

Johnson, P.S., Dale, C.D., Davidson, K.R., and Law, J.R. 1986. Planting northern red oak in the Missouri Ozarks: A prescription. North. J. Appl. For. 3: 66-68.

Loftis, D.L. 1983. Regenerating southern appalachian mixed hardwood stands with the shelterwood method. South. J. Appl. For. 7: 212-217.

Loftis, D.L. 1990. A shelterwood method for regenerating red oak in the Southern Appalachians. For. Sci. 36: 917-929.

Lorimer, C.G. 1989. The oak regeneration problem: New evidence on causes and possible solutions. Forest Resource Analyses No. 8. Univ. of Wisconsin-Madison. 31 pp.

Minter, W.F., Meyers, R.K., and Fisher, B.C. 1992. Effects of tree shelters on northern red oak seedlings planted in harvested forest openings. North. J. Appl. For. 9: 58-63.

Potter, M.J. 1988. Tree shelters improve survival and increase early growth rates. J. For. 86: 39-41.

Pubanz, D.M., Lorimer, C.G., and Guries, R.P. 1989. Effects of understory control on survival and vigor of red oak seedlings beneath a shelterwood. pp. 300-301 in Proc. Seventh Central Hardwood Forest Conf. Rink, G., and C.A. Budelsky (eds.) Carbondale, IL. Gen. Tech. Rep. NC-132.

Tuley, G. 1985. The growth of young oak trees in shelters. Forestry 58: 181-195.

Tworkoski, T.J., Smith, D.W., and Parrish, D.J. 1982. Response of underplanted seedlings to canopy removal in upper Piedmont hardwood stands. pp. 185-188 in Proc. Second Biennial Southern Silvicultural Research Conf. Jones, E.P., Jr. (ed.) Gen. Tech. Rep. SE-24.

Tworkoski, T.J., Smith, D.W., and Parrish, D.J. 1986. Regeneration of red oak, white oak, and white pine by underplanting prior to canopy removal in the Virginia Piedmont. South. J. Appl. For. 10: 206-210.

Wright, G.M., Pope, P.E., Fischer, B.C., Holt, H.A., and Byrnes, W.R. 1984. Chemical weed control to establish natural and artificial oak regeneration in a mechanically thinned upland hardwood stand. pp. 266-272 in Proc. Third Biennial Southern Silvicultural Research Conf. Shoulders, E. (ed.) Gen. Tech. Rep. SO-54.