Tree Planter's Notes, Vol. 45, No. 4 (1994)

Treatments for Enhancing Early Survival and Growth of Northern Red Oak Seedlings

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Early survival and height growth of underplanted 2+0 northern red oak (Quereus rubra L.) *nursery stock and of naturally established seedlings in northern West Virginia were evaluated one field growing season after treatments in a replicated multi-split-plot experiment. Tubex tree shelters 1.5 m (5 ft) tall promoted planted northern red oak height growth and general vigor (form and number of leaves) but did not affect survival. Understory treatment (application of herbicide to stumps) reduced the average height of woody vegetation competing with natural oak seedlings, and survival rates of major competing species (black cherry and red maple) were less. Results suggest that height growth of northern red oak seedlings may be enhanced by using tree shelters and by understory treatment on excellent sites.* Tree Planters' Notes 45(4):137-141; 1994.

Mixed-oak forests on high-quality sites across the eastern United States often do not regenerate to oaks following conventional timber harvesting methods (Trimble 1973, Hilt 1985, Crow 1988). Shade-tolerant species of lesser value are replacing oaks on better sites in many areas (Johnson 1976, Hix and Lorimer 1991). A major hindrance has been the lack of well-established advance regeneration of desirable species such as northern red oak *(Quercus rubra* L.). Understories present in these forests today are developing under much different disturbance regimes than in the past (Nowacki and others 1990, Abrams 1992): fire suppression has replaced frequent burning, for example.

The shelterwood method has been recommended for regenerating mature oak stands that lack adequate advance oak regeneration (Sander and others 1983, Hannah 1988). Loftis (1990) suggested using shelterwood cuts and controlling undesirable understory stems to encourage the development of desirable reproduction. Other researchers have concluded that herbicide control of midstory and understory competition is often needed (Horsley 1982, Janzen and Hodges 1987). Underplanting has been used to supplement natural oak regeneration in areas where oak is scarce (Tworkoski and others 1986). Pubanz and others (1989) found that planted oak seedlings in Wisconsin had better survival, growth, and vigor after overstory density was reduced and the understory controlled. Tree shelters have been found to increase early growth rates of planted oak seedlings (Potter 1988, Minter and others 1992, Smith 1993). Tree shelters also protect trees from many types of animal damage, including deer browsing (Kittredge and others 1992).

Thus, prescriptions that combine the shelterwood method with intensive understory management have been proposed for regenerating oaks naturally (Lorimer 1989), as well as for planting northern red oak (Johnson and others 1986). But few tests of these prescriptions have been done in mixed-oak forests of the central Appalachians. This study was designed to evaluate the usefulness of various combinations of underplanting, shelterwood cutting, tree shelter use, and understory treatment with herbicide in regenerating oak forests on high-quality sites.

Study Area and Methods

The University Forest in northern West Virginia near Morgantown was chosen as the site for this study. In May 1990, a multi-split-plot experiment was initiated with the following levels: site quality, shelterwood cutting, understory herbicide treatment, and tree shelter use on planted northern red oak seedlings. Two types of sites were selected for study: excellent sites, with northeast aspects and an average site index for northern red oak of 27 m at 50 years; and good sites, with northwest aspects and an average site index for northern red oak of 23 m at 50 yr. Three pairs of 0.4-ha (1-acre) plots were located on excellent sites, and two pairs on good sites. Plots within pairs were separated from each other by 20-m (66-ft) buffer strips. On all sites, overstories were dominated by yellowpoplar *(Liriodendron tulipifera L.),* white oak *(Quercus alba* L.), and northern red oak. Soils on the plots were stony sandy loams, and slopes ranged from 10 to 40%. Plots were all located in midslope positions at an average elevation of 675 m (2,215 ft).

During late winter and very early spring 1991, a shelterwood establishment cut was done on one randomly selected plot in each plot pair. These cuts removed overtopped and some intermediate crown-class trees, reducing crown cover from almost 100% to an average of 85%, as measured using a spherical densiometer (Lemmon 1956). Immediately after shelterwood cutting, an understory herbicide treatment was applied to half of each plot, again selected at random, forming 0.2-ha (0.5-ac) subplots. Understory treatment consisted of cutting near the ground all non-oak stems with a diameter at breast height of less than 1.6 cm (0.6 in), and then immediately applying herbicide (either trichlopyr or a mixture of picloram and 2,4-D) to the stumps to control resprouting.

In each plot, four 0.04-ha (0.1-acre) sub-subplots were established around the plot center, sharing the stake as a common corner. Within each subplot, one of the two sub-subplots was randomly chosen for natural regeneration, and 2+0 northern red oak nursery stock was planted on the other. Seedlings were obtained from the state nursery near Parkersburg, West Virginia, and planted during spring 1991. Before planting, seedlings were pruned at 20 cm (8 in) both above and below the root collar. Approximately 25 seedlings were planted per sub-subplot using 3- by 3-m (9.8- by 9.8-ft) spacing. A total of 500 seedlings were planted, about half of them protected by cylindrical Tubex® tree shelters 1.5 m (5 ft) tall. The shelters were pushed down into the soil around the seedlings and fastened to treated wooden stakes.

During summer 1990, initial plot measurements were taken before treatments were applied. On each natural regeneration sub-subplot, all understory tree species were inventoried by species and height class. Then subsamples of the following species were tagged: northern red oak, white oak, black cherry (*Prunus serotina* Ehrh.), and red maple (*Acer rubrum* L.). The location of each tagged seedling was mapped. For each subsampled seedling, total height was measured. To assess the general vigor of oaks, numbers of leaves were counted. Oak seedlings were then assigned to one of the following growth form classes: flat-topped, intermediate, and with distinct central leaders. At the end of the first field growing season (late summer 1991), measurements were repeated on subsampled (tagged) natural oak seedlings and on planted oak seedlings.

Analysis of variance (ANOVA) was used to examine treatment effects on regeneration. The main effects tested for were differences between sites. Percent survival data were arcsine transformed to more closely fit a normal distribution. Natural regeneration of northern red oak and white oak were combined, because white oak was absent or rare on some plots. Because planted seedlings were top--pruned, new shoots formed along stems. Therefore, length of the last annual height growth increment was analyzed instead of total height. Finally, X-square tests were used to detect differences in growth form between treatments. In all analyses, the 0.05 level of significance was used.

Results

Planted seedlings. The overall average survival rate for planted northern red oak seedlings was 88% (McNeel 1993). Survival after the first growing season was not significantly affected by site quality or treatment, including use of tree shelters.

Height growth for planted seedlings was significantly greater with tree shelters than without them (figure 1). No other factor (site quality, shelterwood cutting, or understory treatment) was significantly related to height growth (table 1). However, there were significant interactions between site quality and both understory treatment and tree shelters (table 2). Seedlings on both treated and untreated subplots grew higher on good sites than on excellent ones (table 3). On excellent sites, however, understory treatment significantly improved height growth, while the opposite was true on good sites. By contrast, tree shelters significantly improved height growth on both good and excellent sites.

Tree shelters were the only factor to significantly affect the average number of leaves on planted seedlings (figure 2). Sheltered seedlings produced more leaves than unsheltered seedlings, and they tended to have distinct central leaders (figure 3). Seedlings without tree shelters tended to have more intermediate

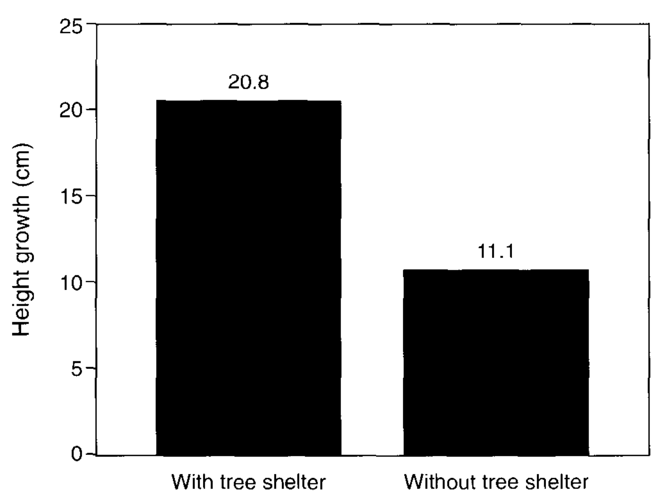

Figure 1—*Tree shelters significantly (P<0.01) improved height growth in planted northern red oak seedlings.*

Table 1—*Height growth of planted northern red oak seedlings after 1 field growing season, by understory treatment, site quality, shelterwood cutting, and use of tree shelters*

	Height growth (cm)			
	With tree shelters[b]		Without tree shelters	
Site/shelterwood[a]	Treated[c]	Untreated	Treated[c]	Untreated
Excellent				
Cut	20.5	18.1	7.1	7.3
Uncut	20.9	21.8	11.6	9.4
Good				
Cut	20.2	22.0	11.1	13.4
Uncut	20.2	22.6	12.2	16.5

[a] Excellent sites = northeast aspects, average site index for northern red oak 27 m at 50 years; good sites = northwest aspects, average site index 23 m. Shelterwood cut = removing overtopped and some intermediate crown-class trees; crown cover reduced to 85% on average.

[b] Cylindrical Tubex tree shelters 1.5 m (5 ft) tall.

[c] Understory treatment = cutting near ground level nonoak stems with dbh < 1.6 cm (0.6 in), then applying trichlopyr or picloram/2,4-D to stumps.

growth form, with less apical dominance. There was, however, a significant interaction effect between shelterwood cutting, understory treatment, and use of tree shelters. Over all sites, 85% of seedlings receiving all three of these treatments had distinct central leaders, compared to only 24% of seedlings receiving none of these treatments.

Natural regeneration. Major competitor species (black cherry and red maple) showed significantly lower early survival rates following understory treatment (table 4). However, survival rates for these species were not significantly related to either site quality or shelterwood cutting.

Table 2—*Analysis of variance of height growth of planted northern red oak seedlings*

Source	df	MS	F	Pr > F
SQ	1	726.23	0.94	0.4038
SC	1	405.82	4.64	0.1202
SQ x SC	1	50.74	0.58	0.5015
UT	1	79.73	4.36	0.0817
SQ x UT	1	319.65	17.50	0.0058
SC x UT	1	19.45	1.06	0.3419
SQ x SC x UT	1	4.51	0.25	0.6368
TS	1	9,678.75	165.61	0.0010
SQ x TS	1	314.89	5.39	0.0206
SC x TS	1	60.24	1.03	0.3100
UT x TS	1	7.57	0.13	0.7187
SQ x SC x TS	1	2.06	0.04	0.8511
SQ x UT x TS	1	11.53	0.20	0.6568
SC x UT x TS	1	29.12	0.50	0.4801
SQ x SC x UT x TS	1	81.51	1.39	0.2377
Error	399	23,318.50	58.44	

Note: SQ = site quality; SC = shelterwood cut; UT = understory treatment; TS = tree shelter.

Table 3—*Height growth of planted northern red oak seedlings after 1 field growing season, by site quality, understory treatment, and use of tree shelters*

	Height growth (cm)	
Treatment	Excellent site	Good site
Understory		
Treated	15.0	15.9
Untreated	14.1	18.6
Tree shelters		
With	20.3	21.3
Without	8.8	13.3

Note: Within columns, means for understory treated/untreated and for tree shelters with/without significantly differ at the 0.05 level.

Mean height of subsampled oaks was 17 cm (6.7 in), whereas subsampled non-oaks averaged 41 cm (16.1 in) in height. There were no significant differences in height related to site quality or shelterwood cutting for either oaks or nonoaks. Although understory treatment significantly reduced the mean height of nonoaks, it did not produce a significant difference in mean height of oaks (figure 4).

Discussion and Conclusions

Of the silvicultural practices examined in this study (shelterwood cutting, understory herbicide treatment, and use of tree shelters), tree shelters were the most effective in promoting the early height growth of

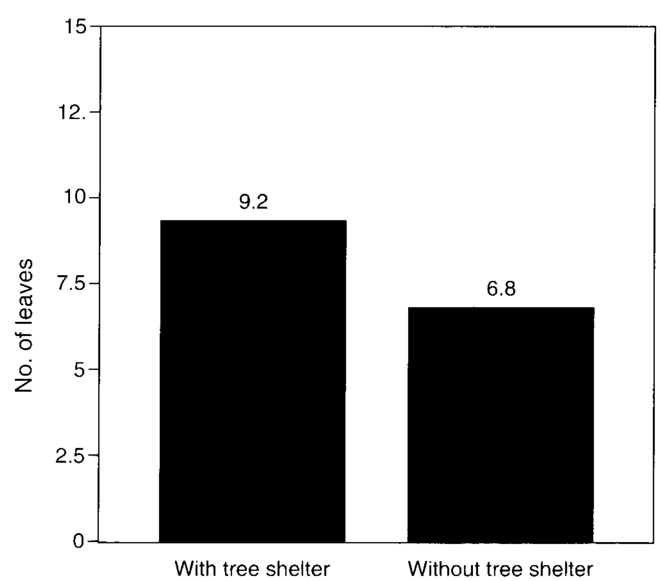

Figure 2—*Planted northern red oak seedlings with tree shelters had significantly (P < 0.01) more leaves than seedlings without tree shelters.*

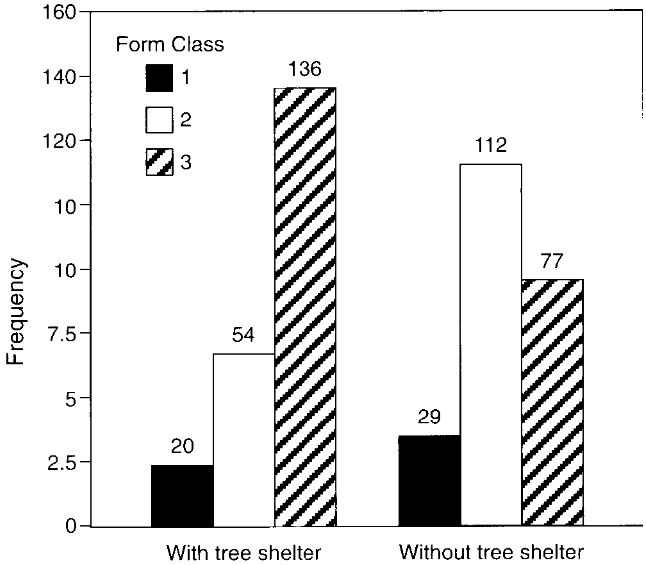

Figure 3—*Frequency of occurence of the three growth form classes from planted northern red oak seedlings with and without tree shelters. Class 1 = flat topped; 2 = intermediate; 3 = with distinct central leader. To a significant (P < 0.01) extent, sheltered seedlings tended to have central distinct leaders.*

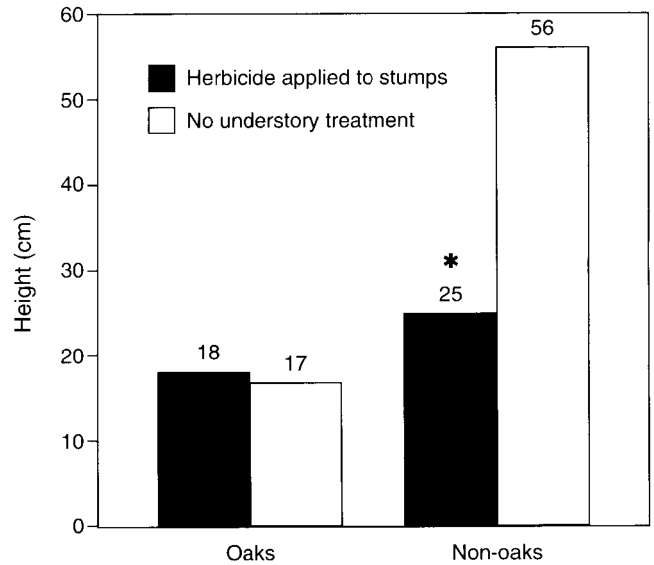

Figure 4—*Mean height of oaks (northern red oak and white oak) and of nonoaks on both untreated subplots and subplots with treated understories (herbicide applied to stumps). Asterisk indicates significant difference (**P** < 0.01) between treated and untreated subplots.*

underplanted northern red oak seedlings on both good and excellent sites. Seedlings with tree shelters also had more leaves and better growth form. Applying herbicide to the stumps of competing vegetation resulted in greater height growth of planted northern red oak seedlings on excellent sites, but not on good sites.

Table 4-*Survival rate of black cherry mid red maple after 1 field growing season, by site quality, understory treatment, and shelterwood cutting*

	Survival rate (%)			
	Black cherry		Red maple	
Site/shelterwood[a]	Treated[b]	Untreated	Treated[b]	Untreated
Excellent site				
Cut	76	93	52	85
Uncut	60	91	56	89
Good site				
Cut	76	85	38	79
Uncut	36	94	9	77
Overal	I 63	91	42	84

Note: For both species, overall means for understory treated and untreated are significantly different from each other at the 0.01 level.

Excellent sites = northeast aspects, average site index for northern red oak 27 m at 50 years; good sites = northwest aspects, average site index 23 m. Shelterwood cut = removing overtopped and some intermediate crown-class trees; crown cover reduced to 85 % on average.

Understory treatment = cutting near ground level nonoak stems with dbh < 1.6 cm (0.6 in), then applying trichlopyr or picloram/2,4-D to stumps.

Although survival of natural seedlings was higher after shelterwood cutting, there was no similar effect on early survival or growth of planted seedlings. Shelterwood establishment cuts were light (no more than 15% canopy cover was removed, on average); more than one removal cut might be necessary to gradually release oaks, stimulating their height growth and helping them against competitors like black cherry and red maple. On excellent sites in the southern Appalachians, frequent light cuts were found to ensure better survival and more rapid height growth of northern red oak seedlings than single heavy cuts (Loftis 1990).

Early survival rates of black cherry and red maple were reduced through understory treatment. Some resprouted, and new establishment occurred, but treatment lowered the average height of these fast-growing oak competitors; although they remained taller on average than oak, their competitive advantage was reduced. After 1 growing season, survival rates of planted northern red oak seedlings were very high. Results indicate that both planted and natural northern red oak seedlings can survive the first growing season, and that use of tree shelters and understory treatment with herbicide can enhance their potential for rapid height growth.

White-tailed deer *(Odocoileus virginianus*) are a major problem in the central Appalachians, and unsheltered seedlings were heavily browsed. The better browse found on excellent sites than on good ones may have attracted more deer, which might explain the greater height growth observed on good sites than on excellent ones for seedlings without tree shelters (table 1). In regions where protection from deer browsing is the major objective, the role of tree shelters in improving survival of sheltered seedlings may be more readily apparent than in this study. On all sites, however, tree shelters not only provided protection from browsing, they also created improved microenvironments for seedling growth.

Underplanting northern red oak appears to be an effective way of supplementing natural regeneration in the central Appalachians. Use of tree shelters can increase the height growth of oak seedlings in this region. However, the high cost of shelters may limit their use in extensive forest management applications.

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