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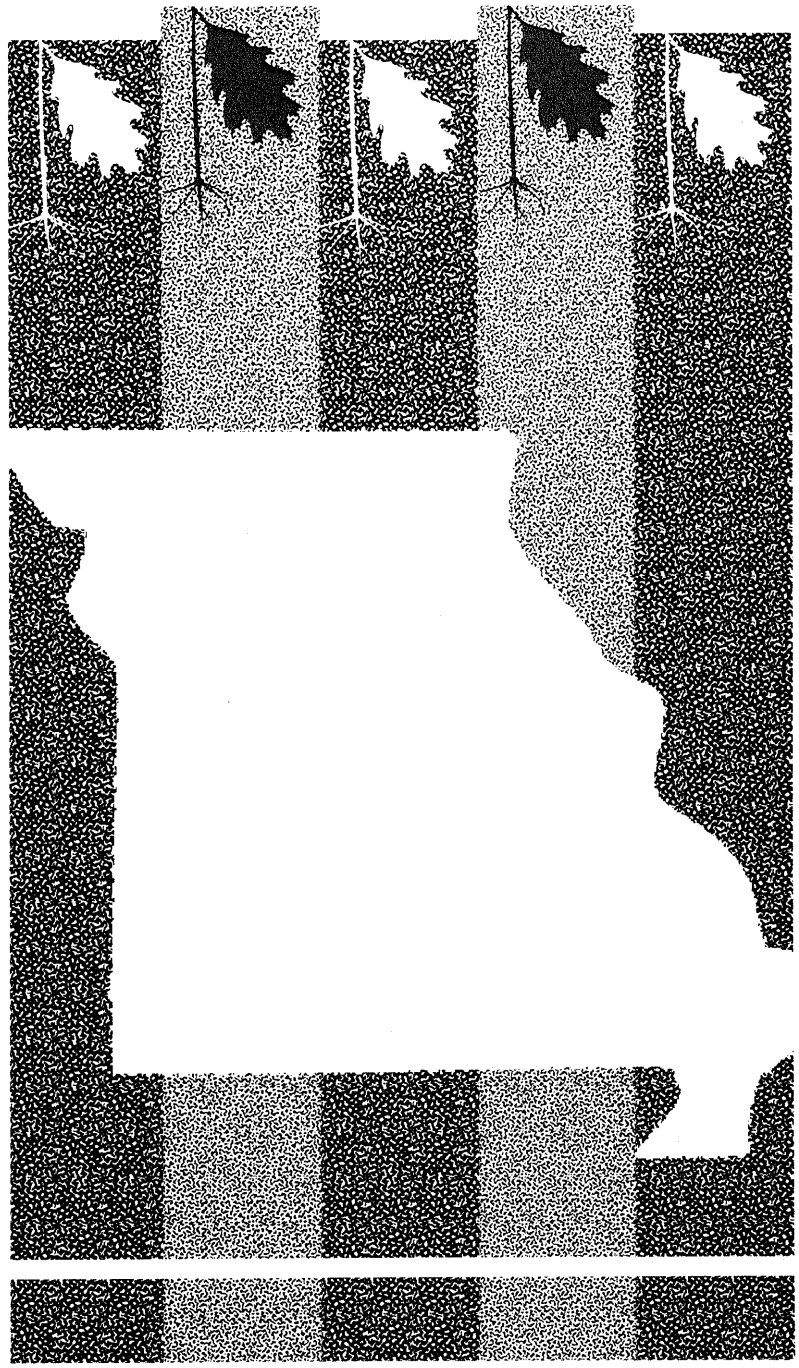

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Underplanting Northern Red Oak In Missouri Without Herbicides[1]

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Results from studies in Missouri have shown that underplanting can be used to regenerate northern red oak (*Quercus rubra* L.) (Johnson 1984, 1988). That research led to a silvicultural prescription that calls for: (1) controlling undesirable woody vegetation with herbicide applied before planting, (2) planting under a shelterwood at 60 percent stocking, (3) using large-diameter (1/2-inch caliper) nursery stock with clipped tops, and (4) removing the shelterwood three growing seasons after planting (Johnson *et al.* 1986). If this prescription is applied, about 60 percent of planted trees should be dominant or codominant 5 years after the shelterwood is removed (Johnson 1989). The prescription is most cost effective when coupled with the guide for evaluating the natural regeneration potential of a stand (Sander *et al.* 1984). This approach forms an objective basis for minimizing planting costs by relying on natural reproduction to provide part of the future stocking of acceptable growing stock.

In the prescription, the objective of applying herbicide is to reduce competition from woody plants less than 2-inches d.b.h. and to eliminate sprouting from stumps of trees removed in harvesting. Applied to unwanted woody vegetation by injection, basal spraying, or spraying of cut stumps, herbicides potentially can control the vegetation that would compete with planted oaks. Several registered herbicides are useful in controlling most woody species in Missouri. However, because of increasing environmental concerns about using herbicides, the possible silvicultural consequence of not using them is the subject of this paper.

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THE DATA

Unfortunately, our planting studies specifically designed to compare herbicide-treated and non-treated plots have not been in place long enough to allow a definitive comparison. Nevertheless, data from two studies on the Mark Twain National Forest provide a basis for a provisional assessment:

1. A red oak underplanting study in its fifth year after overstory removal provided data on the heights of dominant woody competitors and planted trees on herbicide-treated plots. The study included 3,072 planted trees equally distributed over 32 1-acre plots within a 100-acre area on predominantly north-facing slopes on the Potosi Ranger District; site index for red oak ranged from about 60 to 70. All study plots were treated with 2,4-D plus picloram (Tordon RTU) before planting and again before the overstory was removed between the third and fourth growing seasons after planting—in accordance with the prescription. Within each plot, the heights of dominant competitors, defined by the tallest woody stem within 1 m of every fourth planted tree (24/plot), were measured. This mean height was then assumed to be the average canopy height of dominant and codominant trees. Non-oaks were the most frequently occurring dominant competitors. Predominant among these were sassafras (*Sassafras albidum* (Nutt.) Nees), flowering dogwood (*Cornus florida* L.), and blackgum (*Nyssa sylvatica* Marsh.). On many plots, briars (*Rubus* spp.) formed a dense but declining lower layer of competition.

[1] *Paper presented at the Non-herbicide Alternatives for Vegetation Management Seminar; 1989 November 2; Rolla, MO. Sponsored by Mark Twain National Forest and the Missouri Department of Conservation.*

2. A study of natural regeneration in six clearcuts not treated with herbicide that were in their fifth growing season after cutting provided data on 753 dominant and codominant trees including black oak (*Quercus velutina* Lam.), white oak (*Q. alba* L.), scarlet oak (*Q. coccinea* Muench.) and the species listed above. The clearcuts were located on three ranger districts (Salem, Rolla, and Fredericktown) where site index for black oak (*Quercus velutina* Lam.) ranged from about 50 to 75.

Measurements of planted trees and natural vegetation in these stands thus provided data on the heights of planted trees and/or woody vegetation that developed after overstory removal in herbicide-treated and untreated plots. On the planted plots, dominant woody competitors averaged 9.9 feet tall. Planted trees that attained at least 80 percent of that height (7.9 ft) were usually competitively successful, *i.e.*, dominant or codominant. The heights of dominant planted trees were correlated with the heights of dominant competitors: the taller the dominant competitors the taller the planted trees. Thus, planted trees and competitors responded similarly to apparent variation in site quality.

In the clearcutting study, dominant and codominant trees averaged 11.1 feet tall; trees at least 80 percent of that height (8.9 ft) were usually dominant or codominant. Although there was some variation in mean height of competition associated with aspect and slope position, this variation was relatively minor at stand age 5. Based on the clearcut data, no significant differences ($p. \geq 0.05$) were associated with aspect. Although there was some evidence that heights of dominant and codominant trees differed by slope position (upper, middle, and lower), mean differences were 1.3 feet or less.

A PROVISIONAL ASSESSMENT

If we assume that the 1.2-foot difference between the mean height of dominant competitors in stands treated with herbicide (9.9 ft) and those not treated (11.1 ft) is real, how does that difference translate into expected planted tree performance? Because our prescription was based on the probability of a planted tree attaining a given future height (its "success" probability), we can answer that question by increasing that height (the "success" criterion) by 1.2 feet. This is facilitated in the probability model developed for making such predictions by a parameter estimate of the effect of varying the success criterion (Johnson 1984). For example, we usually estimate success probabilities for a success criterion of 80 percent, *i.e.*, planted trees must be at least 80 percent of the mean height of dominant competitors to be deemed successful (Johnson 1989, Johnson and Rogers 1985). However, success probabilities can be estimated for any success criterion.

Thus, to be at least 80 percent of the mean height of dominant competitors in an untreated stand, planted trees must attain a fifth-year height of at least 8.9 feet, which in turn, is 90 percent (8.9/9.9) of the mean height of dominant competitors in the treated stands where the success probability model was developed. Using that model, we could then estimate success probabilities for a success criterion of 90 percent to determine how planted trees might perform in untreated stands. The resulting estimates vary with the initial diameter (caliper) of the nursery stock: larger seedlings yield higher success probabilities. The reciprocals of these probabilities are probably more useful silviculturally than the probabilities themselves because the former represent the number of trees that must be planted to obtain, on the average, one successful (dominant or codominant) tree. For example, if the planting objective were to obtain 100 dominant and codominant trees per acre 5 years after overstory removal and the success probability for a tree of a given caliper were 0.6, then (1/0.6) x 100 or 167 trees per acre would have to be planted.

These numbers, *i.e.*, the reciprocals of the estimated success probabilities, are presented in table 1 for herbicide-treated and untreated stands for a range of initial stem diameters. The numbers for the untreated stands are, of course, hypothetical because planted trees were not actually observed in those stands. The numbers decrease rapidly with increasing caliper of the nursery stock for both treated and untreated stands. This emphasizes the rapid

Table 1.—*Number of 1+1 transplants or 2+0 undercut seedlings needed to obtain one codominant or larger tree 5 years after shelterwood removal with and without herbicide treatment.*[1]

Initial shoot diameter[2] (1/16 in)	Planted trees needed to obtain 1 codominant or larger tree	
	Treated with herbicide[3]	Not treated with herbicide
	Number	
4	3.42	5.52
5	2.58	3.95
6	2.11	3.08
7	1.83	2.55
8	1.64	2.20
9	1.51	1.96
10	1.42	1.78

[1] Based on the reciprocals of the estimated success probabilities (P) for 1+1 nursery stock with tops clipped 6 inches above the root collar; planted trees remained under the shelterwood for three growing seasons. P is given by the logistic regression model:

$$P = [1 + exp(-(5.24 - 0.0627X_1 + 0.957X_2))]^{-1}$$

where P is the probability that a planted tree attains at least the height specified by the success criterion (X_1) (expressed as a percent of the expected mean height of dominant and codominant competitors 5 years after shelterwood removal); *exp* is the base of the natural logarithm (2.71828); and X_2 is the natural logarithm of the cross sectional area of seedling diameter (cm^2) 1 inch above the root collar. Numbers in the table are for $X_1 = 80$ (herbicide-treated) and $X_1 = 90$ (untreated).

[2] Measured 1 inch above the root collar.

[3] Based on the application of Tordon RTU to cut woody understory stems ≥ 0.5-inches d.b.h. and to stumps of overstory trees removed in the shelterwood and final harvest cut.

gain in success probabilities associated with increasing stock size. Based on these numbers, planting nursery stock averaging 1/4-inch caliper would require 61 percent more trees per acre to attain a given future stocking goal in an untreated stand than in an herbicide-treated stand. However, for 5/8-inch trees, only 25 percent more would have to be planted in untreated than treated stands to attain the same stocking goal. Thus, there is a trend toward convergence of estimates for treated and untreated stands with increasing initial caliper of nursery stock. This suggests that at some relatively large initial seedling size, there would be no biological advantage in using herbicide, at least as it has been applied in our study plots. However, these estimates are provisional and should be interpreted with caution for the reasons cited below.

In addition to the heights of dominant competitors, other competition factors can also influence the performance of planted trees. For example, density of competition (including trees, shrubs, and herbs), may be reduced by using herbicides. That reduction, by itself, may accelerate planted tree growth and increase survival. The possible effect, although not considered in the above calculations, may be potentially important. Moreover, planted trees may not have established their longer term crown positions by the end of the first 5-year post-shelterwood period. Relative crown positions of trees shift frequently in even-aged hardwood stands during the first decade of stand development (Lamson and Smith 1978). Weather, disease, and insects also can affect the growth and survival of planted oaks and thus alter competitive relations between planted trees and other vegetation (Law and Gott 1987, Linit *et al.* 1986).

Despite some uncertainties, underplanting northern red oak without herbicides may be a reasonable alternative to using herbicides if relatively modest increases are made in the numbers and/or initial size of nursery stock planted. An added bonus is the savings from not using herbicide, which is estimated at $60 per acre using the method specified in the original prescription. Without herbicides, the estimated cost per acre per 100 competitively successful trees established 5 years after shelterwood removal would be about $101 if nursery stock averaging 0.5 inches in diameter were used (220 trees planted to obtain 100 per acre).[2] In herbicide-treated stands using the same size stock, it would cost about $75 per 100 competitively successful trees *plus* $60 per acre for the herbicide treatment. These estimates assume a nursery stock cost of $258 per 1,000 for 2+0 undercut stock (Johnson 1989) and planting costs of $200 per 1,000 trees planted (Johnson *et al.* 1986). Additional costs may be incurred for marking stands for thinning, laying out lines to assure proper spacing of trees, and related administrative duties.

[2] *The economic advantages of planting large nursery stock are discussed in Johnson 1989.*

The assessment on the previous page suggests that the currently prescribed herbicide treatment is not cost effective nor very biologically effective. However, for the cautionary reasons cited above, these conclusions should be considered provisional until more definitive results are available from more statistically rigorous comparisons of herbicide-treated and untreated plots. Other related considerations are discussed by Johnson *et al.* 1986.

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This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Johnson, Paul S.
1992. **Underplanting northern red oak in Missouri without herbicides.** Gen. Tech. Rep. NC-152. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 4 p.

Describes a provisional assessment of the effectiveness of applying herbicides to woody competitors between 0.5- and 1.5-inches d.b.h. before underplanting northern red oak. Results suggest that no weed control, *i.e.*, not using herbicides, would require only modest increases in the numbers or initial size of nursery stock needed to obtain a given future stocking goal.

KEY WORDS: *Quercus rubra*, artificial regeneration, planting costs, shelterwood, nursery stock.

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