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GROWTH OF HARDWOOD REPRODUCTION AFTER MECHANICAL AND OR CHEMICAL RELEASE: 19-YEAR RESULTS FROM SOUTHWESTERN TENNESSEE

A Thesis

Presented for the

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ABSTRACT

Advanced oak reproduction that has developed in a stand that has been partially cut several times can vary substantially in age or size. Where advanced reproduction varies substantially in age or size in stands that have reached rotation age, complex questions are raised regarding the probable responses of various species, size, and age mixtures of advanced reproduction to liberation, cleaning, coppicing, or other treatments.

This thesis reports the results of a 19-year study of the survival and growth of advanced hardwood reproduction that was released by coppicing, liberation, and liberation-with-cleaning treatments applied in conjunction with a commercial timber harvest in southwestern Tennessee. This reproduction had been established over a period of at least 27 years in a stand that had been partially harvested at least three times during the reproduction period.

Principal findings were as follows.

1. After 19 growing seasons, the coppicing plots contained 333 oaks with d.b.h. greater than or equal to 2.0 inches per acre (principally *Quercus alba* L. and *Quercus falcata* Michx.). The liberation plots contained 600 such oaks per acre after 19 growing seasons, and the liberation-with-cleaning plots contained 700.

2. After 19 growing seasons the liberation-with-cleaning plots contained larger oaks than the liberation or coppicing plots contained.
3. Seven-year data did not indicate that the liberation-with-cleaning plots would contain the largest oaks and the largest numbers of oaks per acre after 19 growing seasons.
4. After 19 growing seasons, the coppicing plots contained no hickories (principally *Carya tomentosa* Poir. Nutt.) with d.b.h. greater than or equal to 2.0 inches. In the liberation and liberation-with-cleaning plots, stocking of hickories declined substantially over 19 growing seasons.

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I. INTRODUCTION

Where advanced oak reproduction is absent, present only in insufficient numbers, or insufficiently robust, clearcutting in upland hardwoods can be expected to yield new stands in which stocking of oaks is reduced (Sander, 1972; Johnson, 1979; Sims, 1980; Wright et al., 1984; Beck and Hooper, 1986). A number of authorities have suggested that partial cutting methods might be used to establish oak reproduction and to promote its growth when more or larger reproduction is wanted (Korstian, 1927; Clark and Watt, 1971; Sander, 1972; Loftis, 1983; Loftis, 1988).

Partial cuttings can yield disappointing results, however. Where partial cutting removes too few trees, oak reproduction simply does not respond positively to the treatment. Heavier cuttings sometimes create conditions under which undesirable vegetation grows very rapidly (McGee, 1975; Sims, 1980; Loftis, 1988). Also, where oak and other advanced reproduction develops in a stand that has been partially cut several times over a period of many years, some of that reproduction can be substantially older and or larger than the rest. Where advanced reproduction varies substantially in age or size in stands that have reached rotation age, complex questions are raised regarding the probable responses of various species, size, and age

mixtures of advanced reproduction to liberation, cleaning, coppicing, or other silvicultural treatments.

It is sometimes recommended that advanced hardwood reproduction larger than some specified size be coppiced when overstories of upland hardwoods stands are harvested. For example, Roach and Gingrich (1968) suggest that all trees with d.b.h. greater than about two inches or height greater than about 25 feet should be severed when stands of upland hardwoods are harvested by clearcutting. They argue that residual poles or large saplings that have been released by harvesting invariably develop heavy branches or excessive numbers of epicormic sprouts and thus have very little value as growing stock. McGee (1982) recommends that both desirable and undesirable species stems in the 2-inch to 12-inch d.b.h. classes be severed when low-quality hardwood stands are clearcut on the Cumberland Plateau. He suggests that trees of this size will, if retained, inhibit the growth of younger and more vigorous reproduction. The Tennessee Forestry Association (undated) recommends that all advanced reproduction that is at least four feet tall and at least .5 inches in diameter at the root collar should be severed when oak-hickory stands are clearcut. The Tennessee Division of Forestry's guidelines for participation in the state-federal Forestry Incentives Program authorize partial reimbursement of the cost of severing all well-advanced

reproduction where oak-hickory stands are regenerated (Michael Williams, 1988: personal communication).

This thesis reports the results of a 19-year study of the survival and growth of advanced hardwood reproduction that was released by coppicing, liberation, and liberation-with-cleaning treatments applied in conjunction with a commercial sawtimber harvest in southwestern Tennessee. This reproduction was established over a period of at least 27 years in a stand that was partially harvested at least three times during the reproduction period. Post-treatment survival and growth of this reproduction is described. It is considered whether 19-year survival and growth of advanced reproduction in the liberation and liberation-with-cleaning treatment plots could have been predicted on the basis of seven-year data. Possible explanations of observed responses of oak reproduction following application of the liberation and liberation-with-cleaning treatments are discussed.

II. STUDY AREA

Location

The study was installed at Ames Plantation, which is located near Grand Junction, in Fayette and Hardeman Counties, in southwestern Tennessee (lat. 35°07' N, long. 89°13' W) (U.S. Geological Survey, 1950).

Climate

Southwest Tennessee's climate is characterized by hot summers, mild winters, and well-distributed precipitation. Mean annual precipitation at Bolivar, Tennessee is 53.6 inches (Dickson, 1960).

Drainage

The study stand is situated on gently rolling ground that is drained by intermittent streams that trend from southeast to northwest.

Soils

The study site's soils have developed on Quaternary loess deposits that overlie Tertiary Coastal Plain sediments of the Claiborne and Wilcox formations (Hardeman, 1966). These formations consist of irregularly-bedded gray-to-white clay, silty clay, lignitic clay, and lignite. Study plots were established on various phases of Ruston, Vicksburg, Loring, and Lexington soils (Ewing, 1956; Countess, 1971). These acidic loams are moderately-well to well-drained,

moderately fertile to fertile, and can support valuable stands of upland hardwoods.

Vegetation

Timber was not harvested commercially on the Ames Plantation between 1903 and 1945, but tenant farmers cut fuelwood and or grazed livestock in the study stand throughout that period and until 1955. It appears that part or all of the study stand was cut over selectively during 1945 and or 1946 (Ewing, 1956). Sawtimber was harvested selectively in the study stand during 1955-1956 and 1961-1962 (James G. Warmbrod, 1987: personal communication).

By 1967 the study stand exhibited an inverse-J diameter distribution and was judged to be less than fully stocked. Basal area of trees with d.b.h. greater than or equal to 2.6 inches was approximately 44 square feet per acre at that time, with some 19 square feet per acre of basal area in trees with d.b.h. greater than or equal or 11.6 inches (Michael L. Countess, undated: unpublished notes).

In early 1967 the stand was dominated by white oak, southern red oak (*Quercus falcata* Michx.), post oak (*Quercus stellata* Wangenh.), and mockernut hickory (*Carya tomentosa* Poir. Nutt.). Blackgum (*Nyssa sylvatica* Marsh.), black cherry (*Prunus serotina* Ehrh.), red maple (*Acer rubrum* L.), American elm (*Ulmus americana* L.), sweetgum (*Liquidambar styraciflua* L.), and common persimmon (*Diospyros virginiana*

L.) also were present in overstory positions (Michael L. Countess, undated: unpublished notes).

Tree species present in the stand's understories were:

white oak
southern red oak
mockernut hickory
blackgum
red maple
northern catalpa (*Catalpa speciosa* Warder ex Engelm.)
black cherry
American holly (*Ilex opaca* Ait.)
eastern redcedar (*Juniperus virginiana* L.)
blackjack oak (*Quercus marilandica* Muenchh.)
common persimmon
shortleaf pine (*Pinus echinata* Mill.)
winged elm (*Ulmus alata* Michx.)
flowering dogwood (*Cornus florida* L.)
eastern redbud (*Cercis canadensis* L.)
sassafras (*Sassafras albidum* [Nutt.] Nees)
river birch (*Betula nigra* L.)

White oak, southern red oak, and mockernut hickory comprised 74 percent of the stand's trees with d.b.h. greater than or equal to 1.0 inches and less than 11.0 inches. Most of the remaining trees in that range of diameters were flowering dogwood and eastern redbud (Countess, 1971).

III. METHODS

Treatments

All of the stand's merchantable trees with d.b.h. greater than or equal to 11.0 inches were harvested during the later part of 1967. Experimental treatments were applied to residual tree-species stems in circular .01-acre plots, and to residual tree-species stems in 66-foot-deep buffer zones encircling the plots, during early 1968. The treatments were as follows.

1. Coppicing. All residual tree-species stems were severed at or near ground level.
2. Liberation. All residual tree-species stems with d.b.h. greater than or equal to 11.0 inches were injected with 2,4,5-T amine. (No such trees were found within the liberation plots; the trees that were deadened were found in the buffer zones that encircled those plots.)
3. Liberation-with-cleaning. All residual trees with d.b.h. greater than or equal to 11.0 inches were injected with 2,4,5-T amine. In the d.b.h.-less-than-11.0-inches class, all tree-species stems except oaks and hickories were injected with 2,4,5-T amine. (No trees with d.b.h. greater than or equal to 11.0 inches were found within the liberation-with-cleaning plots; the large residuals

that were deadened were found in the buffer zones that encircled those plots.)

Each of these treatments was replicated three times (Countess, 1971).

The liberation and liberation-with-cleaning plots were established in areas in which oaks and hickories comprised the bulk of existing reproduction. The coppicing plots were established in areas in which the pretreatment ratio of oak and hickory reproduction to other reproduction was smaller (Tables 1 and 2) (Countess, undated: unpublished notes).

Data Collection

Pretreatment data were collected during the spring of 1968. These data were the heights of all within-plot trees with d.b.h. less than 1.0 inches and the breast-height diameters of all within-plot trees with d.b.h. greater than or equal to 1.0 inches.

Post-treatment data were collected following the 1969, 1970, 1974, and 1986 growing seasons.

The 1969 data were the heights of all liberation and liberation-with-cleaning trees with d.b.h. less than 1.0 inches and the breast-height diameters of all liberation and liberation-with-cleaning trees with d.b.h. greater than or equal to 1.0 inches.

The 1970 data were the heights of all liberation and liberation-with-cleaning trees with d.b.h. less than

Table 1. Pretreatment (1968) composition by treatment, stems with d.b.h. less than 1.0 inches.

Treatment	Species Group	Number of Stems per Acre[a]
coppicing	oak[b]	1800
	hickory[c]	1600
	miscellaneous[d]	2633
liberation	oak	3067
	hickory	1267
	miscellaneous	1033
liberation-with-cleaning	oak	2300
	hickory	1333
	miscellaneous	1767

[a]All figures are summed over three .01-acre plots and expanded to per-acre basis.

[b]Principally *Q. alba* and *Q. falcata*.

[c]Principally *C. tomentosa*.

[d]All other tree species.

Table 2. Pretreatment (1968) composition by treatment, stems with d.b.h. greater than or equal to 1.0 inches.

Treatment	Species Group	Number of Stems per Acre[a]
coppicing	oak[b]	800
	hickory[c]	667
	miscellaneous[d]	900
liberation	oak	3600
	hickory	667
	miscellaneous	1633
liberation-with-cleaning	oak	3833
	hickory	1133
	miscellaneous	1034

[a]All figures are summed over three .01-acre plots and expanded to per-acre basis.

[b]Principally *Q. alba* and *Q. falcata*.

[c]Principally *C. tomentosa*.

[d]All other tree species.

1.0 inches and the breast-height diameters of all liberation and liberation-with-cleaning trees with d.b.h. greater than or equal to 1.0 inches. Coppicing-plot trees with d.b.h. less than 1.0 inches were counted but were not measured.

The 1974 data were the heights of all coppicing, liberation, and liberation-with-cleaning trees with d.b.h. less than 1.0 inches and the breast-height diameters of all coppicing, liberation, and liberation-with-cleaning trees with d.b.h. greater than or equal to 1.0 inches.

The heights and breast-height diameters of all within-plot trees with d.b.h. greater than or equal to 2.0 inches were measured in 1986.

The author devised a tree grading system and used it to grade these trees. Tree grades were assigned on the basis of counts of butt-log defects: a tree with a 9-foot butt section that was free of visible defects was graded 1; a tree with a butt section that had one visible defect was graded 2; a tree with a butt section that had two visible defects was graded 3; and so on, except than any tree that had five or more visible butt-log defects was graded 6. The defects that were tallied for grading purposes were crook, sweep, fork, presence of multiple stems, and 90-degree butt-section faces bearing potentially persistent branches.

The ages of two codominant or dominant oaks in each liberation and liberation-with-cleaning plot were determined by increment boring in 1986.

IV. RESULTS

Trees per Acre by Treatment

It has already been noted that the coppicing plots contained fewer oak stems and proportionally more miscellaneous stems than the liberation and liberation-with-cleaning plots contained before the treatments were applied. Miscellaneous stems were more numerous in the coppicing plots than in the liberation and liberation-with-cleaning plots when final post-treatment tallies were made in 1974 (stems with d.b.h. less than 1.0 inches) and in 1986 (stems with d.b.h. greater than or equal to 2.0 inches) (Tables 3 and 4).

In the liberation plots, ingrowth of oaks from the less-than-1.0-inches d.b.h. class was insufficient to offset mortality of oaks in the greater-than-or-equal-to-1.0-inches class during any measurement-to-measurement interval. In the liberation-with-cleaning plots, ingrowth more than counterbalanced mortality of oaks in the d.b.h.-greater-than-or-equal-to-1.0-inches class through 1970, however.

Numbers of trees per acre for individual species are given in Appendix A, Tables A-1, A-2, and A-3.

Mean d.b.h. by Treatment

Mean d.b.h. for oaks was greater than mean d.b.h. for miscellaneous stems in the coppicing plots in 1968, before

Table 3. Numbers of larger stems per acre by treatment, species group, and year.[a]

Treatment	Species Group	Trees per Acre				
		1968	1969	1970	1974	1986
coppicing	oak[b]	800	no data		2433	333
	hickory[c]	667	"	"	767	0
	miscellaneous[d]	900	"	"	2632	399
liberation	oak	3600	3433	3167	2767	600
	hickory	667	600	633	533	67
	miscellaneous	1633	1333	1266	932	166
liberation-with-cleaning	oak	3833	4000	4166	3767	700
	hickory	1133	1200	1200	1000	133
	miscellaneous	1034	0	166	33	33

[a]Figures for 1968 through 1974 are for stems with d.b.h. greater than or equal to 1.0 inches. Figures for 1986 are for stems with d.b.h. greater than or equal to 2.0 inches. All figures are summed over three .01-acre plots and expanded to per-acre basis.

[b]Principally *Q. alba* and *Q. falcata*.

[c]Principally *C. tomentosa*.

[d]All other tree species.

Table 4. Numbers of smaller stems per acre by treatment, species group, and year.[a]

Treatment	Species Group	Stems per Acre 1968	1969	1970	1974
coppicing	oak[b]	1800	no data	4467[e]	2400
	hickory[c]	1600	" "	2867[e]	1867
	miscellaneous[d]	2633	" "	1200[e]	4867
liberation	oak	3067	2333	2567	2567
	hickory	1267	1233	1167	867
	miscellaneous	1033	600	700	1500
liberation-with-cleaning	oak	2300	1800	1767	2033
	hickory	1333	1100	933	967
	miscellaneous	1767	33	333	667

[a]All figures are for stems with d.b.h. less than 1.0 inches. All figures are summed over three .01-acre plots and expanded to per-acre basis.

[b]Principally *Q. alba* and *Q. falcata*.

[c]Principally *C. tomentosa*.

[d]All other tree species.

[e]Adapted from Countess, 1971.

the treatment was applied, but was less than mean d.b.h. for miscellaneous stems in those plots in 1986 (Table 5). In the liberation plots, diameter growth of oaks kept pace with diameter growth of miscellaneous stems from 1968 through 1986, and mean d.b.h. of oaks was greater than mean d.b.h. of miscellaneous stems in those plots in 1986. In 1986 mean d.b.h. of oaks in the liberation-with-cleaning plots was greater than mean d.b.h. of oaks in the liberation or coppicing plots.

Duncan's Multiple Range Test was applied to the oak group d.b.h. data for 1968, 1974, and 1986 (Tables 6, 7, and 8). Mean d.b.h. of oaks in the liberation-with-cleaning plots was significantly greater (at alpha = .05) than mean d.b.h. of oaks in the coppicing plots in 1974 and in 1986. Supplementary statistical analysis of d.b.h. data is shown in Appendix B.

Mean Height by Treatment

The mean height of liberation plot oaks with d.b.h. less than 1.0 inches increased from measurement to measurement from 1968 through 1975, but the mean height of liberation-with-cleaning plot oaks with d.b.h. less than 1.0 inches decreased from 1968 through 1970 (Table 9).

The mean height of miscellaneous stems was greater than the mean height of oaks in the coppicing and liberation plots in all measurement years, but the mean height of

Table 5. Mean d.b.h. in inches by treatment, species group, and year.[a]

Treatment	Species Group	Mean D.B.H. (Inches) 1968	1969	1970	1974	1986
coppicing	oak[b]	3.1	no data		1.8	3.5
	hickory[c]	1.9	"	"	1.2	e
	miscellaneous[d]	2.5	"	"	1.6	4.0
liberation	oak	2.1	2.3	2.4	3.1	4.8
	hickory	2.2	2.4	2.6	3.2	4.2
	miscellaneous	2.0	2.2	2.3	2.9	4.6
liberation-with-cleaning	oak	2.2	2.3	2.5	2.8	5.4
	hickory	2.1	2.1	2.1	2.3	4.0
	miscellaneous	1.8	e	1.4	1.3	2.0

[a]Figures for 1968 through 1974 are for stems with d.b.h. greater than or equal to 1.0 inches. Figures for 1986 are for stems with d.b.h. greater than or equal to 2.0 inches. All figures are means over three .01-acre plots.

[b]Principally Q. alba and Q. falcata.

[c]Principally C. tomentosa.

[d]All other tree species.

[e]No stems in category.

Table 6. 1968 oak group diameter separations.[a] Duncan's Multiple Range Test at alpha = .05.

Treatment	Mean D.B.H. (Inches)[b]	Duncan Grouping[c]	N
coppicing	3.121	A	24
liberation-with-cleaning	2.157	B	115
liberation	2.074	B	108

[a]Oak group consists of Q. alba and Q. falcata (principally). Data were breast-height diameters in inches of oak group stems with d.b.h. greater than or equal to 1.0 inches.

[b]Figures are averages over three .01-acre plots.

[c]Means with the same grouping letter are not significantly different at alpha = .05.

Table 7. 1974 oak group diameter separations.[a] Duncan's Multiple Range Test at alpha = .05.

Treatment	Mean D.B.H. (Inches)[b]	Duncan Grouping[c]	N
liberation	3.063	A	83
liberation-with-cleaning	2.781	A	113
coppicing	1.764	B	73

[a]Oak group consists of Q. alba and Q. falcata (principally). Data were breast-height diameters in inches of oak group stems with d.b.h. greater than or equal to 1.0 inches.

[b]Figures are averages over three .01-acre plots.

[c]Means with the same grouping letter are not significantly different at alpha = .05.

Table 8. 1986 oak group diameter separations.[a] Duncan's Multiple Range Test at alpha = .05.

Treatment	Mean D.B.H. (Inches)[b]	Duncan Grouping[c]	N
liberation-with-cleaning	5.386	A	21
liberation	4.783	AB	18
coppicing	3.480	B	10

[a]Oak group consists of Q. alba and Q. falcata (principally). Data were breast-height diameters in inches of oak group stems with d.b.h. greater than or equal to 1.0 inches.

[b]Figures are averages over three .01-acre plots.

[c]Means with the same grouping letter are not significantly different at alpha = .05.

Table 9. Mean height in feet by treatment, species group, and year[a].

Treatment	Species Group	Mean Height (Inches) 1968	1969	1970	1974	1986
coppicing	oak[b]	4.9	no data		9.9	36.4
	hickory[c]	4.2	"	"	9.0	e
	miscellaneous[d]	5.3	"	"	10.1	37.8
liberation	oak	3.7	4.2	4.4	6.6	41.2
	hickory	3.7	4.8	3.6	6.3	39.5
	miscellaneous	5.0	5.7	6.2	7.1	42.2
liberation-with-cleaning	oak	6.8	5.7	5.6	6.4	47.9
	hickory	6.4	5.8	5.1	6.4	36.8
	miscellaneous	6.5	2.8	5.5	5.6	14.0

[a]Figures for 1968 through 1974 are for stems with d.b.h. less than 1.0 inches. Figures for 1986 are for stems with d.b.h. greater than or equal to 2.0 inches. All figures are means over three .01-acre plots.

[b]Principally Q. alba and Q. falcata.

[c]Principally C. tomentosa.

[d]All other tree species.

[e]No stems in category.

miscellaneous stems was less than the mean height of oaks in the liberation-with-cleaning plots in all measurement years.

In 1986 the mean height of oaks with d.b.h. greater than 2.0 inches was greatest in the liberation-with-cleaning plots, intermediate in the liberation plots, and least in the coppicing plots.

Duncan's Multiple Range Test was applied to the oak group height data for 1968, 1974, and 1986 (Tables 10, 11, and 12). Differences between the treatment means in 1986 were not significant at alpha = .05.

The mean height of the oaks in one coppicing plot (52 feet) is much greater than the mean heights of oaks in the other coppicing plots (Table 13). The odd coppicing plot contains three southern red oaks and no white oaks. The southern red oaks in this plot were 54, 53, and 49 feet tall in 1986.

Duncan's Multiple Range Test was applied to the white oak group (principally Q. alba) height data for 1986 (Table 14). In 1986 the mean height of liberation-with-cleaning treatment white oaks with d.b.h. greater than or equal to 2.0 inches was significantly greater than the mean height of coppicing treatment white oaks in that diameter class.

Duncan's Multiple Range Test was also applied to the red oak group (principally Q. falcata) height data for 1986 (Table 15). These by-treatment mean heights did not

Table 10. 1968 oak group height separations.[a] Duncan's Multiple Range Test at alpha = .05.

Treatment	Mean Height (Feet)[b]	Duncan Grouping[c]	N
liberation-with-cleaning	6.828	A	69
coppicing	4.859	A	54
liberation	3.695	A	92

[a]Oak group consists of Q. alba and Q. falcata (principally). Data were total heights in feet of oak group stems with d.b.h. less than 1.0 inches.

[b]Figures are averages over three .01-acre plots.

[c]Means with the same grouping letter are not significantly different at alpha = .05.

Table 11. 1974 oak group height separations.[a] Duncan's Multiple Range Test at alpha = .05.

Treatment	Mean Height (Feet)[b]	Duncan Grouping[c]	N
coppicing	9.903	A	72
liberation	6.551	B	77
liberation-with-cleaning	6.434	B	61

[a]Oak group consists of *Q. alba* and *Q. falcata* (principally). Data were total heights in feet of oak group stems with d.b.h. less than 1.0 inches.

[b]Figures are averages over three .01-acre plots.

[c]Means with the same grouping letter are not significantly different at alpha = .05.

Table 12. 1986 oak group height separations.[a] Duncan's Multiple Range Test at alpha = .05.

Treatment	Mean Height (Feet)[b]	Duncan Grouping[c]	N
liberation-with-cleaning	47.857	A	21
liberation	41.167	A	18
coppicing	36.400	A	10

[a]Oak group consists of Q. alba and Q. falcata (principally). Data were total heights in feet of oak group stems with d.b.h. less than 1.0 inches.

[b]Figures are averages over three .01-acre plots.

[c]Means with the same grouping letter are not significantly different at alpha = .05.

Table 13. Plot mean heights in feet: 1986 oak group data.[a]

Treatment	Plot	N	Mean Height (feet)	Standard Deviation
liberation-with-cleaning	1	10	48.600	17.655
	2	5	48.600	12.720
	3	6	51.000	8.899
coppicing	4	4	30.250	6.397
	5	3	52.000	2.646
	6	3	29.000	3.606
liberation	7	4	40.750	5.909
	8	8	40.750	13.530
	9	6	42.000	14.519

[a]Oak group consists of *Q. alba* and *Q. falcata* (principally). Data are total heights in feet of oak group stems with d.b.h. greater than or equal to 2.0 inches.

Table 14. 1986 white oak group height separations.[a] Duncan's Multiple Range Test at alpha = .05.

Treatment	Mean Height (Feet)[b]	Duncan Grouping[c]	N
liberation-with-cleaning	44.077	A	13
liberation	39.308	AB	13
coppicing	30.500	B	6

[a]White oak group consists of Q. alba (principally). Data were total heights in feet of white oak group stems with d.b.h. greater than or equal to 2.0 inches.

[b]Figures are averages over three .01-acre plots.

[c]Means with the same grouping letter are not significantly different at alpha = .05.

Table 15. 1986 red oak group height separations.[a] Duncan's Multiple Range Test at alpha = .05.

Treatment	Mean Height (Feet)[b]	Duncan Grouping[c]	N
liberation-with-cleaning	54.000	A	8
liberation	46.000	A	5
coppicing	45.250	A	4

[a]Red oak group consists of Q. falcata (principally). Data were total heights in feet of red oak group stems with d.b.h. greater than or equal to 2.0 inches.

[b]Figures are averages over three .01-acre plots.

[c]Means with the same grouping letter are not significantly different at alpha = .05.

differ significantly at alpha = .05. Heights of red oaks with d.b.h. greater than or equal to 2.0 inches varied substantially within and among plots that received the same treatment (Table 16).

Supplementary statistical analysis of height data is shown in Appendix C.

Tree Grades by Treatment and Species

In 1986 the liberation-with-cleaning plots contained 1.5 times as many grade 1 oaks as the coppicing plots contained, and the liberation plots contained 1.2 times as many grade 1 oaks as the coppicing plots (Table 17).

The coppicing plots contained equal numbers of grade 1 white oaks and grade 1 red oaks. The liberation plots contained 1.5 times as many grade 1 white oaks as grade 1 red oaks. The liberation-with-cleaning plots contained twice as many grade 1 white oaks as grade 1 red oaks.

The coppicing plots contained six grade 1 miscellaneous trees (200 trees per acre). The liberation plots contained only one grade 1 miscellaneous tree (33 trees per acre), and the liberation-with-cleaning plots contained none.

Ages of Dominant and Codominant Oaks

Ages of two dominant and or codominant oaks in each liberation and liberation-with-cleaning plot were determined by counting annual growth rings in cores that were extracted from standing trees at a height of 18 inches above stem

Table 16. Plot mean heights in feet: 1986 red oak group data.[a]

Treatment	Plot	N	Mean Height (Feet)	Standard Deviation
liberation-with-cleaning	1	4	55.500	16.842
	2	2	49.500	20.506
	3	2	55.500	6.364
coppicing	4	1	25.000	---
	5	3	52.000	2.646
	6	0	---	---
liberation	7	4	40.750	5.909
	8	1	67.000	---
	9	0	---	---

[a]Red oak group consists of *Q. falcata* (principally). Data are total heights in feet of red oak group stems with d.b.h. greater than or equal to 2.0 inches.

Table 17. Numbers of stems by tree grade, species group, and treatment in 1986.[a]

Treatment	Species Group	Tree Grade 1[b]	2	3	4	5	6[c]
coppicing	white oak[d]	4	1	0	0	1	0
	red oak[e]	4	0	0	0	0	0
	hickory[f]	0	0	0	0	0	0
	miscellaneous[g]	6	0	0	0	0	6
liberation	white oak	6	3	1	0	1	2
	red oak	4	0	0	0	0	1
	hickory	1	1	0	0	0	0
	miscellaneous	1	2	2	0	0	1
liberation-with-cleaning	white oak	8	1	3	0	0	1
	red oak	4	1	1	0	0	2
	hickory	3	0	0	0	1	0
	miscellaneous	0	0	0	0	0	1

[a]Grades of trees that had d.b.h. greater than or equal to 2.0 inches in 1986. Figures are summed over three .01-acre plots.

[b]Highest quality.

[c]Lowest quality.

[d]Principally Q. alba.

[e]Principally Q. falcata.

[f]Principally C. tomentosa.

[g]All other tree species.

groundline (Table 18). These data indicate that oaks that were codominant or dominant in 1986 passed 18 inches in height between 1941 and 1957. This is consistent with records that show that fuelwood was removed from the stand prior to 1945 and that selective sawtimber harvests were conducted in 1945-1946 and 1955-1956.

Table 18. Ages of dominant or codominant oaks in 1986.[a]

Treatment	Plot	Age (Years) Tree 1	Tree 2
liberation	A	32	40
	B	35	35
	C	36	37
liberation-with-cleaning	A	41	35
	B	38	29
	C	38	45

[a]Q. alba and Q. falcata. Ages determined by counting annual growth rings in cores that were extracted at a height of 18 inches above stem groundline.

V. DISCUSSION

Principal Findings

Each of the release methods tested--coppicing, liberation, and liberation-with-cleaning--yielded large numbers of oaks after 19 years. In 1986 the liberation-with-cleaning plots contained 700 oaks with d.b.h. greater than or equal to 2.0 inches per acre, the liberation plots contained 600 such oaks per acre, and the coppicing plots contained 333 such oaks per acre. It is hardly surprising that the liberation and liberation-with-cleaning plots contained more oaks than the coppicing plots contained at that time, as advanced oak reproduction was more abundant in the liberation and liberation-with-cleaning plots than in the coppicing plots when the study was initiated.

What is more interesting is that large advanced oak reproduction in the liberation and liberation-with-cleaning plots grew satisfactorily after it was released. Some of this reproduction had d.b.h. greater than 2.0 inches when the treatments were applied, and it is commonly held that oak reproduction with d.b.h. greater than about two inches is unlikely to respond satisfactorily to release. Why, then, did larger oak reproduction in the liberation and liberation-with-cleaning plots grow well in this case?

The reproduction in question was growing in a stand that had been disturbed by partial cutting at least three

times since 1945 and that was understocked when release treatments were applied in 1968. The stand's reduced stocking and this history of repeated cuttings suggest that the large stems that were released had never undergone long periods of suppression and were not badly suppressed when they were released.

Also, it has been found that response of advance oak reproduction to release decreases as tree age increases in relation to stem diameter (Gingrich, 1970; McGee, 1981). None of the codominant or dominant oaks bored in 1986 was much more than 27 years old when the treatments were applied. It is possible that ratios of stem diameter to tree age were relatively high in the case of large advanced reproduction in the liberation and liberation-with-cleaning plots.

Finally, virtually all miscellaneous group trees were eliminated from the liberation-with-cleaning plots by injection in 1968. This wholesale elimination of miscellaneous group stems would have made increased quantities of water and nutrients available to the existing oak reproduction. It is possible that access to increased quantities of water and nutrients enabled large oak reproduction to respond with unusual vigor to release from overhead shade in this instance.

Measurement data collected after the seventh growing season did not indicate that the liberation-with-cleaning

treatment would contain the largest oaks and the greatest numbers of oaks after 19 growing seasons. The liberation-with-cleaning treatment immediately eliminated almost all of the miscellaneous group stems that were present in 1968. At the end of three growing seasons, however, numbers of miscellaneous group stems with d.b.h. less than 1.0 inches had begun to recover, and this trend continued through the 1974 growing season. Mean diameter of liberation-with-cleaning oaks with d.b.h. greater than or equal to 1.0 inches increased only rather slowly from 1968 through 1974, and mean height of liberation-with-cleaning oaks with d.b.h. less than 1.0 inches actually declined from 1968 through 1970.

All larger hickories disappeared from the coppicing plots over the course of 19 years, and numbers of hickories in the liberation and liberation-with-cleaning plots declined substantially during the same period. Shorter-term diameter and height data gave little or no indication that this would be the case; stocking of hickories apparently declined sharply only after 1974.

Suggestions for Further Research

It has been shown that it can be very difficult to evaluate the effectiveness of treatments that release oak and hickory reproduction on the basis of three-year or seven-year data. Future work aimed at evaluating the

effectiveness of these hardwood release treatments should be regarded as long-term research. Facilities for long-term data storage and record storage will be required. Where research projects runs for many years, there will be occasional or periodic changes in personnel. If the details of procedures for data collection and interpretation are established and carefully documented before fieldwork begins, then changes in personnel will not result in unnecessary confusion with respect to experimental methods.

Efficiency will be increased if greater care is taken to ensure that comparable measurements are obtained each time data are collected. In the case of the present study, heights only of trees with d.b.h. less than 1.0 inches were measured in 1968, 1969, 1970, and 1974, while heights only of trees with d.b.h. greater than or equal to 2.0 inches were measured in 1986. Because the 1986 height data were not directly comparable with data collected in any other year, opportunities for analysis and interpretation were reduced.

Experimental design should be improved before further research is undertaken. Release treatments should be randomized with respect to initial stand composition, stocking, and structure. Additional treatments should be tested. A commercial clearcutting treatment (a treatment in which only merchantable sawtimber would be removed) could be regarded as a control. A coppicing-with-cleaning treatment

has potential to yield oak-dominated stands and should be tested for that reason.

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APPENDICES

APPENDIX A

Table A-1. Trees per acre in coppicing plots: individual species.[a]

Group or Species	Trees per Acre 1968	1974	1986
white oak group[b]	400	833	200
red oak group[c]	400	1600	133
hickory group[d]	667	767	0
common persimmon	100	333	33
black cherry	133	567	233
blackgum	100	200	33
American elm	67	33	0
sassafras	0	33	0
flowering dogwood	367	1122	100
eastern redcedar	0	0	0
red mulberry[e]	33	0	0
redbud	100	333	0
red maple	0	0	0

[a]Figures for 1968 and 1974 are for stems with d.b.h. greater than or equal to 1.0 inches. Figures for 1986 are for stems with d.b.h. greater than or equal to 2.0 inches. All figures are summed over three .01-acre plots and expanded to per-acre basis.

[b]Principally *Q. alba*.

[c]Principally *Q. falcata*.

[d]Principally *C. tomentosa*.

[e]*Morus rubra* L.

Table A-2. Trees per acre in liberation plots: individual species.[a]

Group or Species	Trees per acre				
	1968	1969	1970	1974	1986
white oak group[b]	3000	2867	2600	2367	433
red oak group[c]	600	567	567	400	167
hickory group[d]	667	600	633	533	67
common persimmon	67	67	33	33	0
black cherry	267	167	233	267	100
blackgum	133	167	100	100	33
American elm	100	33	33	33	0
sassafras	0	0	0	0	0
flowering dogwood	833	733	633	433	33
eastern redcedar	33	33	67	33	0
red mulberry[e]	100	100	100	0	0
redbud	33	0	0	0	0
red maple	67	33	67	33	0

[a]Figures for 1968 and 1974 are for stems with d.b.h. greater than or equal to 1.0 inches. Figures for 1986 are for stems with d.b.h. greater than or equal to 2.0 inches. All figures are summed over three .01-acre plots and expanded to per-acre basis.

[b]Principally *Q. alba*.

[c]Principally *Q. falcata*.

[d]Principally *C. tomentosa*.

[e]*Morus rubra* L.

Table A-3. Trees per acre in liberation-with-cleaning plots: individual species.[a]

Group or Species	Trees per acre				
	1968	1969	1970	1974	1986
white oak group[b]	2033	2133	2333	2233	433
red oak group[c]	1800	1867	1933	1533	267
hickory group[d]	1133	1200	1200	1000	133
common persimmon	0	0	0	0	0
black cherry	33	0	0	0	0
blackgum	67	0	100	33	0
American elm	0	0	0	0	0
sassafras	67	0	33	0	0
flowering dogwood	867	0	33	0	33
eastern redcedar	0	0	0	0	0
red mulberry[e]	0	0	0	0	0
redbud	0	0	0	0	0
red maple	0	0	0	0	0

[a]Figures for 1968 and 1974 are for stems with d.b.h. greater than or equal to 1.0 inches. Figures for 1986 are for stems with d.b.h. greater than or equal to 2.0 inches. All figures are summed over three .01-acre plots and expanded to per-acre basis.

[b]Principally *Q. alba*.

[c]Principally *Q. falcata*.

[d]Principally *C. tomentosa*.

[e]*Morus rubra* L.

APPENDIX B

ANOVA: 1968 d.b.h. data for species group white oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	26.000	3.250	2.40	0.018
error	154	208.430	1.353		
total	162	234.430			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	12.713	6.357	4.70	0.010
plot(trt)	6	18.252	3.042	2.25	0.042

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	12.713	6.357	2.09	0.205

Mean separations: 1968 d.b.h. data for species group white oak

Alpha: 0.05 DF: 6 MSE: 3.042

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
coppicing	2.800	A	12
liberation + cleaning	2.216	A	61
liberation	1.984	A	90

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. by plot within treatment; 1968 data for species group white oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	19	2.116	0.670
	2	28	2.018	0.810
	3	14	2.750	1.361
coppicing	4	7	2.000	0.963
	5	1	3.600	---
	6	4	4.000	3.702
liberation	7	5	1.360	0.270
	8	39	2.002	0.892
	9	46	2.037	1.345

ANOVA: 1968 d.b.h. data for species group red oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	7	36.318	5.188	6.99	Pr<0.001
error	76	56.394	0.742		
total	83	92.712			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	4.445	2.223	3.00	0.056
plot(trt)	5	17.916	3.582	4.83	0.001

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	4.445	2.223	0.62	0.574

Mean separations: 1968 d.b.h. data for species group red oak

Alpha: 0.05 DF: 5 MSE: 3.582

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
coppicing	3.442	A	12
liberation	2.522	A	18
liberation + cleaning	2.091	A	54

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1968 data for species group red oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	25	2.096	0.799
	2	19	2.016	0.486
	3	10	2.220	0.410
coppicing	4	0	---	---
	5	9	4.022	1.626
	6	3	1.700	0.794
liberation	7	9	3.011	0.764
	8	8	2.162	1.084
	9	1	1.000	---

ANOVA: 1968 d.b.h. data for species group white oak and red oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	44.786	5.598	4.66	Pr<0.001
error	238	285.681	1.200		
total	246	330.468			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	13.676	6.838	5.70	0.004
plot(trt)	6	22.567	3.761	3.13	0.006

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	13.676	6.838	1.82	0.241

Mean separations: 1968 d.b.h. data for species group white oak and red oak

Alpha: 0.05 DF: 6 MSE: 3.761

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
coppicing	3.121	A	24
liberation + cleaning	2.157	B	115
liberation	2.074	B	108

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1968 data for species group white oak and red oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	44	2.105	0.738
	2	47	2.017	0.691
	3	24	2.529	1.088
coppicing	4	7	2.000	0.963
	5	10	3.980	1.539
	6	7	3.014	2.928
liberation	7	14	2.421	1.027
	8	47	2.030	0.916
	9	47	2.015	1.338

ANOVA: 1968 d.b.h. data for species group hickory

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	5.241	0.655	0.75	0.648
error	65	56.792	0.874		
total	73	62.034			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	0.101	0.050	0.06	0.944
plot(trt)	6	4.584	0.764	0.87	0.519

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	0.101	0.050	0.07	0.937

Mean separations: 1968 d.b.h. data for species group hickory

Alpha: 0.05 DF: 6 MSE: 0.764

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	2.200	A	20
liberation + cleaning	2.091	A	34
coppicing	1.945	A	20

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1968 data for species group hickory

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	1	2.000	---
	2	11	1.945	0.705
	3	22	2.168	0.785
coppicing	4	10	1.760	0.875
	5	5	2.380	0.858
	6	5	1.880	0.602
liberation	7	12	2.475	1.306
	8	2	1.300	0.141
	9	6	1.950	1.328

ANOVA: 1968 d.b.h. data for species group miscellaneous

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	11.714	1.464	0.98	0.454
error	98	146.013	1.490		
total	106	157.727			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	3.730	1.865	1.25	0.291
plot(trt)	6	3.334	0.556	0.37	0.895

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	3.730	1.865	3.36	0.105

Mean separations: 1968 d.b.h. data for species group miscellaneous

Alpha: 0.05 DF: 6 MSE: 0.556

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
coppicing	2.541	A	27
liberation	1.980	B	49
liberation + cleaning	1.816	B	31

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1968 data for species group miscellaneous

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	17	1.941	0.658
	2	5	1.640	0.541
	3	9	1.678	0.628
coppicing	4	10	2.600	1.869
	5	3	1.767	0.473
	6	14	2.664	1.712
liberation	7	28	2.079	1.414
	8	12	1.892	0.708
	9	9	1.789	0.810

ANOVA: 1969 d.b.h. data for species group white oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	9.992	1.998	1.40	0.229
error	144	205.981	1.430		
total	149	215.974			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	6.414	6.414	4.48	0.036
plot(trt)	4	7.767	1.942	1.36	0.252

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	6.414	6.414	3.30	0.1433

Mean separations: 1969 d.b.h. data for species group white oak

Alpha: 0.05 DF: 4 MSE: 1.942

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation + cleaning	2.417	A	64
liberation	2.171	A	86

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1969 data for species group white oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	18	2.272	0.707
	2	32	2.297	1.119
	3	14	2.879	1.550
liberation	7	5	1.380	0.303
	8	43	2.137	1.003
	9	38	2.313	1.514

ANOVA: 1969 d.b.h. data for species group red oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	4	5.468	1.367	2.01	0.103
error	68	46.213	0.680		
total	72	51.681			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	2.451	2.451	3.61	0.062
plot(trt)	3	2.286	0.762	1.12	0.347

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	2.451	2.451	3.22	0.171

Mean separations: 1969 d.b.h. data for species group red oak

Alpha: 0.05 DF: 3 MSE: 0.762

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	2.712	A	17
liberation + cleaning	2.218	A	56

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1969 data for species group red oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	26	2.204	0.835
	2	20	2.145	0.620
	3	10	2.400	0.585
liberation	7	9	3.022	0.879
	8	8	2.362	1.320
	9	0	---	---

ANOVA: 1969 d.b.h. data for species group white oak and red oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	4.938	0.988	0.82	0.540
error	217	262.875	1.211		
total	222	267.814			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	0.259	0.259	0.21	0.644
plot(trt)	4	4.711	1.178	0.97	0.424

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	0.259	0.259	0.22	0.664

Mean separations: 1969 d.b.h. data for species group white oak and red oak

Alpha: 0.05 DF: 4 MSE: 1.779

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation + cleaning	2.324	A	120
liberation	2.260	A	103

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1969 data for species group white oak and red oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	44	2.232	0.778
	2	52	2.238	0.954
	3	24	2.679	1.245
liberation	7	14	2.436	1.082
	8	51	2.173	1.047
	9	38	2.313	1.514

ANOVA: 1969 d.b.h. data for species group hickory

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	5.038	1.008	1.00	0.426
error	48	48.202	1.004		
total	53	53.239			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	0.007	0.007	0.01	0.934
plot(trt)	4	3.813	0.953	0.95	0.444

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	0.007	0.007	0.01	0.936

Mean separations: 1969 d.b.h. data for species group hickory

Alpha: 0.05 DF: 4 MSE: 0.953

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	2.417	A	18
liberation +cleaning	2.097	A	36

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1969 data for species group hickory

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	1	2.100	--
	2	12	1.900	0.747
	3	23	2.200	0.837
liberation	7	12	2.592	1.330
	8	2	1.250	0.212
	9	4	2.475	1.541

ANOVA: 1969 d.b.h. data for species group miscellaneous

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	2	0.577	0.289	0.18	0.835
error	37	58.851	1.591		
total	39	59.428			

Source	DF	Type III SS	MS	F	Pr>F
trt	0	0.000	---	---	---
plot(trt)	2	0.577	0.289	0.18	0.835

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	0	0	---	---	---

Mean d.b.h. (in.) by plot within treatment; 1969 data for species group miscellaneous

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation	7	26	2.304	1.423
	8	9	2.189	0.686
	9	5	1.940	1.057

ANOVA: 1970 d.b.h. data for species group white oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	12.254	2.451	1.36	0.244
error	139	250.784	1.804		
total	144	263.038			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	5.637	5.637	3.12	0.079
plot(trt)	4	11.236	2.809	1.56	0.189

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	5.637	5.637	2.01	0.230

Mean separations: 1970 d.b.h. data for species group white oak

Alpha: 0.05 DF: 4 MSE: 2.809

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation + cleaning	2.519	A	67
liberation	2.351	A	78

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1970 data for species group white oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	20	2.400	0.909
	2	33	2.306	1.196
	3	14	3.193	1.588
liberation	7	4	1.500	0.392
	8	38	2.374	1.174
	9	36	2.422	1.733

ANOVA: 1970 d.b.h. data for species group red oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	8.445	1.689	2.07	0.080
error	69	56.274	0.816		
total	74	64.719			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	0.094	0.094	0.11	0.736
plot(trt)	4	5.748	1.437	1.76	0.146

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	0.094	0.094	0.07	0.811

Mean separations: 1970 d.b.h. data for species group red oak

Alpha: 0.05 DF: 4 MSE: 1.437

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	2.853	A	17
liberation + cleaning	2.400	A	58

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1970 data for species group red oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	27	2.426	0.976
	2	20	2.335	0.693
	3	11	2.455	0.693
liberation	7	9	3.278	0.973
	8	7	2.571	1.292
	9	1	1.000	---

ANOVA: 1970 d.b.h. data for species group white oak and red oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	6.641	1.328	0.88	0.492
error	214	321.386	1.502		
total	219	328.026			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	0.032	0.032	0.02	0.885
plot(trt)	4	6.612	1.653	1.10	0.357

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	0.032	0.032	0.02	0.897

Mean separations: 1970 d.b.h. data for species group white oak and red oak

Alpha: 0.05 DF: 4 MSE: 1.653

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation + cleaning	2.464	A	125
liberation	2.441	A	95

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1970 data for species group white oak and red oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	47	2.415	0.938
	2	53	2.317	1.028
	3	25	2.868	1.306
liberation	7	13	2.731	1.183
	8	45	2.404	1.179
	9	37	2.384	1.725

ANOVA: 1970 d.b.h. data for species group hickory

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	7.487	1.497	1.23	0.309
error	49	59.570	1.216		
total	54	67.057			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	0.013	0.013	0.01	0.918
plot(trt)	4	5.066	1.267	1.04	0.395

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	0.013	0.013	0.01	0.924

Mean separations: 1970 d.b.h. data for species group hickory

Alpha: 0.05 DF: 4 MSE: 1.267

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	2.558	A	19
liberation + cleaning	2.117	A	36

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1970 data for species group hickory

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	1	2.200	---
	2	13	2.008	0.925
	3	22	2.177	0.902
liberation	7	11	2.909	1.386
	8	2	1.300	0.283
	9	6	2.333	1.607

ANOVA: 1970 d.b.h. data for species group miscellaneous

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	6.106	1.221	0.63	0.679
error	37	71.840	1.942		
total	42	77.845			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	1.622	1.622	0.84	0.367
plot(trt)	4	2.288	0.572	0.29	0.880

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	1.622	1.622	2.84	0.167

Mean separations: 1970 d.b.h. data for species group miscellaneous

Alpha: 0.05 DF: 4 MSE: 0.572

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	2.289	A	38
liberation + cleaning	1.360	A	5

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1970 data for species group miscellaneous

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	1	2.600	---
	2	2	1.000	0.000
	3	2	1.100	0.141
liberation	7	26	2.354	1.514
	8	8	2.125	1.112
	9	4	2.200	1.395

ANOVA: 1974 d.b.h. data for species group white oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	30.884	3.861	1.43	0.188
error	154	415.626	2.699		
total	162	446.510			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	13.031	6.515	2.41	0.093
plot(trt)	6	8.799	1.463	0.54	0.776

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	13.031	6.515	4.45	0.065

Mean separations: 1974 d.b.h. data for species group white oak

Alpha: 0.05 DF: 6 MSE: 1.463

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	2.956	A	71
liberation + cleaning	2.770	A	67
coppicing	1.872	B	25

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1974 data for species group white oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	17	2.700	1.074
	2	33	2.630	1.463
	3	17	3.112	2.025
coppicing	4	12	1.825	0.533
	5	3	1.700	0.557
	6	10	1.980	0.851
liberation	7	3	1.600	0.000
	8	37	3.046	1.779
	9	31	2.981	2.151

ANOVA: 1974 d.b.h. data for species group red oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	7	53.447	7.635	7.56	Pr<0.001
error	98	98.941	1.010		
total	105	152.388			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	34.393	17.196	17.03	Pr<0.001
plot(trt)	5	3.264	0.653	0.65	0.665

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	34.393	17.196	26.34	0.002

Mean separations: 1974 d.b.h. data for species group red oak

Alpha: 0.05 DF: 5 MSE: 0.653

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	3.692	A	12
liberation + cleaning	2.796	B	46
coppicing	1.708	C	48

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1974 data for species group red oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	19	3.005	1.348
	2	19	2.532	1.195
	3	8	2.925	0.858
coppicing	4	3	1.333	0.252
	5	34	1.794	0.513
	6	11	1.545	0.457
liberation	7	9	3.678	1.291
	8	3	3.733	2.359
	9	0	---	---

ANOVA: 1974 d.b.h. data for species group white oak and red oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	76.694	9.587	4.72	Pr<0.001
error	260	528.328	2.032		
total	268	605.022			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	65.877	32.938	16.21	Pr<0.001
plot(trt)	6	4.290	0.715	0.35	0.908

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	65.877	32.938	46.04	Pr<0.001

Mean separations: 1974 d.b.h. data for species group white oak and red oak

Alpha: 0.05 DF: 6 MSE: 0.715

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	3.063	A	83
liberation + cleaning	2.781	A	113
coppicing	1.764	B	73

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1974 data for species group white oak and red oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	36	2.861	1.219
	2	52	2.594	1.360
	3	25	3.052	1.720
coppicing	4	15	1.726	0.523
	5	37	1.786	0.509
	6	21	1.752	0.693
liberation	7	12	3.158	1.448
	8	40	3.098	1.800
	9	31	2.981	2.151

ANOVA: 1974 d.b.h. data for species group hickory

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	40.383	5.048	5.02	Pr<0.001
error	60	60.310	1.005		
total	68	100.692			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	12.760	6.380	6.35	0.003
plot(trt)	6	3.442	0.574	0.57	0.752

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	12.760	6.380	11.12	0.010

Mean separations: 1974 d.b.h. data for species group hickory

Alpha: 0.05 DF: 6 MSE: 0.574

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	3.150	A	16
liberation + cleaning	2.327	B	30
coppicing	1.217	C	23

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1974 data for species group hickory

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	1	2.600	---
	2	11	2.009	0.696
	3	18	2.506	0.901
coppicing	4	17	1.229	0.285
	5	3	1.200	0.000
	6	3	1.167	0.115
liberation	7	12	3.242	1.715
	8	1	1.900	---
	9	3	3.200	1.997

ANOVA: 1974 d.b.h. data for species group miscellaneous

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	6	39.675	6.612	9.96	Pr<0.001
error	101	67.060	0.664		
total	107	106.734			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	25.409	12.704	19.13	Pr<0.001
plot(trt)	4	2.789	0.697	1.05	0.385

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	25.409	12.704	18.22	0.010

Mean separations: 1974 d.b.h. data for species group miscellaneous

Alpha: 0.05 DF: 4 MSE: 0.697

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	2.875	A	28
coppicing	1.546	A	79
liberation + cleaning	1.300	A	1

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1974 data for species group miscellaneous

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	0	---	---
	2	0	---	---
	3	1	1.300	---
coppicing	4	26	1.600	0.444
	5	26	1.554	0.476
	6	27	1.485	0.449
liberation	7	16	3.019	1.581
	8	7	3.014	0.999
	9	5	2.220	1.392

ANOVA: 1986 d.b.h. data for species group white oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	6	35.422	5.904	1.60	0.189
error	25	92.347	3.694		
total	31	127.769			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	25.476	12.738	3.45	0.048
plot(trt)	4	13.108	3.277	0.89	0.486

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	25.476	12.738	3.89	0.115

Mean separations: 1986 d.b.h. data for species group white oak

Alpha: 0.05 DF: 4 MSE: 3.277

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation + cleaning	4.954	A	13
liberation	4.677	A	13
coppicing	2.700	A	6

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1986 data for species group white oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	6	4.033	1.777
	2	3	5.733	2.654
	3	4	5.750	1.923
coppicing	4	3	2.733	1.185
	5	0	---	---
	6	3	2.667	0.493
liberation	7	0	---	---
	8	7	4.186	1.508
	9	6	5.250	2.624

ANOVA: 1986 d.b.h. data for species group red oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	6	32.981	5.497	1.17	0.392
error	10	46.862	4.686		
total	16	79.842			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	12.315	6.158	1.31	0.311
plot(trt)	4	26.409	6.602	1.41	0.300

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	12.315	6.158	0.93	0.465

Mean separations: 1986 d.b.h. data for species group red oak

Alpha: 0.05 DF: 4 MSE: 6.602

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation + cleaning	6.088	A	8
liberation	5.060	A	5
coppicing	4.650	A	4

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1986 data for species group red oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	4	6.350	3.074
	2	2	6.700	3.677
	3	2	4.950	0.636
coppicing	4	1	2.200	---
	5	3	5.467	1.320
	6	0	---	---
liberation	7	4	4.200	0.600
	8	1	8.500	---
	9	0	---	---

ANOVA: 1986 d.b.h. data for species group white oak and red oak

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	48.787	6.098	1.43	0.214
error	40	170.564	4.264		
total	48	219.351			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	24.779	12.390	2.91	0.066
plot(trt)	6	24.183	4.031	0.95	0.474

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	24.779	12.390	3.07	0.120

Mean separations: 1986 d.b.h. data for species group white oak and red oak

Alpha: 0.05 DF: 6 MSE: 4.031

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation + cleaning	5.386	A	21
liberation	4.783	AB	18
coppicing	3.480	B	10

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1986 data for species group white oak and red oak

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	10	4.960	2.517
	2	5	6.120	2.680
	3	6	5.483	1.572
coppicing	4	4	2.600	1.003
	5	3	5.467	1.320
	6	3	2.667	0.493
liberation	7	4	4.200	0.606
	8	8	4.725	2.068
	9	6	5.250	2.604

ANOVA: 1986 d.b.h. data for species group hickory

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	3	9.302	3.101	1.32	0.458
error	2	4.687	2.343		
total	5				

Source	DF	Type III SS	MS	F	Pr>F
trt	1	0.040	0.040	0.02	0.908
plot(trt)	2	9.248	4.624	1.97	0.336

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	0.040	0.040	0.01	0.934

Mean separations: 1986 d.b.h. data for species group hickory

Alpha: 0.05 DF: 2 MSE: 4.624

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	4.150	A	2
liberation + cleaning	3.950	A	4

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1986 data for species group hickory

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	0	---	---
	2	3	3.933	1.531
	3	1	4.000	---
liberation	7	1	6.300	---
	8	1	2.000	---
	9	0	---	---

ANOVA: 1986 d.b.h. data for species group miscellaneous

Model: d.b.h. = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	6	16.804	2.801	0.94	0.504
error	11	32.727	2.975		
total	17	49.531			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	5.837	2.919	0.98	0.406
plot(trt)	4	10.862	2.716	0.91	0.490

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	5.837	2.919	1.07	0.423

Mean separations: 1986 d.b.h. data for species group miscellaneous

Alpha: 0.05 DF: 4 MSE: 2.716

Treatment	Mean d.b.h. (in.)	Duncan grouping*	N
liberation	4.640	A	5
coppicing	4.017	A	12
liberation + cleaning	2.000	A	1

*Means with the same letter are not significantly different at this alpha.

Mean d.b.h. (in.) by plot within treatment; 1986 data for species group miscellaneous

Treatment	Plot	N	Mean d.b.h. (in.)	SD
liberation + cleaning	1	0	---	---
	2	1	2.000	---
	3	0	---	---
coppicing	4	4	4.900	2.273
	5	7	3.500	1.457
	6	1	4.100	---
liberation	7	3	4.533	1.498
	8	1	6.500	---
	9	1	3.100	---

APPENDIX C

ANOVA: 1968 height data for species group white oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	589.840	73.730	7.57	Pr<0.001
error	159	1548.857	9.741		
total	167	2138.697			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	283.851	141.926	14.57	Pr<0.001
plot(trt)	6	316.072	52.679	5.41	Pr<0.001

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	283.851	141.926	2.69	0.146

Mean separations: 1968 height data for species group white oak

Alpha: 0.05 DF: 6 MSE: 52.679

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	6.592	A	62
coppicing	4.666	A	32
liberation	3.764	A	74

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1968 data for species group white oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	13	7.323	3.638
	2	24	8.112	3.713
	3	25	4.752	2.474
coppicing	4	10	3.230	3.087
	5	7	2.971	2.223
	6	15	6.413	4.573
liberation	7	7	1.643	0.941
	8	48	3.454	1.531
	9	19	5.326	3.427

ANOVA: 1968 height data for species group red oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	7	256.994	36.713	3.48	0.005
error	39	411.020	10.539		
total	46	668.013			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	183.931	91.966	8.73	0.001
plot(trt)	5	103.940	20.788	1.97	0.104

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	183.931	91.966	4.42	0.078

Mean separations: 1968 height data for species group red oak

Alpha: 0.05 DF: 5 MSE: 20.788

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	8.914	A	7
coppicing	5.141	AB	22
liberation	3.411	B	18

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1968 data for species group red oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	1	15.000	---
	2	1	13.000	---
	3	5	6.820	5.209
coppicing	4	0	---	---
	5	19	4.947	2.565
	6	3	6.367	4.384
liberation	7	9	2.389	1.774
	8	8	4.588	4.184
	9	1	3.200	---

ANOVA: 1968 height data for species group white oak and red oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	713.321	89.165	8.77	Pr<0.001
error	206	2093.528	10.163		
total	214	2806.848			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	404.283	202.141	19.89	Pr<0.001
plot(trt)	6	325.028	54.171	5.33	Pr<0.001

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	404.283	202.141	3.73	0.088

Mean separations: 1968 height data for species group white oak and red oak

Alpha: 0.05 DF: 6 MSE: 54.171

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	6.828	A	69
coppicing	4.859	A	54
liberation	3.695	A	92

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1968 data for species group white oak and red oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	14	7.871	4.053
	2	25	8.320	3.780
	3	30	5.097	3.070
coppicing	4	10	3.230	3.087
	5	26	4.415	2.593
	6	18	6.406	4.414
liberation	7	16	2.062	1.476
	8	56	3.616	2.797
	9	20	5.220	3.369

ANOVA: 1968 height data for species group hickory

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	199.249	24.906	2.68	0.010
error	117	1086.143	9.283		
total	125	1285.393			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	175.603	87.801	9.46	Pr<0.001
plot(trt)	6	26.574	4.429	0.48	0.824

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	175.603	87.801	19.82	0.002

Mean separations: 1968 height data for species group hickory

Alpha: 0.05 DF: 6 MSE: 4.429

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	6.420	A	40
coppicing	4.152	B	48
liberation	3.674	B	38

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1968 data for species group hickory

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	7	7.829	2.480
	2	14	5.943	2.314
	3	19	6.253	3.826
coppicing	4	22	3.959	2.702
	5	15	3.907	2.207
	6	11	4.873	3.444
liberation	7	17	3.512	4.256
	8	10	3.610	1.842
	9	11	3.982	2.359

ANOVA: 1968 height data for species group miscellaneous

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	109.010	13.626	1.07	0.384
error	154	1952.377	12.678		
total	162	2061.387			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	49.455	24.727	1.95	0.146
plot(trt)	6	51.138	8.523	0.67	0.672

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	49.455	24.727	2.90	0.131

Mean separations: 1968 height data for species group miscellaneous

Alpha: 0.05 DF: 6 MSE: 8.523

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	6.489	A	53
coppicing	5.337	A	79
liberation	5.006	A	31

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1968 data for species group miscellaneous

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	10	6.930	5.055
	2	12	7.458	4.366
	3	31	5.971	3.271
coppicing	4	9	5.889	4.910
	5	36	4.806	2.681
	6	34	5.753	3.691
liberation	7	26	4.935	3.426
	8	2	3.650	0.071
	9	3	6.533	1.498

ANOVA: 1969 height data for species group white oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	235.448	47.090	5.63	Pr<0.001
error	99	827.585	8.359		
total	104	1063.033			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	73.285	73.285	8.77	0.004
plot(trt)	4	195.201	48.800	5.84	Pr<0.001

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	73.285	73.285	1.50	0.288

Mean separations: 1969 height data for species group white oak

Alpha: 0.05 DF: 4 MSE: 48.800

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	5.616	A	50
liberation	4.376	A	55

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1969 data for species group white oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	11	6.182	2.709
	2	16	7.425	3.898
	3	23	4.087	2.460
liberation	7	5	1.680	0.634
	8	34	3.991	2.457
	9	16	6.038	3.581

ANOVA: 1969 height data for species group red oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	3	60.493	20.164	2.34	0.115
error	15	129.232	8.616		
total	18	189.725			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	23.358	23.358	2.71	0.120
plot(trt)	2	21.031	10.516	1.22	0.323

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	23.358	23.358	2.22	0.275

Mean separations: 1969 height data for species group red oak

Alpha: 0.05 DF: 2 MSE: 10.516

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	6.875	A	4
liberation	3.340	A	15

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1969 data for species group red oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	0	---	---
	2	0	---	---
	3	4	6.875	3.731
liberation	7	8	2.800	2.223
	8	5	3.000	2.978
	9	2	6.350	4.172

ANOVA: 1969 height data for species group white oak and red oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	273.667	54.733	6.51	Pr<0.001
error	118	991.620	8.404		
total	123	1265.287			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	96.552	96.552	11.49	0.001
plot(trt)	4	199.959	49.990	5.95	Pr<0.001

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	96.552	96.552	1.93	0.237

Mean separations: 1969 height data for species group white oak and red oak

Alpha: 0.05 DF: 4 MSE: 49.990

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	5.709	A	54
liberation	4.154	A	70

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1969 data for species group white oak and red oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	11	6.182	2.709
	2	16	7.425	3.898
	3	27	4.500	2.783
liberation	7	13	2.369	1.827
	8	39	3.864	2.508
	9	18	6.072	3.514

ANOVA: 1969 height data for species group hickory

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	48.710	9.742	0.85	0.523
error	64	737.405	11.522		
total	69	786.114			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	13.587	13.587	1.18	0.282
plot(trt)	4	32.751	8.188	0.71	0.588

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	13.587	13.587	1.66	0.267

Mean separations: 1969 height data for species group hickory

Alpha: 0.05 DF: 4 MSE: 8.188

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	5.773	A	33
liberation	4.816	A	37

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1969 data for species group hickory

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	5	6.260	2.728
	2	12	6.008	1.734
	3	16	5.444	3.489
liberation	7	17	4.047	4.181
	8	9	4.667	2.455
	9	11	6.127	4.050

ANOVA: 1969 height data for species group miscellaneous

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	3	23.749	7.916	0.66	0.588
error	15	179.398	11.960		
total	18	203.146			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	10.133	10.133	0.85	0.372
plot(trt)	2	15.720	7.860	0.66	0.533

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	10.133	10.133	1.29	0.374

Mean separations: 1969 height data for species group miscellaneous

Alpha: 0.05 DF: 2 MSE: 7.860

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation	5.711	A	18
liberation + cleaning	2.800	A	1

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1969 data for species group miscellaneous

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	0	---	---
	2	1	2.800	---
	3	0	---	---
liberation	7	16	5.588	3.458
	8	1	4.100	---
	9	1	9.300	---

ANOVA: 1970 height data for species group white oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	118.264	23.653	2.99	0.014
error	106	837.576	7.901		
total	111	955.840			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	33.609	33.609	4.25	0.042
plot(trt)	4	84.655	21.164	2.68	0.036

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	71.879	71.879	3.40	0.139

Mean separations: 1970 height data for species group white oak

Alpha: 0.05 DF: 4 MSE: 21.164

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	5.710	A	50
liberation	4.608	A	62

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1970 data for species group white oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	11	6.345	3.492
	2	16	6.538	2.807
	3	23	4.830	2.638
liberation	7	6	2.083	1.357
	8	36	4.578	2.716
	9	20	5.420	3.051

ANOVA: 1970 height data for species group red oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	2	6.821	3.411	0.46	0.638
error	15	110.430	7.362		
total	17	117.251			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	2.455	2.455	0.33	0.572
plot(trt)	1	4.186	4.186	0.57	0.462

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	2.455	2.455	0.59	0.584

Mean separations: 1970 height data for species group red oak

Alpha: 0.05 DF: 1 MSE: 4.186

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	4.333	A	3
liberation	3.307	A	15

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1970 data for species group red oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	0	---	---
	2	0	---	---
	3	3	4.333	0.945
liberation	7	8	2.812	2.495
	8	7	3.871	3.293
	9	0	---	---

ANOVA: 1970 height data for species group white oak and red oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	160.493	32.099	4.17	0.002
error	124	953.408	7.689		
total	129	1113.901			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	82.623	82.623	10.75	0.001
plot(trt)	4	109.258	27.314	3.55	0.009

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	82.623	82.623	3.02	0.157

Mean separations: 1970 height data for species group white oak and red oak

Alpha: 0.05 DF: 4 MSE: 27.314

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	5.632	A	53
liberation	4.355	A	77

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1970 data for species group white oak and red oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	11	6.345	3.492
	2	16	6.538	2.807
	3	26	4.773	2.495
liberation	7	14	2.500	2.050
	8	43	4.463	2.787
	9	20	5.420	3.051

ANOVA: 1970 height data for species group hickory

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	60.596	12.119	1.44	0.225
error	57	480.861	8.436		
total	62	541.457			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	23.673	23.673	2.81	0.099
plot(trt)	4	27.794	6.948	0.82	0.516

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	23.673	23.673	3.41	0.139

Mean separations: 1970 height data for species group hickory

Alpha: 0.05 DF: 4 MSE: 6.948

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	5.075	A	28
liberation	3.623	A	35

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1970 data for species group hickory

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	4	5.225	2.442
	2	11	5.945	2.925
	3	13	4.292	2.906
liberation	7	17	3.165	3.555
	8	8	4.612	2.158
	9	10	3.610	2.142

ANOVA: 1970 height data for species group miscellaneous

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	5	22.386	4.477	0.43	0.825
error	25	261.885	10.475		
total	30	284.271			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	8.410	8.410	0.80	0.379
plot(trt)	4	19.324	4.831	0.46	0.764

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	8.410	8.410	1.74	0.258

Mean separations: 1970 height data for species group miscellaneous

Alpha: 0.05 DF: 4 MSE: 4.831

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation	6.152	A	21
liberation + cleaning	5.480	A	10

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1970 data for species group miscellaneous

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	2	3.500	1.273
	2	1	3.100	---
	3	7	6.386	2.739
liberation	7	18	6.172	3.498
	8	1	5.900	---
	9	2	6.100	2.687

ANOVA: 1974 height data for species group white oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	536.768	67.096	8.24	Pr<0.001
error	149	1212.758	8.139		
total	157	1749.526			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	426.044	213.022	26.17	Pr<0.001
plot(trt)	6	144.422	24.070	2.96	0.009

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	426.044	213.022	8.85	0.016

Mean separations: 1974 height data for species group white oak

Alpha: 0.05 DF: 6 MSE: 24.070

Treatment	Mean height (ft.)	Duncan grouping*	N
coppicing	10.158	A	38
liberation + cleaning	6.471	B	49
liberation	6.470	B	71

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1974 data for species group white oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	11	7.218	1.951
	2	24	6.654	3.418
	3	14	5.571	2.174
coppicing	4	21	8.857	3.198
	5	4	13.000	3.464
	6	13	11.385	2.181
liberation	7	2	3.000	1.414
	8	34	6.115	2.822
	9	35	7.014	2.881

ANOVA: 1974 height data for species group red oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	7	231.777	33.111	3.31	0.006
error	44	440.682	10.016		
total	51	672.459			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	115.743	57.871	5.78	0.006
plot(trt)	5	124.904	24.981	2.49	0.045

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	115.743	57.871	2.32	0.194

Mean separations: 1974 height data for species group red oak

Alpha: 0.05 DF: 5 MSE: 24.981

Treatment	Mean height (ft.)	Duncan grouping*	N
coppicing	9.618	A	34
liberation	7.500	A	6
liberation + cleaning	6.283	A	12

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1974 data for species group red oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	10	6.840	2.007
	2	0	---	---
	3	2	3.500	0.707
coppicing	4	2	10.000	7.071
	5	29	9.345	3.298
	6	3	12.000	3.464
liberation	7	1	16.000	---
	8	2	6.000	3.536
	9	3	5.667	2.538

ANOVA: 1974 height data for species group white oak and red oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	653.070	81.634	8.97	Pr<0.001
error	201	1829.680	9.103		
total	209	2482.750			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	484.169	242.084	26.59	Pr<0.001
plot(trt)	6	104.530	17.422	1.91	0.080

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	484.169	242.084	13.90	0.006

Mean separations: 1974 height data for species group white oak and red oak

Alpha: 0.05 DF: 6 MSE: 17.422

Treatment	Mean height (ft.)	Duncan grouping*	N
coppicing	9.903	A	72
liberation	6.551	B	77
liberation + cleaning	6.434	B	61

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1974 data for species group white oak and red oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	21	7.038	1.937
	2	24	6.654	3.418
	3	16	5.312	2.152
coppicing	4	23	8.957	3.418
	5	33	9.788	3.480
	6	16	11.500	2.338
liberation	7	3	7.333	7.572
	8	36	6.108	2.805
	9	38	6.908	2.848

ANOVA: 1974 height data for species group hickory

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	218.435	27.304	3.27	0.002
error	102	851.874	8.352		
total	110	1070.309			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	199.243	99.621	11.93	Pr<0.001
plot(trt)	6	22.874	3.812	0.46	0.839

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	199.243	99.621	26.13	0.001

Mean separations: 1974 height data for species group hickory

Alpha: 0.05 DF: 6 MSE: 3.812

Treatment	Mean height (ft.)	Duncan grouping*	N
coppicing	9.018	A	56
liberation + cleaning	6.400	B	29
liberation	6.323	B	26

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1974 data for species group hickory

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	6	5.667	3.095
	2	16	6.475	2.558
	3	7	6.857	4.488
coppicing	4	29	8.552	2.384
	5	13	9.077	3.451
	6	14	9.929	2.814
liberation	7	6	6.333	3.386
	8	11	6.245	1.978
	9	6	6.411	3.230

ANOVA: 1974 height data for species group miscellaneous

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	7	596.087	85.155	7.24	Pr<0.001
error	203	2386.704	11.757		
total	210	2982.791			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	262.897	131.448	11.18	Pr<0.001
plot(trt)	5	17.166	3.433	0.29	0.917

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	262.897	131.448	38.29	Pr<0.001

Mean separations: 1974 height data for species group miscellaneous

Alpha: 0.05 DF: 5 MSE: 3.433

Treatment	Mean height (ft.)	Duncan grouping*	N
coppicing	10.116	A	146
liberation	7.087	B	45
liberation + cleaning	5.590	C	20

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1974 data for species group miscellaneous

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	0	---	---
	2	2	7.900	0.283
	3	18	5.333	2.722
coppicing	4	28	10.107	3.510
	5	34	9.853	4.587
	6	84	10.226	3.381
liberation	7	26	6.962	2.905
	8	5	6.880	3.287
	9	14	7.393	1.539

ANOVA: 1986 height data for species group white oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	6	1140.969	190.161	1.37	0.267
error	25	3482.750	139.310		
total	31	4623.719			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	875.474	437.737	3.14	0.061
plot(trt)	4	382.442	95.611	0.69	0.608

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	875.474	437.737	4.58	0.092

Mean separations: 1986 height data for species group white oak

Alpha: 0.05 DF: 4 MSE: 95.611

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	44.077	A	13
liberation	39.308	AB	13
coppicing	30.500	B	6

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1986 data for species group white oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	6	39.000	16.149
	2	3	48.000	10.583
	3	4	48.750	9.912
coppicing	4	3	32.000	6.557
	5	0	---	---
	6	3	29.000	3.606
liberation	7	0	---	---
	8	7	37.000	9.074
	9	6	42.000	14.519

ANOVA: 1986 height data for species group red oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	6	1447.368	241.228	1.69	0.222
error	10	1430.750	143.075		
total	16	2878.118			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	532.283	266.141	1.86	0.206
plot(trt)	4	1152.000	288.000	2.01	0.168

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	532.283	266.141	0.92	0.468

Mean separations: 1986 height data for species group red oak

Alpha: 0.05 DF: 4 MSE: 288.000

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	54.000	A	8
liberation	46.000	A	5
coppicing	45.250	A	4

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1986 data for species group red oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	4	55.500	16.842
	2	2	49.500	20.506
	3	2	55.500	6.364
coppicing	4	1	25.000	---
	5	3	52.000	2.646
	6	0	---	---
liberation	7	4	40.750	5.909
	8	1	67.000	---
	9	0	---	---

ANOVA: 1986 height data for species group white oak and red oak

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	8	2156.216	269.527	1.67	0.136
error	40	6454.600	161.365		
total	48	8610.816			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	956.606	478.303	2.96	0.063
plot(trt)	6	1164.871	194.145	1.20	0.325

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	956.606	478.303	2.46	0.166

Mean separations: 1986 height data for species group white oak and red oak

Alpha: 0.05 DF: 6 MSE: 194.145

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation + cleaning	47.857	A	21
liberation	41.167	A	18
coppicing	36.400	A	10

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1986 data for species group white oak and red oak

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	10	45.600	17.665
	2	5	48.600	12.720
	3	6	51.000	8.899
coppicing	4	4	30.250	6.397
	5	3	52.000	2.646
	6	3	29.000	3.606
liberation	7	4	40.750	5.909
	8	8	40.750	13.530
	9	6	42.000	14.519

ANOVA: 1986 height data for species group hickory

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	3	494.667	164.889	1.36	0.450
error	2	242.667	121.333		
total	5	737.333			

Source	DF	Type III SS	MS	F	Pr>F
trt	1	13.333	13.333	0.11	0.772
plot(trt)	2	484.583	242.292	2.00	0.334

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	1	13.333	13.333	0.06	0.836

Mean separations: 1986 height data for species group hickory

Alpha: 0.05 DF: 2 MSE: 242.292

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation	39.500	A	2
liberation + cleaning	36.750	A	4

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1986 data for species group hickory

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	0	---	---
	2	3	37.333	11.015
	3	1	35.000	---
coppicing	4	0	---	---
	5	0	---	---
	6	0	---	---
liberation	7	1	55.000	---
	8	1	24.000	---
	9	0	---	---

ANOVA: 1986 height data for species group miscellaneous

Model: height = treatment plot(treatment)

Source	DF	SS	MS	F	Pr>F
model	6	993.536	165.589	1.08	0.429
error	11	1682.464	152.951		
total	17	2676.000			

Source	DF	Type III SS	MS	F	Pr>F
trt	2	732.472	366.236	2.39	0.137
plot(trt)	4	330.586	82.646	0.54	0.710

Test of hypothesis using Type III MS for plot(trt) as the error term:

Source	DF	Type III SS	MS	F	Pr>F
trt	2	732.472	366.236	4.43	0.097

Mean separations: 1986 height data for species group miscellaneous

Alpha: 0.05 DF: 4 MSE: 82.646

Treatment	Mean height (ft.)	Duncan grouping*	N
liberation	42.200	A	5
coppicing	37.750	A	12
liberation + cleaning	14.000	B	1

*Means with the same letter are not significantly different at this alpha.

Mean height (ft.) by plot within treatment; 1986 data for species group miscellaneous

Treatment	Plot	N	Mean height (ft.)	SD
liberation + cleaning	1	0	---	---
	2	1	14.000	---
	3	0	---	---
coppicing	4	4	41.250	10.966
	5	7	35.429	12.647
	6	1	40.000	---
liberation	7	3	39.000	13.454
	8	1	56.000	---
	9	1	38.000	---

VITA

Alan Royes Salmon was born in California in 1950. He studied at the University of Western Ontario, London, and received that school's general Bachelor of Arts degree in 1973. Mr. Salmon enrolled at The University of Tennessee, Knoxville, in 1985 and will be awarded the degree of Master of Science, with a major in Forestry, in August 1989.