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# Growth of hardwood reproduction after mechanical and or chemical release : 19-year results from southwestern Tennessee

Alan Royes Salmon

To the Graduate Council:

I am submitting herewith a thesis written by Alan Royes Salmon entitled "Growth of hardwood reproduction after mechanical and or chemical release : 19-year results from southwestern Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Forestry.

G.R. Wells, Major Professor

We have read this thesis and recommend its acceptance:

Edward R. Buckner, Hal DeSelm, Charles E. McGee

Accepted for the Council:
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To the Graduate Council:

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Date July 27, 1989

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

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee Knoxville

Alan Royes Salmon

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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.