AN ECONOMIC ANALYSIS OF CHRISTMAS TREE FERTILIZATION

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ABSTRACT

AN ECONOMIC ANALYSIS OF

CHRISTMAS TREE FERTILIZATION

by David N. Larsen

This report was undertaken to determine the economic returns to fertilization of Christmas trees. The economic model used for the analysis is based on a survey of growers and secondary information sources.

The questionnaire, sent to growers who had used fertilizers, was used to gather information about species most commonly fertilized, situations where fertilization is needed, fertilizer application procedures, fertilizers used, and situations where fertilizing has been successful. On the basis of this background information, financial returns to fertilization of white spruce, balsam fir, Douglas fir and eastern white pine were determined.

The species most likely to benefit from fertilization are Douglas fir, the spruces, the true firs and eastern white pine. The most marked improvement in trees should result on coarse textured soils.

The successful use of fertilizers depends on a combination of factors: the species planted; soil fertility and the use of cultural practices, such as, weed control in conjunction with fertilizer applications. When the nutrients required are not known, a complete fertilizer (N-P-K) is recommended. Nitrogen is the next most impor-

tant fertilizer.

Christmas tree plantations which are intensively managed to produce quality trees will earn the best return on fertilizer inputs when nutrient deficiencies exist. Fertilizing may increase the quality of Christmas trees produced by improving color, increasing needle retention, helping to provide for stronger branches and stimulating growth. Fertilization may also allow growers to shorten rotations.

The analysis shows that an increase in tree quality brought about by fertilization that results in an increase in market price of 25 cents per tree will increase returns to investment by 2-4 percent. Returns may be increased 10 percent or more if the rotations are shortened one or more years as a result of fertilization.

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By

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CHAPTER I

INTRODUCTION

The trend in the Christmas tree business is toward the production of high quality trees. Production of quality trees often calls for intensive management. The use of fertilizers can often contribute to improved quality in Christmas trees, and in many instances, may also shorten the time required to produce quality trees. However, fertilizer use remains limited at present because many growers are uncertain about the effects and profitability. Growers are unsure about which species may need to be fertilized, which textured soils are most likely to be nutrient deficient, which fertilizers should be used, when the fertilizers should be applied and what quantity of fertilizer is needed.

This economic analysis of Christmas tree fertilization was undertaken to indicate the probable economic consequences of fertilization. The specific objectives of this study are twofold: (1) to determine the extent and nature of the use of fertilizers in Christmas tree production; and (2) to determine the economics of fertilizer use in the Christmas tree industry.

PROCEDURE

Data on the use of fertilizers for Christmas tree production was obtained from a questionnaire survey of progressive Christmas tree growers and from secondary sources of information. A prelim-

inary survey of 105 Christmas tree growers throughout the United States and Canada was made in July, 1966 (Appendix A). In August, a more extensive questionnaire (Appendix B) was submitted to growers who had used fertilizers. The data from this second questionnaire was used to identify the extent of usage of fertilizers, the types of fertilizers applied, the species fertilized, and the timing of fertilization.

Data obtained from the sample of growers was used in conjunction with secondary data sources to develop a theoretical model to analyze the economics of fertilization. This model assumes that growers are progressive, use intensive management and have sizeable plantation operations.

PRODUCTION AND CONSUMPTION OF CHRISTMAS TREES

All 50 states presently produce some Christmas trees, with the major production in the Lake States region and the Pacific Coast and Northwest region. In 1964 the Lake States of Michigan, Wisconsin and Minnesota had 32 percent of the production. The second most important region, the Pacific Coast and Northwest--which is comprised of Montana, Idaho, Washington, Oregon and California--had 26 percent of the production.

The ten most important species produced for the year 1964 were the following: Scotch pine (Pinus sylvestris), 27 percent; Douglas fir (Pseudotsuga menziesii), 22 percent; balsam fir (Abies balsamea), 12 percent; black spruce (Picea mariana), 7 percent; Eastern redcedar (Juniperus virginiana), 7 percent; red pine (Pinus resinosa), 6 percent; white spruce (Picea glauca), 3 percent; white fir (Abies

concolor), 2 percent; white pine (Pinus monticola and P. strobus), 2 percent; and Norway spruce (Picea abies), 2 percent (Sowder, 1966). The first five species accounted for 75 percent of the market in 1964; the top ten for 90 percent of the market. In all there were at least 32 different species included in the national figures for 1964.

Consumption of natural Christmas trees has shown some fluctuation due to natural and economic changes. Consumption rose from 38 million trees in 1955 to 44 million trees in 1962. There was a decline to 41 million trees in 1964 which reflected some inroads by artificial Christmas trees. However, domestic production for the years 1962-64 remained fairly stable at about 33 million trees, while the decline was mainly in trees imported from Canada.

THE ROLE OF PLANTATIONS

The earliest known Christmas tree plantation in the United States was begun in the year 1901. Since then, especially since the later years of the 1950's, the use of plantations for growing Christmas trees has expanded rapidly. As late as 1955, 87 percent of the nation's Christmas trees came from unmanaged natural stands (Sowder, 1957). In 1964, wild trees had 56 percent of the market (Sowder, 1966). By 1980 the number of plantation grown trees is expected to double and the demand for Christmas trees will be met primarily with cultured trees. These cultured trees will be grown in managed plantations or in managed natural stands.

Michigan provides an excellent example of the development of Christmas tree plantations. In 1952 production was about 1 million

trees, but only 120,000 were plantation grown. In 1962 production was 3.2 million trees with 3.1 million trees from plantations (James, 1966).

Suitable wild trees are becoming scarce and the management of Christmas tree lands is becoming increasingly important. In 1964, 6 percent of the natural stands received management, 70 percent of the farm plantations received management and 84 percent of the non-farm plantations were managed (Sowder, 1965). These figures indicate the increasing importance of managed plantations and managed natural stands where cultural practices are used to produce high quality trees.

The cultural practices which may be used in producing quality trees include weed control, insect and disease control, pruning and shearing, and fertilizing. Improvements in harvesting and marketing techniques can also contribute to the quality trend.

THE MARKETING TREND

Quality of trees is one of the key factors in successful competition by producers. Characteristics such as needle retention, color, fragrance, shape, appearance and the ability of the limbs to support decorations all contribute to the quality of the trees. It is also desirable for the trees to have springy branches which will allow placing them in small diameter packages for shipment. Yet, the trees should return to their natural shape when used by consumers.

The marketing phase of the Christmas tree industry reflects the importance of high quality trees. Federal grading was initiated in 1958 to help standardize grade specifications. As more nation-wide

marketing agreements are made, uniform quality standards should become more prevalent.

Marketing areas are undergoing changes as a result of recent innovations in the packaging and transportation of trees. It is now feasible to ship trees from the major production areas to any of the 48 contiguous states for a reasonable freight cost. Thus industrialized areas in such states as Texas and California can now attract high quality trees from distant production areas.

CHAPTER II

FACTORS CONSIDERED IN DETERMINING RETURNS TO FERTILIZER INPUTS

The harvest of any crop removes some of the available soil nutrients and may limit those available for following crops. For Christmas trees the nutrient drain can be substantial.

The purpose of this study is to analyze possible returns which a grower may receive if he uses fertilizers in growing Christmas trees. The procedure will be to develop a model and to analyze various fertilizer timings and variations to estimate the returns which may be received. In order to keep the alternatives on a comparable basis they are analyzed using a perpetual series of rotations to determine the rates of return earned on invested funds. By this method the alternatives which give growers the best long run return on their investment can be determined.

The information available on the use of fertilizers by Christmas tree growers is very limited. In a survey of Michigan Christmas tree growers (James, 1959), it was found that only 2-4 percent of the growers of spruce and 1-2 percent of the growers of all other species had used fertilizers in their plantations. Usually only a single application was made on a portion of the plantation.

Current information on the use of fertilizers was obtained from two questionnaires distributed during the summer of 1966. The preliminary questionnaire (Appendix A) was sent to 105 growers throughout the United States and Canada. These growers were selected be-

cause they were believed to have progressive Christmas tree operations. Over 75 percent of the questionnaires were returned and over 60 percent of the respondents indicated they had used fertilizers in their plantations. Eighty percent of those who used fertilizers reported they had harvested fertilized trees; nearly three-fourths who used fertilizers reported they had observed positive effects from fertilizing.

A second, more comprehensive questionnaire (Appendix B), was submitted to 56 growers who had used fertilizers. A total of 39 valid questionnaires were returned (Table 1). Eighty percent reported that the use of fertilizers was economic, but usually only under certain conditions. Additional data gathered from this questionnaire will be cited extensively in the discussion that follows.

Table 1. Origin of growers surveyed with the comprehensive questionnaire, the method used and the number of questionnaires used to compile the results

Origin of Growers Surveyed	Number of Growers Surveyed	Methods used to survey growers		Valid Questionnaires
		Personal Interviews	Questionnaires Mailed	
Preliminary Questionnaire	52 1/	12	40	35
Volunteered at the National Christmas Tree Growers' Convention	4	4	---	4
Total	56	16	40	39

1/ These growers reported using fertilizers in the preliminary questionnaire.

REASONS FOR USING FERTILIZERS

Objectives--Basically there are three reasons for using fertilizers: (1) getting the trees growing after they are planted (particularly for Douglas fir, the spruces and true firs); (2) keeping the trees growing at the optimum rate during the rotation (as a rule of thumb, 12 inches per year); and (3) improving the quality of the trees. The first two essentially shorten the rotation, i.e., get the trees to the merchantable size in the shortest time possible, consistent with quality objectives.

Growers are primarily concerned with the third objective--improved quality. Quality characteristics which may be improved by fertilization are included in Table 2.

The questionnaire indicated that a darker foliage (improved color) was the primary reason for fertilizing. Other important reasons were: to increase the rate of growth, improve needle retention, increase the number of buds and increase the size of the needles. Additional reasons included better survival, increased vigor, greater density, a better root system and stimulation of cone production. Most of these reasons reflect an improvement in quality.

Recognizing the need--Visual symptoms are normally used to determine fertilizer needs. Soil tests are not regarded as precise enough to determine tree nutrient needs, and foliar analysis is still regarded as a research tool. Fertilizer needs may be shown by the widespread presence of any of the following: poor foliage color during the growing season, needles shorter than are characteristic of the species, general chlorosis followed by browning and finally dying

Table 2. Desirable characteristics of Christmas trees and those characteristics which fertilization may improve

Characteristics which fertilizers may improve	Desirable characteristics for Christmas trees
X	Good needle retention indoors for several weeks
X	Dark green or blue-green color
X	Limbs flexible enough for packaging
X	Improved shipping quality
X	Whorls of limbs spaced 12-14 inches
X	Luxuriant foliage
X	Dense foliage
X	Profuse budding so there are many lateral branches
	Limbs strong enough to support ornaments
	Trees symmetrical in shape
	Pleasant fragrance
	Straight stem
	No evidence of insect attack
	Good branching angle
	Taper varying from 60 to 80 percent

of the needles, decrease in the number of years the needles persist, short terminal growth, sparse natural weed cover, presence of mosses and patches of bare soil.

Species which may benefit--The species most likely to benefit from fertilization are eastern white pine, Douglas fir, the spruces and the true firs. These are the species and species groups which research indicates will likely respond to fertilizer applications (Bell and White, 1966). Douglas fir, the spruces and true firs grow slowly during the 2 or 3 years following planting. White (1965) indicates that the three or four years of stagnation which the spruces may suffer is partially a combination of limited fertility and water availability, and weed competition.

Growers reported that the species most commonly fertilized were Douglas fir, white spruce, eastern white pine, Norway spruce, balsam fir and Scotch pine. Nearly all the growers of Douglas fir (94 percent) had used fertilizers. The percentages of growers who used fertilizers with the other major species were: white spruce, 79 percent; eastern white pine, 69 percent; Norway spruce, 68 percent; balsam fir, 61 percent; and Scotch pine, 53 percent.

The species which will be used in this economic evaluation are eastern white pine, Douglas fir, white spruce and balsam fir. Eastern white pine and Douglas fir will be used in the context of application to those specific species. For white spruce and balsam fir the results should apply to other species of their respective genus. White spruce and balsam fir were chosen to represent their respective species group because cost information is available for these species, both of which are in the list of the ten most important

Christmas tree species (Table 3).

Soils most likely to need fertilization--Coarse textured soils will generally benefit most from fertilization. White (1967) indicates that most of the Christmas tree plantations in the nation are located on medium to poor soils. These poorer soils are generally coarse textured.

Growers most frequently listed sandy, loamy sand and clay loam soil textures. Seventy percent indicated they had some trees growing on sandy or loamy sand soils.

For this study the assumption is made that the coarse textured soils are being fertilized, although it is recognized that other soils may need to be fertilized, depending on local conditions.

FERTILIZERS AND RELATED COSTS

Fertilizer alternatives and costs--The fertilizers which are most likely to improve the growth of Christmas trees are either complete fertilizers or one of the three major nutrients. The use of complete fertilizers (N-P-K) is recommended by Bell and White (1966) if information of a specific deficiency is lacking. In the Pacific Northwest, Turner and Buhaly (1966) have found that nitrogen fertilizers may be sufficient to improve quality and growth of Douglas fir Christmas trees.

Fertilizers used by growers sampled range from micro-nutrients to complete and organic fertilizers. Eighty-four different fertilizers were listed by the respondents. Over 90 percent listed at least one complete fertilizer (N-P-K). Only 5 percent of the growers said they had used slow release fertilizers. Natural organic matter

Table 3. The ten most important Christmas tree species produced in the United States, 1964

Species	Millions of trees harvested [1]	Percent of total production
Scotch pine	9.0	27
Douglas fir	7.3	22
Balsam fir	4.1	12
Black spruce	2.5	7
Eastern red cedar	2.3	7
Red pine	2.0	6
White spruce	.9	3
White fir	.7	2
Eastern and western white pines	.7	2
Norway spruce	.5	2
	30.0	90

[1] Includes natural and plantation grown trees.

Source: Sowder, 1966

such as chicken manure was also used by only 5 percent.

For this study two fertilizers are considered: one common nitrogen source and one complete fertilizer. They are urea (45-0-0) and 16-8-8. Two other common fertilizers are listed in Tables 4, 5, and 6, but they are not analyzed because they are more expensive per unit of nutrient supplied than those chosen for analysis.

Although slow release fertilizers may be of some value with the spruces and firs (Bell and White, 1966), they will not be included because of the limited cost information presently available. White (1965) does say that the metal ammonium phosphates cost 2.5 to 3.5 cents per 2 ounce application. The soluble complete fertilizers in perforated plastic sacks are more expensive.

Fertilizer prices will vary from area to area depending on the transportation cost and demand. For this analysis the prices used are those which were derived from price quotations in Michigan (urea, 0.72 cents per ounce of nitrogen and 16-8-8, 1.65 cents per ounce of nitrogen). Table 5 and Table 6 show the costs for various quantities of each fertilizer.

Fertilizer application rates and costs--The time required to apply fertilizers will vary with the amount of fertilizer placed around a tree. Estimates range from 100 trees per hour to 360 trees per hour.

For this study it is assumed that 150 trees may be fertilized per hour when less than 6.5 ounces of fertilizer is applied per tree, and that 100 trees may be fertilized per hour when 6.5 to 16 ounces are applied per tree. This time includes moving between trees. Using a labor cost of $1.75 per hour the costs are 1.16 cents per tree

Table 4. Ounces of fertilizer needed to obtain alternative rates of nitrogen application per tree

Fertilizer materials used	Ounces of nitrogen applied per tree					
	.5	1	1.5	2	3	4
	(Ounces of fertilizer per tree)					
12-12-12	4.17	8.33	12.50	16.67	25.00	33.33
16-8-8	3.12	6.25	9.37	12.50	18.75	25.00
NH_4NO_3 (33% N)	1.52	3.03	4.55	6.06	9.09	12.12
Urea (45% N)	1.11	2.22	3.33	4.44	6.67	8.89

Table 5. Approximate cost of fertilizer materials at various rates of nitrogen 1/

Fertilizer materials used	Ounces of nitrogen applied per tree					
	.5	1	1.5	2	3	4
	(Cents per tree)					
12-12-12	1.07	2.13	3.20	4.27	6.40	8.63
16-8-8	0.82	1.65	2.47	3.29	4.94	6.59
NH_4NO_3 (33% N)	0.38	0.76	1.14	1.51	2.27	3.02
Urea (45% N)	0.36	0.72	1.08	1.43	2.15	2.86

1/ Based on fertilizer prices as of January, 1967. See Table 6 for prices per ton.

Table 6. Fertilizer prices in Michigan, Spring, 1967 [1]

Fertilizer materials	Average retail price/ton [2]	Price per pound of nitrogen [3]
	(Dollars)	(Cents)
12-12-12	$ 81.90	34.13
16-8-8	84.90	26.34
NH_4NO_3 (33% N)	79.82	12.09
Urea (45% N)	102.96	11.44

[1] Prices based on price quotations from two major fertilizer companies in Michigan (includes 4 percent sales tax).

[2] Fertilizers in 80 or 100 pound bags.

[3] Each price based on a 1-ton purchase.

for the lower application rate and 1.75 cents per tree for the larger applications. The method of application is hand application around each tree. The quantities applied to individual trees will vary with their sizes and with respect to year of harvest. The application of these granular fertilizers will be assumed to be in April or early May, as this is the optimum time to stimulate growth.

In this analysis it will be assumed that when an application is made in the second or third year following planting it is 16-8-8 (0.5 ounce of nitrogen), in the fourth year, 16-8-8 (1.0 ounce of nitrogen), in the fifth year, 16-8-8 (1.5 ounces of nitrogen, and in the sixth year (balsam fir and Douglas fir only), 16-8-8 (1.5 ounces of nitrogen). A 2-ounce application of urea is assumed to be applied two growing seasons prior to harvest for each alternative fertilizer routine considered. Quantities and timing of fertilizer applications for the alternatives considered are shown diagrammatically in Figures 1-4.

Frequency of fertilizer applications--Christmas trees should only require a few applications of fertilizer during the rotation. With an application in the first couple of years, another one is probably not necessary until a year prior to harvest. The assumed application schedules are shown in Figures 1-4.

PLANTATION SPECIFICATIONS

Plantation establishment costs--The assumed costs for the establishment of the plantations are shown in Table 7. The costs for eastern white pine, white spruce, and Douglas fir were taken from Bell and White (1966). Balsam fir establishment costs were based on

Table 7. Christmas tree plantation establishment costs per acre

Species and spacing	Machine planting in herbicide treated rows without furrows[3]	Remarks	Total cost using recommended stock
Eastern white pine[1] 6 x 6	$38.11-$57.36 Average $48.46	Add $10 per acre if 2-1 transplants are used.	$ 58.46
White spruce[1] 5 x 5	$59.01-$106.70 Average $76.37	Add $40 per acre if 3-1 or 2-2 transplants are used.	$116.37
Douglas fir[1] 5 x 5	$65.97-$132.83 Average $93.44	Add $17 per acre if 2-1 or 2-2 transplants are used.	$110.44
Balsam fir[2] 5 x 5	$157.95	Price of 2-2 transplants are included in the planting price.	$157.95

[1] Bell and White, 1966

[2] Estimate based on the following costs: planting stock, $75/M; herbicide, $8.95/Acre; and cost of planting, $25/M.

[3] Includes cost of herbicide and application to 2-foot wide rows.

estimates by growers.

Tree spacing in the plantations--The spacing of the trees used are those recommended by Bell and White (1966) and are included in Table 8. Eastern white pine spacing is 6 x 6. For white spruce, balsam fir and Douglas fir the spacing is 5 x 5. Six by six spacing gives 1210 trees per acre and 5 x 5 spacing gives 1740 trees.

Rotation lengths--The rotation lengths to be used in this economic analysis are taken from the following figures reported by Bell and White (1966): eastern white pine, 5-8 years; white spruce, 8-11 years; balsam fir, 12-16 years; and Douglas fir, 12-16 years. Bell and White also state that a 2-3 year fallow period will be necessary for sanitary purposes to prepare the fields for the next rotation.

For this analysis, the rotation lengths for the control rotations will be assumed as follows: white pine, 8 years; white spruce, 11 years; balsam fir, 12 years; and Douglas fir, 12 years. To these will be added 2 years for the sanitation-fallow period. This is necessary because a perpetual series of rotations are used to place the various alternatives in comparable terms.

This analysis will show the effects of shortening the rotations up to 3 years, depending on the species. Hacskaylo (1964) found that rotations for the spruces and firs could be shortened from 10-14 years to 6 or 7 years as a result of fertilization.

Shearing costs--Dambach (1961) estimates the shearing cost for five shearings during the rotation at 16 cents per tree. Hilliker[1/]

1/ Personal correspondence with Richard L. Hilliker, University of Wisconsin, Madison, February 28, 1967.

Table 8. Species recommended for plantation grown, cultured trees, in the regions designated

Common name	Normal rotation in years[1]	Geographic section of the United States where species are recommended for planting
Scotch pine	5-7	New England, Southeastern states, Central states, Northeastern states, Lake states, Plains states
Eastern white pine	5-7	Central states, New England, Lake states, Northeastern states, Southeastern states
Norway spruce	8-11	Central states, Plains states, Lake states, Northeastern states, New England, Southeastern states
White spruce	8-11	Lake states, New England, Northeastern states
Balsam fir	12-16	Lake states, New England
Douglas fir	12-16	West Coast, Rocky Mountains, Lake states
Fraser fir	12-16	Southeast, New England, Lake states
Red fir	12-16	West Coast, Southwest
White fir	12-16	West Coast, Southwest

[1] These rotations do not include the 2-year fallow-sanitation period which will be included in the economic analysis. See Figures 1-4 for diagrams of the rotations used.

Source: Bell and White, 1966

reports using a shearing rate for balsam fir which varies from 45 to 175 trees per hour, depending on the size of the trees. The cost was estimated to vary from 1-4 cents per tree per shearing depending on size.

For this economic analysis it will be assumed that the shearing cost will be 1 cent per tree for the first two shearings, 2 cents per tree for the second two shearings and 3 cents per tree for the remainder of the rotation, including the year of harvest. This will mean shearing rates which are approximately 175, 90 and 60 trees per hour, respectively. It is recognized that there may be variations in the number of trees sheared each year as well as variations between species. To compensate for this, the 3 cents per tree rate will be used for the 1253 trees harvested for balsam fir, white spruce and Douglas fir. For eastern white pine the 3 cent rate will be used for all 1089 trees assumed to survive the first year.

Chemical weed control--Weed control costs can vary a great deal depending on the fertility of the soil and the use of fertilizers. White (1965) indicates that a hand application in 2-foot wide bands costs: 0.9 cents per tree for 5 x 5 spacing, and 1.00 cents per tree for 6 x 6 spacing.

For simplicity of analysis it will be assumed that chemical weed control will cost $9.00 per acre when needed. Applications assumed for this analysis are shown in Figures 1-4.

Harvesting costs--The harvesting costs in this analysis are assumed to include marking, cutting, dragging, trimming, tying, and transporting the trees to a wholesale location. Dambach (1961) estimated these costs to total 23 cents per tree harvested for his

Norway spruce and Scotch pine plantations. The time and costs for these various operations can vary greatly depending on species and other factors. Fox (1961) found in a time study using white, red, jack and Scotch pine that cutting, dragging, loading, hauling, unloading and grading took 207, 299, 233 and 82 minutes per 100 trees, respectively.

Determining a precise cost is difficult and there is only limited information available. For this study the harvesting operation as described above will be assumed to cost 25 cents per tree.[1/] This will also include any cost involved in removing limbs from stumps following the harvest.

Annual costs--For the economic analysis an annual cost of $25.00 per acre is assumed. The annual cost is substantial because of the specialty nature of the Christmas tree crop. Taxes of $3.00 per acre per year are not uncommon. Management costs valued at $4.00 per hour also add a substantial amount to the annual cost. Other expenses, such as bookkeeping, insurance, fire protection, hired equipment, fencing, small tools and many miscellaneous items may increase the annual cost. Also, the size of the enterprise will affect the economies of scale attained. The $25.00 cost per acre each year is arbitrary, but appears reasonable.

MARKETING ASSUMPTIONS

Survival and marketing percentages--There is limited information

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1/ The 25 cents assumed will include tying the trees with twine, but will not cover the additional cost involved if Vexar is used. Vexar would probably cost 10-15 cents per tree additional.

available on the percentages of planted trees that survive and are harvested. Fox (1961) at the University of Illinois found 8 year survival as follows: white pine, 85, 83 and 79 percent for plantings made in 1950, 1951 and 1952, respectively. He also found that 138 trees on the average were required to produce 100 salable trees.

The assumptions made are: (1) 90 percent of the trees survive the first year; and (2) 80 percent of the surviving trees are merchantable. This means approximately 139 trees must be planted to yield 100 salable Christmas trees.

Merchantable product specifications--Market indications as noted by James (1959) and Trocke (1966) indicate that 5- to 7-foot trees are the most in demand. Therefore, for this analysis 6-foot trees are assumed to be the management objective. It is also assumed that the desired growth is 1-foot per year. This will place the whorls of branches close enough together to give adequate density.

Grades and wholesale prices for trees--There is little empirical data available on the distribution of various grades and the prices received for each species by grade. Trocke (1966) reported that the average price paid wholesale for all species varied from $2.03 in the North Central and New England states to a high of $2.93 in the western states. Fox (1961) had a price list for Illinois for 1959 which showed the prices for red, white and Scotch pine 6-foot tall as follows: U.S. No. 2, $1.40; U.S. No. 1, $1.90 and U.S. Premium, $2.14. The market report for 1966[1/] stated that wholesale prices

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1/ Market reports from member areas emphasize demands for quality trees. American Christmas Tree Journal. 11(1):35-44.

for balsam fir in Maine ranged from $3.50 to $4.00 per tree in 1966. In the state of Washington, Douglas fir wholesaled for $0.35 to $0.40 per foot ($2.10 to $2.40 for 6-foot trees).

Information on the percentage of harvestable trees per grade is not available. Since a reasonable estimate of marketing percentages is available, it is assumed that: (1) 90 percent of the trees survive the first year of the rotation; and (2) 80 percent of those that survive the first year are marketable. This means that 72 percent of the trees planted will be salable.

The grade breakdown assumes that 50 percent of the total trees are U.S. No. 1 or U.S. Premium, and 22 percent are U.S. No. 2.

The price assumptions are as follows:

1) eastern white pine -- U.S. No. 1 or better, $2.50,
   U.S. No. 2, $1.50
2) balsam fir -- U.S. No. 1 or better, $3.50,
   U.S. No. 2, $1.75
3) white spruce -- U.S. No. 1 or better, $2.50,
   U.S. No. 2, $1.50
4) Douglas fir -- U.S. No. 1 or better, $2.50,
   U.S. No. 2, $1.50

THE ECONOMIC MODEL

This section will briefly explain the specifications of the economic model and how the flow diagrams, Figures 1-4, can be used. The assumptions underlying the alternative rotations and management systems may be broken down into two classes, one of which is constant for all four species and one which varies by species (Table 9). The

assumed specifications that are constant are:

1) chemical weed control cost (as shown in Figures 1-4)--$9.00 per acre
2) annual cost--$25.00
3) fertilizer application method--hand application around each tree
4) fertilizer costs--16-8-8, 1.65 cents per ounce of nitrogen; urea, 0.72 cents per ounce of nitrogen
5) cost to apply the fertilizers--150 trees per hour, 1.16 cents per tree; 100 trees per hour, 1.75 cents per tree
6) tree size marketed--6-foot trees
7) time of year fertilizers are applied--April or early May
8) harvesting and baling cost--$0.25 per tree
9) shearing cost--see Table 9

The costs which are used in the economic analysis are shown in Figures 1-4. To show how the costs may be calculated, alternative 1 for white spruce (Figure 1) will be explained. Starting at the top of the diagram the first cost incurred is for establishing the plantation (year 1). In year 2, applications of fertilizer (16-8-8) and chemical weed control are applied. In year 3 additional chemical weed control is applied. In year 4 fertilization, weed control and shearing occur. Continuing down alternative 1, there is an application of urea in year 7 and harvest at the end of year 8, followed by a 2-year sanitation-fallow period. The total costs incurred each year for the white spruce alternatives are shown in Table 11.

Weed control is assumed to be used in the last two growing seasons because of the application of urea. Many growers may consider the weed control unnecessary. If this expenditure is not made it will mean a savings of about 1 cent per tree. This will not change the rates of return calculated and shown in Table 15.

Table 9. Species specifications for the fertilizer analysis[1/]

Species and spacing	Plantation establishment cost per acre	First year survival per acre	Shearing cost per tree			Years in the rotation	Number of trees harvested per acre	Wholesale selling price/tree		Merchantable trees by grade	
			1st and 2 shearings	3rd and 4 shearings	Additional shearings			U.S.No. 1 or better	U.S.No. 2	U.S.No. 1 or better	U.S.No. 2
White spruce 5 x 5	$116.35	1566	$0.01	$0.02	$0.03	10, 11 and 13	1253	$2.50	$1.50	870	383
Douglas fir 5 x 5	$110.44	1566	$0.01	$0.02	$0.03	11, 12 and 14	1253	$2.50	$1.50	870	383
Balsam fir 5 x 5	$157.95	1566	$0.01	$0.02	$0.03	11, 12 and 14	1253	$3.50	$1.75	870	383
Eastern white pine 6 x 6	$ 58.46	1089	$0.01	$0.02	$0.03	9, 10 and 11	871	$2.50	$1.50	605	266

[1/] Specifications which are constant for all species are listed on page 24.

Table 10. Fertilizer applications used for the four species[1/]

Species	Year of application	Quantity of nitrogen per tree (ounces)	Cost in cents	Fertilizer
Douglas fir and Balsam fir	2	.5	.82	16-8-8
	3	.5	.82	16-8-8
	4	1.0	1.65	16-8-8
	5	1.5	2.47	16-8-8
	6	1.5	2.47	16-8-8
	8	2.0	1.43	Urea
	9	2.0	1.43	Urea
	11	2.0	1.43	Urea
White spruce	2	.5	.82	16-8-8
	3	.5	.82	16-8-8
	4	1.0	1.65	16-8-8
	5	1.5	2.47	16-8-8
	6	1.5	2.47	16-8-8
	7	2.0	1.43	Urea
	8	2.0	1.43	Urea
Eastern white pine	2	.5	.82	16-8-8
	3	.5	.82	16-8-8
	4	1.0	1.65	16-8-8
	5	1.5	2.47	16-8-8
	6	2.0	1.43	Urea
	7	2.0	1.43	Urea
	8	2.0	1.43	Urea

[1/] No single alternative will use all of the applications shown. The timing of fertilizer applications for the alternative fertilizer routines considered are given in Figures 1-4.

Figure 1. Flow chart of alternative fertilized rotations of white spruce Christmas trees

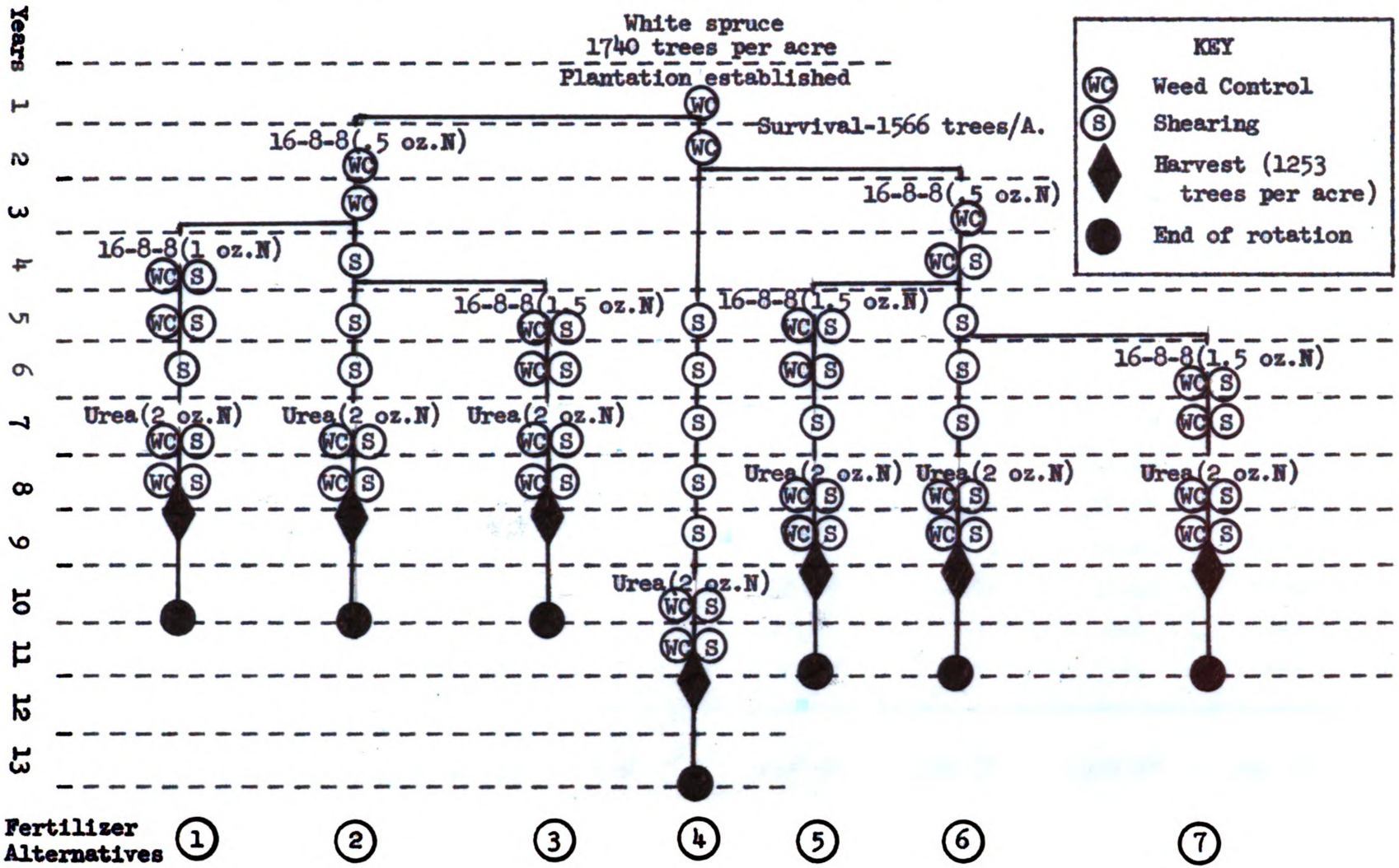

Table 11. Total cost per acre per year for white spruce fertilizer alternatives

Year	Alternative fertilizer routines						
	1	2	3	4	5	6	7
	Total cost per year in dollars						
1	141.37	141.37	141.37	141.37	141.37	141.37	141.37
2	65.01	65.01	65.01	34.00	34.00	34.00	34.00
3	34.00	34.00	34.00	25.00	65.01	65.01	65.01
4	93.66	40.66	40.66	25.00	49.66	49.66	49.66
5	49.66	49.66	116.06	40.66	40.66	40.66	116.06
6	56.32	56.32	65.32	40.66	131.72	56.32	65.32
7	105.88	105.88	105.88	56.32	65.32	56.32	56.32
8	384.84	384.84	384.84	56.32	112.15	112.15	112.15
9	40.65	40.65	40.65	62.59	384.84	384.84	384.84
10	25.00	25.00	25.00	112.15	40.65	40.65	40.65
11	---	---	---	384.84	25.00	25.00	25.00
12	---	---	---	40.65	---	---	---
13	---	---	---	25.00	---	---	---
Total cash outlay during the rotation (without interest)	996.39	943.39	1018.79	1044.56	1090.38	1005.98	1090.38

Figure 2. Flow chart of alternative fertilized rotations of Douglas fir Christmas trees

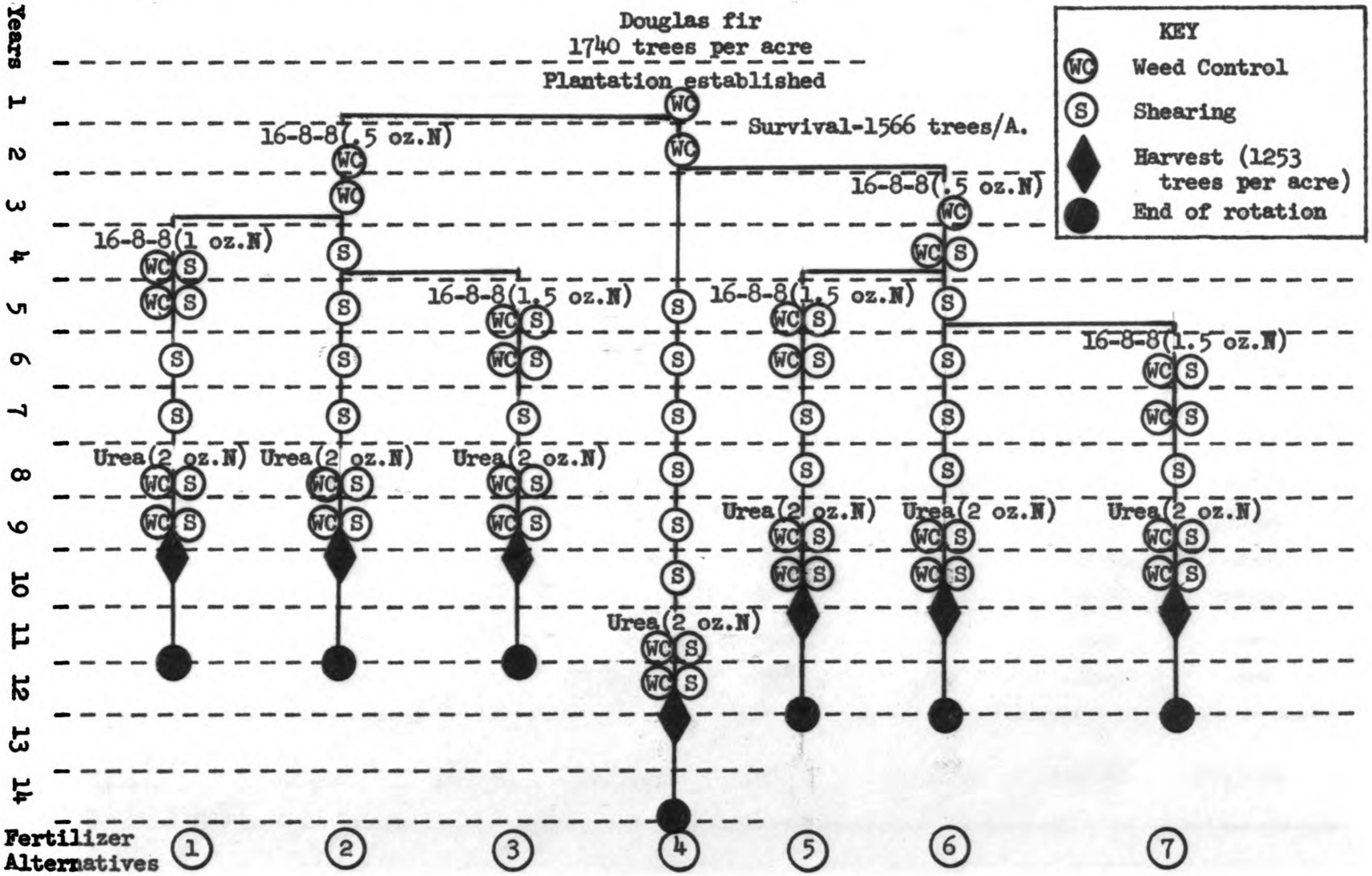

Table 12. Total cost per acre per year for Douglas fir fertilizer alternatives

Year	Alternative fertilizer routines						
	1	2	3	4	5	6	7
	Total cost per year in dollars						
1	135.44	135.44	135.44	135.44	135.44	135.44	135.44
2	65.01	65.01	65.01	34.00	34.00	34.00	34.00
3	34.00	34.00	34.00	25.00	65.01	65.01	65.01
4	93.66	40.66	40.66	25.00	49.66	49.66	49.66
5	49.66	40.66	116.06	40.66	116.06	40.66	40.66
6	56.32	56.32	65.32	40.66	65.32	56.32	131.72
7	56.32	56.32	56.32	56.32	56.32	56.32	65.32
8	112.15	112.15	112.15	56.32	62.59	62.59	62.59
9	384.84	384.84	384.84	62.59	112.15	112.15	112.15
10	40.65	40.65	40.65	62.59	384.84	384.84	384.84
11	25.00	25.00	25.00	112.15	40.65	40.65	40.65
12	---	---	---	384.84	25.00	25.00	25.00
13	---	---	---	40.65	---	---	---
14	---	---	---	25.00	---	---	---
Total cash outlay during the rotation (without interest)	1053.05	991.05	1075.45	1101.22	1147.04	1062.64	1147.04

Figure 3. Flow chart of alternative fertilized rotations of balsam fir Christmas trees

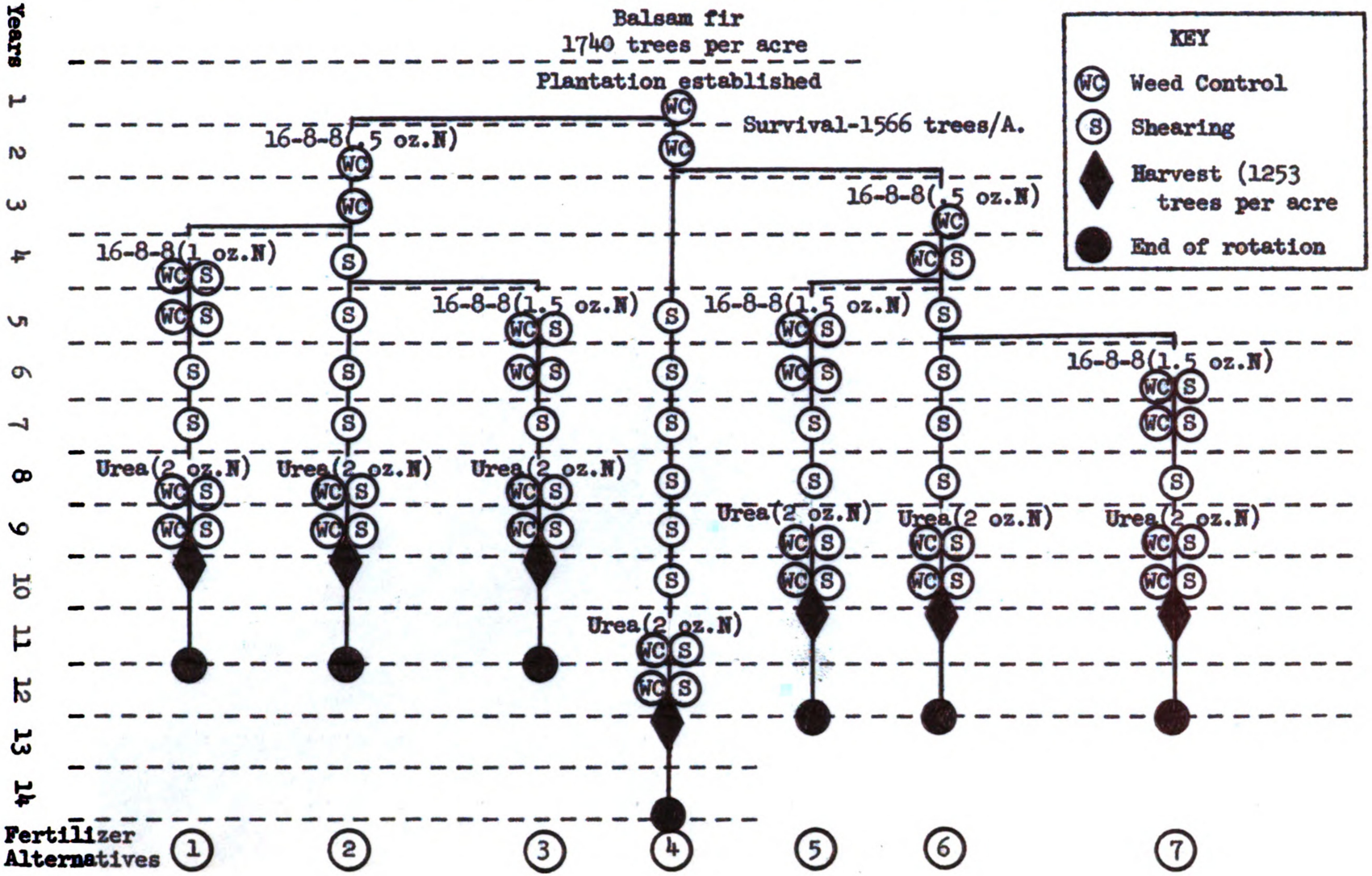

Table 13. Total cost per acre per year for balsam fir fertilizer alternatives

Year	Alternative fertilizer routines						
	1	2	3	4	5	6	7
	Total cost per year in dollars						
1	182.95	182.95	182.95	182.95	182.95	182.95	182.95
2	65.01	65.01	65.01	34.00	34.00	34.00	34.00
3	34.00	34.00	34.00	25.00	65.01	65.01	65.01
4	93.66	40.66	40.66	25.00	49.66	49.66	49.66
5	49.66	40.66	116.06	40.66	116.06	40.66	40.66
6	56.32	56.32	65.32	40.66	65.32	56.32	131.72
7	56.32	56.32	56.32	56.32	56.32	56.32	65.32
8	112.15	112.15	112.15	56.32	62.59	62.59	62.59
9	384.84	384.84	384.84	62.59	112.15	112.15	112.15
10	40.65	40.65	40.65	62.59	384.84	384.84	384.84
11	25.00	25.00	25.00	112.15	40.65	40.65	40.65
12	---	---	---	384.84	25.00	25.00	25.00
13	---	---	---	40.65	---	---	---
14	---	---	---	25.00	---	---	---
Total cash outlay during the rotation (without interest)	1100.56	1038.56	1122.96	1148.73	1194.55	1110.15	1194.55

Figure 4. Flow chart of alternative fertilized rotations of eastern white pine Christmas trees

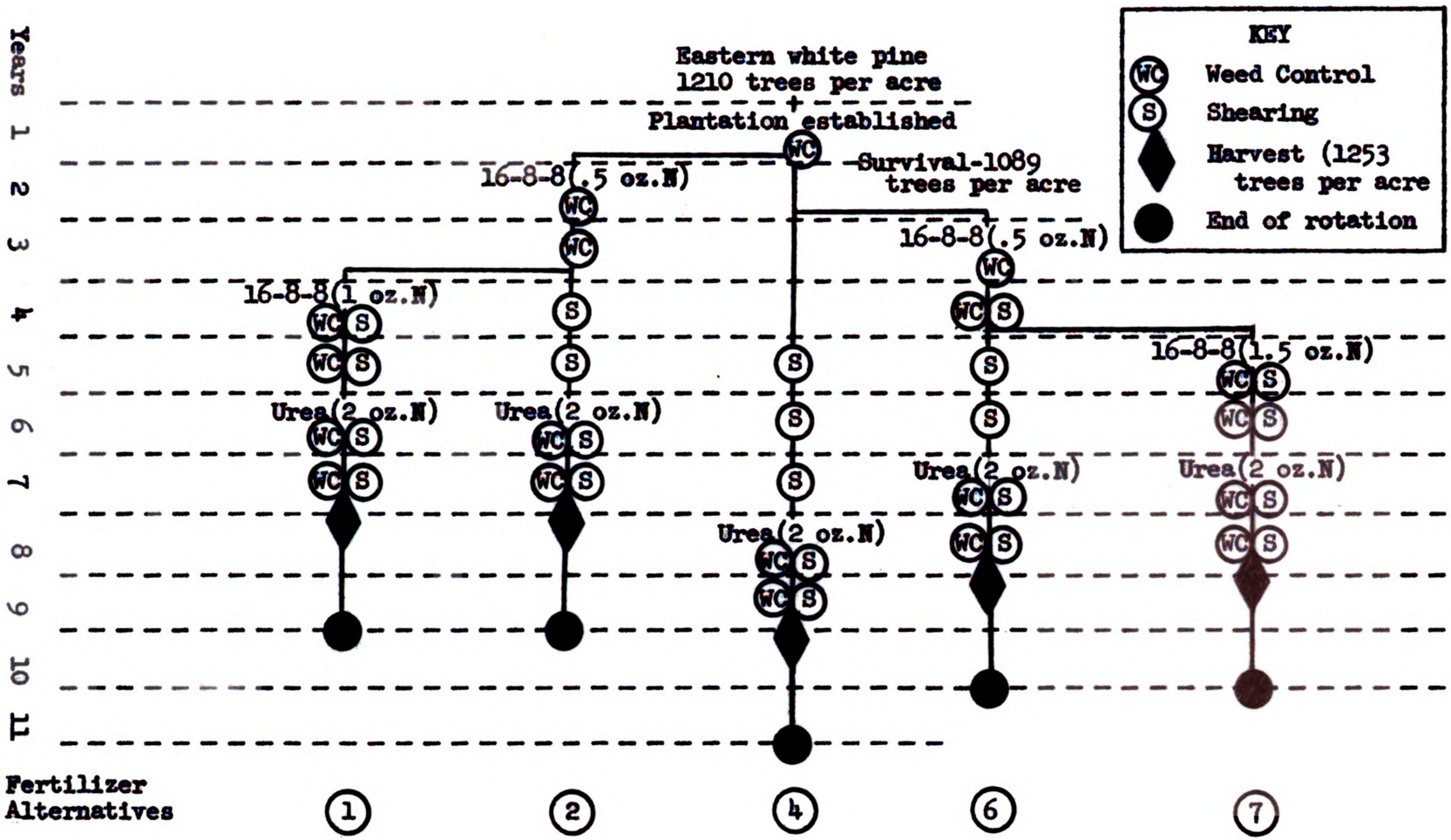

Table 14. Total cost per acre per year for eastern white pine fertilizer alternatives

Year	Alternative fertilizer routines						
	1	2	3	4	5	6	7
	Total cost per year in dollars						
1	83.46	83.46	---	83.46	---	83.46	83.46
2	55.56	55.56	---	34.00	---	34.00	34.00
3	34.00	34.00	---	25.00	---	55.56	55.56
4	75.49	35.89	---	25.00	---	44.89	44.89
5	44.89	35.89	---	35.89	---	35.89	90.85
6	83.99	83.99	---	35.89	---	46.78	55.78
7	284.42	284.42	---	46.78	---	83.99	83.99
8	35.90	35.90	---	83.99	---	284.42	284.42
9	25.00	25.00	---	284.42	---	35.90	35.90
10	---	---	---	35.90	---	25.00	25.00
11	---	---	---	25.00	---	---	---
Total cash outlay during the rotation (without interest)	722.71	674.11	---	715.33	---	729.89	793.85

CHAPTER III

ANALYSIS OF RETURNS TO FERTILIZER APPLICATIONS

The objective of this study was to analyze possible economic returns as a result of fertilization. To explore this objective, the impact of quality improvements and alternative rotation lengths were analyzed. Findings indicated that the quality of trees may be improved and rotations shortened where nutrition is limited. The greatest impact will be with marginal operations, since the use of fertilizers may make the difference between loss or profit.

Two tables have been constructed from the economic model developed in Chapter II. The internal rates of interest are shown in Table 15 and an example of soil expectation values using 10 percent compound interest is shown in Appendix C.

The computation of rates of return (compounded annual interest) and soil expectation values were computed at Michigan State University using a modified version of the computer program developed by Row (1963). The method included the use of a perpetual series of rotations to place all alternatives in the same terms. Lundgren (1966) discusses this concept:

> ...the present net value for one rotation can be used to compare investments, but only if the rotation ages (investment periods) are the same. If rotation ages are not the same, the present net values must be adjusted to put them on a common basis before a valid comparison can be made.

Since many large growers are in business for twenty years or more, the perpetual series of rotations should approximate their long range

Table 15. Rates of return to investments using compound interest and a perpetual series of rotations

Species and spacing	Price alternatives: 50% U.S.No. 1 or better	Price alternatives: 22% U.S.No. 2	Alternative fertilizer routines: 1	2	3	4	5	6	7
			Percent						
White spruce 5 x 5	$2.50	$1.50	33	36	34	23	28	30	28
	$2.75	$1.75	36	40	37	25	31	32	30
	$3.00	$2.00	38	42	40	27	33	35	33
	$3.25	$2.25	41	45	43	29	36	37	35
Douglas fir 5 x 5	$2.50	$1.50	28	30	28	20	23	25	23
	$2.75	$1.75	31	33	31	22	25	27	26
	$3.00	$2.00	33	35	33	24	28	29	28
	$3.25	$2.25	35	37	35	25	29	31	30
Balsam fir 5 x 5	$3.50	$1.75	32	34	32	23	27	29	27
	$3.75	$2.00	34	36	34	24	29	30	29
	$4.00	$2.25	36	37	36	25	30	32	31
	$4.25	$2.50	38	39	38	26	32	33	32
Eastern white pine 6 x 6	$2.50	$1.50	43	45	--	32	--	35	33
	$2.75	$1.75	47	49	--	34	--	39	36
	$3.00	$2.00	50	53	--	37	--	41	39
	$3.25	$2.25	53	56	--	39	--	44	42

planning.

Data given in Table 15 may be used to analyze three results of fertilization: (1) an improvement in quality as reflected in an in-grade improvement in price; (2) a shorter rotation; and (3) a shorter rotation as well as an improvement in price.

White spruce was analyzed using four price increments, and three different rotation lengths, as follows: (1) a 10 year period, with the harvest in the eighth year; (2) an 11 year period with the harvest in the ninth year; and (3) a 13 year period with the harvest in the eleventh year (the rotation length expected without fertilization).

By observing Table 15 it can be seen that using alternative 4 (13 year rotation), the return may be increased as much as 6 percent. If the rotation is 10 years, the return could be increased as much as 9 percent. The greatest impact occurs when the rotation is shortened, consistent with quality requirements. By comparing alternatives 2 and 4 it can be seen that returns could be increased 13 percent by shortening the rotation 3 years. The increase could be as much as 22 percent if quality improvements accompany a shorter rotation.

The results for Douglas fir and balsam fir are similar to those of white spruce. The greatest increases result from a combination of a shorter rotation and an improvement in quality.

Eastern white pine shows the highest rate of return. It differs from the other species in that the trees are spaced 6 x 6. Returns can range from 2 to 11 percent with quality improvements. If the rotation is shortened 2 years and the price received per tree is

increased 75 cents, the return could be increased as much as 24 percent.

One word of caution when comparing the returns from these four species: It is not the author's intent to imply that white pine is the best species to be grown. There are many factors to be considered, e.g., the market situation and soils.

The economic returns as shown in Table 15 are based on a theoretical model. As many factors as possible were considered, but some were not included, e.g., insect and fire losses. Labor and machinery requirements were assumed to be hired. Undoubtedly other items were inadvertently overlooked in the model situation. However, the high interest rates do indicate there are possibilities to increase profits.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The fertilization of Christmas trees is receiving serious consideration among growers, since it is a means of improving trees growing on coarse textured soils. Combined with the other cultural techniques now used on plantations, it can contribute substantially to quality. The quality factors which may be improved include color, needle retention, density, growth and overall appearance.

In a 1966 survey the author found that over 80 percent of the growers who have used fertilizers believe they have economic potential if used properly. The survey also indicated that growers generally do not have a well-conceived plan when using fertilizers.

Quality is essential in the Christmas tree industry, especially since consumers have become quality conscious and are willing to pay higher prices. Those marginal producers who are not willing to invest additional money to improve quality may find that their trees are no longer marketable.

Christmas tree growers who have coarse textured soils should consider using fertilizers if their Douglas fir, balsam fir, spruces or true firs lack the quality characteristics expected for the species, and/or are growing too slowly. For Scotch pine there is no evidence to indicate that fertilization will improve Christmas tree quality, and fertilization is not recommended. Fall color problems with Scotch pine are usually a result of the genetic characteristics

of the variety planted and cannot be corrected by fertilizer applications.

The fertilizers which current research indicates will be of the most importance in Christmas tree production are complete (N-P-K) and nitrogen fertilizers. In this study 16-8-8 and urea (45-0-0) were used.

The model was developed using all factors which could be easily quantified. The author wishes to point out that such factors as insect and disease control were not included. These are real costs, but items which cannot be included with accuracy. Oversights such as these have contributed to the high interest rates calculated. Nevertheless, the large interest rates do indicate that there is potential for sizeable profits in the Christmas tree industry.

This study indicates that the fertilization of Christmas trees has considerable potential, especially on the coarse textured soils. The next desirable step appears to be an intensive and well-documented study of fertilizer use on plantations.

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APPENDIX A

CONFIDENTIAL CONFIDENTIAL

PRELIMINARY CHRISTMAS TREE FERTILIZATION QUESTIONNAIRE
Michigan State University

July, 1966

1. Have you used fertilizers on any of your Christmas trees?

   Yes ( ) No ( )

2. Have you harvested any Christmas trees that have been fertilized? Yes ( ) No ( )

3. What types and analyses of fertilizer have you used?

4. Have you observed any effects on quality, grade, or selling price as a result of fertilization? Yes ( ) No ( )

5. Will you be available for a personal interview at the National Christmas Tree Growers' Convention at Stevens Point, Wisconsin, in August? Yes ( ) No ( )

A stamped addressed envelope is enclosed for your convenience.

APPENDIX B

CONFIDENTIAL CONFIDENTIAL

CHRISTMAS TREE FERTILIZATION SURVEY
Michigan State University

August, 1966

1. Name _____
   Address _____
   _____
   Occupation _____

2. Do you grow Christmas trees as your: a. occupation ( ),
   b. part-time job ( ), c. hobby ( ), d. other _____?

3. How many years have you been in the Christmas tree plantation business? _____ years.

4. Your total acreage in Christmas tree plantations (including access lanes)? _____ acres.

5. What size planting stock do you use? (e.g. 2-0, 2-2)

Species	Nursery age
_____	_____
_____	_____
_____	_____

6. What texture (particle size) soil do you have? a. sandy ( ),
   b. loamy sand ( ), c. loam ( ), d. gravelly loam ( ),
   e. silt loam ( ), f. clay loam ( ), g. clay ( ).

7. In the following table record any observations on quality, color, grade or selling price as a result of fertilizing.

	QUALITY		GRADE		COLOR		SELLING PRICE		
	No change	Improved	No change	Improved	No change	Improved	No change	Improved	How much increase/tree
a. Scotch pine									
b. Red pine									
c. Austrian pine									
d. Norway spruce									
e. White spruce									
f. Black spruce									
g. Balsam fir									
h. Douglas fir									
i. E. white pine									
j. _____									

How was quality improved? _____

How was the grade improved? _____

Does fertilizing appear to be economic and profitable? _____

8. In the following table fill in the fertilizer analyses used for each species, the quantity applied per tree or per acre, the man-hours per treatment per tree or acre, year of application in the rotation, date of application, the form the fertilizer is in, the method of placement, the number of years the fertilizer stimulates growth, and the number of trees harvested per acre.

Species	Fertilizer Analyses	Quantity applied per tree or acre	Man-hours per treatment per tree or acre	Year in rotation	Date when fertilizer is applied	Fertilizer form: 1) granular, 2) liquid, 3) slow-release	Method of placement: 1) broadcast, 2) side dressing, 3) in hole, 4) spray	No. of years growth is stimulated	No. of trees harvested per acre
Douglas fir									
White spruce									
Balsam fir									

9. What is your fertilization routine? _____

_____

_____

_____

10. What are your objectives in using fertilizers? (Place in numerical order): a. better survival ( ), b. longer needles ( ), c. darker foliage ( ), d. faster growth ( ), e. better needle retention ( ), f. more buds set ( ), g. other (specify) _____ ( ).

11. What adverse effects have you observed from fertilizing?

_____

_____

_____

Which fertilizers were these? _____

_____

_____

12. Do you have any detailed records, i.e. case histories for any fertilized blocks of trees? Would you be willing to make this information available to us?

_____

_____

_____

_____

APPENDIX C

Soil expectation values for all alternatives using 10 percent compound interest and a perpetual series of rotations[1/]

Species and spacing	Price alternatives: 50% U.S.No. 1 or better	&	22% U.S.No. 2	Alternatives in fertilizer routines: 1	2	3	4	5	6	7
White spruce 5 x 5	$2.50	&	$1.50	1079.28	1186.94	1102.47	623.61	852.33	924.97	845.07
	$2.75	&	$1.75	1310.49	1424.76	1340.30	778.18	1056.87	1129.51	1049.61
	$3.00	&	$2.00	1541.71	1662.59	1578.13	932.74	1261.41	1334.05	1254.15
	$3.25	&	$2.25	1772.93	1900.41	1815.95	1087.30	1465.95	1538.59	1458.68
Douglas fir 5 x 5	$2.50	&	$1.50	874.81	939.15	859.25	481.43	647.05	723.22	653.97
	$2.75	&	$1.75	1079.35	1143.69	1063.78	616.92	824.30	900.46	831.22
	$3.00	&	$2.00	1283.89	1348.23	1268.32	752.41	1001.55	1077.71	1008.47
	$3.25	&	$2.25	1488.43	1552.76	1472.86	887.90	1178.79	1254.96	1185.72
Balsam fir 5 x 5	$3.50	&	$1.75	1438.90	1503.24	1423.34	840.52	1130.12	1206.28	1137.04
	$3.75	&	$2.00	1643.44	1707.78	1627.88	976.01	1307.37	1383.53	1314.29
	$4.00	&	$2.25	1847.98	1912.32	1832.41	1111.49	1484.61	1560.78	1491.54
	$4.25	&	$2.50	2052.52	2116.86	2036.95	1246.98	1661.86	1738.03	1668.79
Eastern white pine 6 x 6	$2.50	&	$1.50	935.94	992.61	---	649.53	---	758.42	694.61
	$2.75	&	$1.75	1129.96	1186.63	---	791.71	---	923.74	859.93
	$3.00	&	$2.00	1323.99	1380.66	---	933.89	---	1089.06	1025.25
	$3.25	&	$2.25	1518.02	1574.69	---	1076.08	---	1254.38	1190.57

[1/] This table can be used to determine the best alternative for each species. It cannot be used to determine the best alternative between species.

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