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INTRODUCTION

The forests and forest lands of Montana represent assets that have not been used to their full potential. Research is necessary to provide guidance to those who would attempt to reach such a goal. The following study should serve to further development in one facet of that goal, the problem of obtaining maximum production and economic return from forest lands growing Douglas-fir *(Pseudotsuga menziesii, var. glauca)*, suitable for Christmas tree production.

The Montana production of Christmas trees has more than doubled in the period 1942 to 1956, with the 1956 production estimated to be more than four million trees annually (6,7). The demand for Christmas trees has increased over a period of years but the number and size of existing stands capable of producing high quality trees has been rapidly declining. The increased demand, and need for subsequent production, has produced a situation of inadequate supply that is of increasing concern. If Montana cannot meet the demand, other areas of the United States undoubtedly will, and they may permanently absorb a large percentage of the business. This would materially reduce the annual revenue, estimated to be in excess of two million dollars, that Montana producers could receive.

Within the Christmas tree industry the producers are regarded as those who own, cut, grade, and otherwise handle and prepare the trees for eventual distribution to the consumer. A portion of the producers, (the owners of the land on which the trees or stumpage is located,) would be particularly affected by any shift in the production area. Their income will decline in the future if they cannot supply the tree quality the market demands, or, should they attempt to fill their orders with poor quality trees.

In the past there were large wild areas from which to select trees, thereby giving the cutter an opportunity to pick high quality trees if he so desired. These areas have declined in volume while the demand has gradually risen. The cutter now is forced to cut more trees of lower quality in order to meet his production goal. The effect of this has been detrimental to the reputation of Montana trees.

Huey (7) determined that Montana supplied approximately three fourths of the Christmas trees shipped into Chicago in the early 1930's. In 1949 Montana producers supplied only half of the trees sold in this same area. He explained this decline as follows:

> "As mentioned previously, freight rates and competition with locally grown trees are said to be factors in the shift but some operators feel strongly that the declining quality of the trees has also contributed to the trend. They say that western Montana producers have been unable to supply heavy, bushy, high quality trees in the number desired. Significantly enough, several companies have expressed a preference to ship Montana Douglas-fir to localities where there is little competition with species from other regions."

Herrington (6) indicates that in the five years previous to 1955 the Illinois import of Montana trees dropped from 600,000 to 166,000.

The situation with respect to low quality trees being produced is not unique to Montana as illustrated by Abbott and Trenk (1) of Wisconsin, who state:

"It is from the standpoint of quality that Wisconsin grown trees suffer in the market. One purchasing agent for a large chain in southern Wisconsin reports that his experience with native (Wisconsin) trees is such that he prefers to ship in from the mountains of the West; Douglas-fir trees which may have been cut as early as October."

Christmas tree quality may be improved by the cultural practice of shearing and through forestry practices such as thinning stands to their proper density. Fire prevention, insect and fungi control, and the reduction of competition by removal of brush and undesirable tree species also will assist in improving quality.

Two solutions to meet the competition of other areas with suitable trees are possible: better cultural management of the existing stands; and the establishment and maintenance of Christmas tree plantations. Both solutions require intensive economic and forestry management in order to produce high quality crops. Plantations are becoming more important in their contribution to the total Christmas tree production. This is evidenced by the harvest in 1955 of approximately three and one-third million trees or about thirteen per cent of the total trees harvested in the United States in that year (12). However, the establishment of plantations is a more costly and time consuming task, in addition to the other management costs, than the use of naturally established wild stands.

Quality Defined

Since quality is the deciding factor in consumer acceptance of Christmas trees, it is necessary to define, as nearly as possible, what the consumer means when he refers to a "high quality" tree.

A great deal of research has been directed, in the past, toward a definition of quality that would be acceptable throughout the industry. From their observations Huey and Hutchison developed a grading system entitled "Proposed Grading Rules for Douglas-fir Christmas Trees" (14), which included many opinions of consumers and producers. This was one of the first attempts to establish standards of quality. Robert Stone, after further study and consultations, developed "The Revised Hutchison-Huey Grading System for Montana Douglas-fir Christmas Trees." Stone's system differed somewhat from the original but both his and Huey and Hutchisons' standards serve to illustrate that most consumers desire trees which conform to certain patterns. These patterns are defined in the grading rules through the use of "factors."

The five factors determining quality are: density, taper, balance, foliage, and defects. All are combined to varying degrees to determine how "high quality" the tree in question is. An important consideration concerning the factors is that they can all be manipulated in varying amounts by established Christmas tree cultural practices. Therefore, using the proper cultural practice the quality or grade of trees can be improved.

One cultural practice, shearing, can be used to advantage in directly improving three of the factors: density, taper, and balance. It can also improve the other two indirectly in varying amounts. Shearing is recognized by several leading authors in the Christmas tree industry, as being successful from a cultural standpoint and economically feasible (2, 3, 4, 5, 9, 11, 13, 15.) Loren and Jokela (8), after conducting a study involving the grading of Christmas trees on a plantation in Illinois, reached the following conclusion:

"Growing Christmas trees without benefit of shearing or shaping is a poor investment. One cannot rely on nature alone to produce quality trees with good form and density, even in well-spaced plantations."

Shearing Defined

Shearing, while relatively new to the Christmas tree industry, is a well established practice in the horticulture profession. This type of tree and shrub pruning, or shaping, has been practiced in the United States for many years. Its use in the Christmas tree industry is new. In the past there has not been any great need for Christmas trees which had been cultured because of the large number of acceptable wild grown trees. Exotic tree species such as Scotch Pine, (*Pinus sylvestris*), have recently been introduced into the Christmas tree industry. With this species shearing is almost always necessary to produce an acceptable tree. This has created interest in shearing of native species.

Shearing, or tip pruning, as it is sometimes called, is practiced by pruning a portion of the terminal ends of the lateral branches and terminal leaders of trees. Figure 1, page 3, illustrates the fundamental practices involved. The amount of pruning done on any specific tree is determined by the tree's original condition. The time of pruning is de-

termined by the species of tree. Douglas-fir may be sheared any time after the new year's growth has matured, usually not earlier than the first of July. The terminal leader should be cut late in the growing season after the next year's buds have developed.

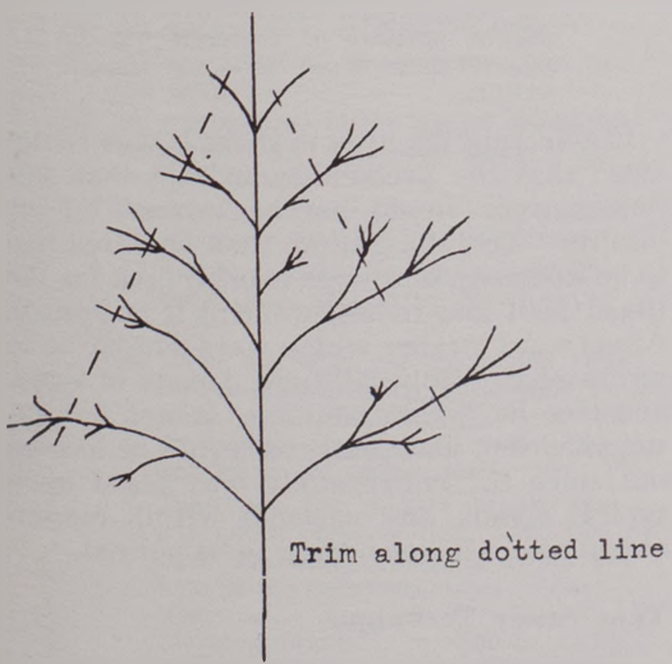
By trimming, or shearing, it is possible to control the amount of over-all taper that a tree has and it is also possible to control the balance or uniformity of the branches. The foliage density, a very important factor, may also be controlled as the sheared tree attempts to overcome the loss of leaves by adventitious budding and through accelerated growth of the remaining buds.

OBJECTIVES OF THE STUDY

Although shearing has proven itself to be beneficial, and its manner of employment has been definitely established, there was no indication in the review of literature, pertinent to the subject, of research having been done on the cost of application. Three authors, (8, 9, 10), have indicated a number representing their estimate of the number of trees that can be sheared per hour or day. There is no accompanying evidence to indicate how the production costs of the Christmas tree industry can or cannot absorb the price of shearing.

In this study the principal objective to be gained was the determination of shearing production in typical wild stands of western Montana Douglas-fir on a per day and hour basis in a reliable manner. Secondary objectives include the integrating of the production figures into a reliable cost analysis of shearing and pointing out factors significantly important to consider in using shearing as a cultural tool in the industry.

Figure 1. A diagrammatic sketch of shearing



Tree branches should be sheared along the dotted lines, to conform their outline to a symmetrical cone.

Part of the lateral branches may not need to be sheared, while in some cases several small branchlets upon one branch may need to be.

In nearly all cases, the terminal leader should be shortened. The leaders should be cut late in the growing season, with the cut being made immediately above a healthy appearing bud. The leader length should not exceed six to eight inches after cutting.

LOCATION OF STUDY AND SOURCE OF ADDITIONAL INFORMATION

The time study work of this problem was conducted on the Lubrecht Experimental Forest during the summer months of 1956. The Lubrecht Experimental Forest is a unit of the Forest and Conservation Experiment Station of the School of Forestry, Montana State University. It covers an area of 22,000 acres located in a Douglas-fir - Ponderosa pine type, and is situated thirty miles north of Missoula, Montana, on the Blackfoot River. All facilities, men, and equipment were furnished by the Forest and Conservation Experiment Station.

PLAN OF INVESTIGATION

The field portion of the time study was conducted in two parts after instruction, training, and practicing by the men who were to do the shearing and assist in recording of data. Part I concerns the selection of approach and the tool to employ in shearing. This was conducted using timed tests and employing men previously selected.

Part II of the time study field work was the tests to determine hourly and daily production using the same men, each being timed for three consecutive days, and using the tool and approach determined in Part I.

The trees sheared, in all phases of the time study were grouped into classes consisting of two foot height groups. This procedure was adopted to facilitate the calculation in the analysis of data. The number of classes

TABLE 1. CLASS NUMBERS AND HEIGHTS USED IN ALL TIME STUDY WORK.

Class Number	Tree Height
2	2 Feet to 4 Feet
3	4 " to 6 "
4	6 " to 8 "
5	8 " to 10 "
6	10 " to 12 "

set up was five, with the assumption that the greatest height tree that could be sheared would be twelve feet. Shearing height is limited to approximately two feet above a man's head, with a slight increased height advantage, usually not exceeding two feet, due to the slope. Table 1, page 4, illustrates the classes and heights used.

Tools Employed

Although some information was disclosed in the review of literature as to the proper tool to use, there was no definite agreement as to the best one nor was there any particular reason cited why the selected tools were recommended. Cope, and Lorenze and Jokela (3, 8,), advocate pruning shears, with Cope's only comment being to the effect that hedge shears would be faster than pruning shears but would not do a satisfactory job if the trees were to be harvested the same year. It was therefore necessary to test and choose the most suitable implement from the three which appeared most promising. It was recognized that many tools could be employed in shearing, from the pocket knife to scissors, but the element of speed of use eliminated consideration of most of the tools. Speed, coordinated with quality of production, was believed to be important since the economical application of shearing depends upon this factor. Therefore, the following tools were selected subjectively as the three most practical, and were used in the test:

(1) **Hedge Pruning Shears**, two handled type, with handles cork covered and having eight inch serrated cutting blades.

(2) **Pruning Clippers**, one handed type, with metal handles and having two inch cutting blades.

(3) **Grass Shears**, one handed, with off-set metal handles and having five inch cutting blades.

Slope Approaches Tested

Of possible importance in shearing was the direction of approach to the trees, as to slope. Since this study primarily concerns western Montana, where slope of varying percent is nearly always encountered, it was attempted to determine the one best suited to shearing.

The three principal methods of approach were tested; from below, or shearing uphill; from above, or downhill approach; and from the side or along the contour.

Shearing Area

The area to be sheared was selected based upon the following considerations:

(1) It should be a favorable site for Christmas tree growth. (The approximate distance between branch whorls should be about six inches.)

(2) Foliage of trees on the site should be of good color and there should not be evidence of excessive frost damage to the terminal leaders.

(3) Height of trees should be predominantly between two and twelve feet.

(4) Percentage of slope should be as little as possible, not flat but beyond twenty percent, if practical, and the slope should be uniform throughout.

(5) The area should be accessable by truck (½ ton pick-up,) and not have an excessive amount of material on the ground that would seriously impede walking.

In selecting the area to shear it was recognized that the probability existed that sufficient trees would not be located in one locality. Therefore, more than one area had to be selected, to provide enough area for the timed tests and remeasurement if necessary. Areas were located which were similar as to uniformity of slope, altitude, density of stand, and tree height distribution. It was not anticipated that identical areas could be located but since the entire study was based upon typical stands, any variance within reasonable limits, was considered to be normal.

Time Study Technique

The general time study technique used in this problem was derived from the following two sources:

Motion and Time Study by Ralph M. Barnes, John Wiley and Sons, Inc., Third Edition, 1954.

Barnes is chiefly concerned with time studies conducted in manufacturing concerns, and the classical background of time and motion studies. The specific methods outlined are not practical in a study such as this but the general principles were followed.

Time Study Technique by Lee M. James, Journal of Forestry, September, 1949, Pages 708 to 712.

This article outlines the essentials necessary in time studies conducted in the forest industries. James advocates a continuous reading system of recording time as used in this study, and he also indicates that many minute details should not be recorded separately in forestry because of their unimportance in the industry. James' technique was used as a basis for this time study.

Instruction, Training and Practice

Prior to the timed tests all of the individuals concerned were given instructions consisting of the following points:

(1) A general outline of the purpose and objectives of the problem.
(2) Why the individuals must do their jobs conscientiously and accurately. (For calculation and accuracy purposes the problem must be conducted along pre-designed lines with little or no deviation.)
(3) An explanation of shearing, both verbal and diagrammatic.
(4) An explanation of shearing benefits.
(5) A demonstration of shearing given by the author.
(6) An explanation of the use of the tools to be tested and a demonstration of the method of use.
(7) During the timed tests the man shearing must conduct himself as follows:
   a. Be prepared to start work immediately upon arrival at the shearing area.
   b. Have all tools pre-sharpened before he arrives at the shearing area each day of the timing, and have sharpening equipment with him and know its proper use.
   c. Take two ten minute breaks per day and a one-half hour lunch period, the time or taking to be as near to the following times as practical.

Morning break	10:00 to 10:10
Lunch hour	12:00 to 12:30
Afternoon break	2:00 to 2:10

Training consisted of the men shearing under direct and constant supervision and corrections in their methods were made when needed. The men were trained in the use of all tools which were to be tested.

After the men were thoroughly versed in the proper method of shearing, under direct supervision, they were given sufficient practice time to gain speed, while alternating the tools and approaches.

The instruction, training and practice was conducted as outlined and appeared to be adequate. The period of instruction and demonstration consisted of two hours. Ten hours were used for the training and practice. Each man sheared the entire ten hours, using, alternately three tools and three approaches while under constant supervision. Approximately two thousand trees were sheared during this period.

Insufficient shearing of the foliage was the most common error committed during practice. Unforeseen in the beginning, was an explanation for special consideration for trees having unusual characteristics such as double tops and frost damage. These problems were taken up individually with each man as they arose. The men were instructed to shear the trees as though they were normal with the exception of double topped trees, in which case the poorest of the two tops should be cut out.

Constant supervision was essential at the beginning of the training and practice. This was seldom necessary toward the end of the period.

The final two parts of the time study required the use of three men to be timed and one man to assist in recording data. These three shearers were to be chosen from the five sophomore University students, classified to be semi-skilled and hired for the summer season of 1956 on the Lubrecht Forest.

Since the selection was so limited, the only consideration given as to choice of men was the ability of the individual to perform the shearing job properly. It was attempted to choose three of the five who appeared to be most nearly equal in shearing ability in an effort to keep the variable of men as small as possible. After the practice period was completed, three men were chosen who were of similar height and appeared nearly equal in their production. One man of the five was eliminated due to his height being considerably greater than the others. One was eliminated due to his lack of enthusiasm for the work.

STUDY RESULTS

Part. I. Tool and Approach Testing

This portion of the problem, the determination of the most efficient method of slope approach to the tree and the most efficient tool to use, followed immediately after the instruction, training and practice.

This phase was conducted in a manner that made recording as simple as possible. Each of the three men were used separately but identically, as to procedure. Each man sheared a total of four and one-half hours, broken down to one and one-half hours per tool and one-half per approach per tool. This was accomplished by the man using the first of the three tools continuously for one and one-half hours. During the first half hour he approached all of the trees he was to shear from one of the three approaches, i.e., from below. The second half hour he approached the trees from another angle, i.e., from the side, and the third half hour he approached the trees from the remaining approach, from above. At the completion of this one and one-half hours, the man used the second of the two tools and approached the trees in the manner described above, for one and one-half hours; he then repeated, using the third tool.

A record was kept of the number of trees within each class sheared, time consumed, and the tool and approach employed for each tree sheared. (A sample form of this record is illustrated on page 14 of the appendix.) From the record it was possible to determine when the man shearing should change from one approach to another and when the period of time for each tool had elapsed. As the periods of time were confined to one and one-half hours, it was not believed that it would be necessary to have delays. In the event something unforeseen had arisen within any period, it was assumed that it would be necessary to remeasure the entire hour and one-half period. The periods were not all run concurrently, although to eliminate possible errors in recording, an attempt was made to run them concurrently as much as possible.

The method of timing was by use of a wrist watch having a sweep second hand. Two accounts, shearing time and travel time, were differentiated in each period. Travel time constituted all time consumed when the man was not actually shearing. Shearing time was composed only of the actual shearing time, which began when the man started his first cut on a tree and stopped when he made the last motion of cutting the same tree.

Travel time constituted the balance of the hour and one-half period. It included traveling to the first tree, travel between trees and travel from the last tree. This undoubtedly included many minute elements such as selection of trees to shear or the adjustment of the mens' feet before shearing but these elements were not considered to be essential to the objectives of the study and were therefore assumed to be part of the travel time.

Part I. Results

The planning for this phase was followed as previously outlined. As each tree was sheared by the man being timed, the assistant to the timer and recorder immediately measured the tree by use of a twelve foot stick, marked at two foot intervals, and gave this

TABLE 2. INDICATING THE NUMBER OF TREES SHEARED IN EACH COMBINATION OF TOOL AND APPROACH

		Tool A Approach			Tool B Approach			Tool C Approach		
		A	B	C	A	B	C	A	B	C
Man	Tree Class	No. of Trees	No. of Trees	No. of Trees	No. of Trees	No. of Trees	No. of Trees	No. of Trees	No. of Trees	No. of Trees
	2	18	11	10	16	15	16	10	17	6
	3	15	18	13	9	20	11	20	10	17
1	4	8	10	12	10	9	14	10	9	13
	5	5	2	2	8	2	2	4	2	4
	Total	46	41	37	43	46	43	44	38	40
	2	14	19	18	21	12	9	14	16	14
	3	19	17	20	19	12	13	13	22	20
2	4	15	2	11	7	9	17	11	18	15
	5	1	3	1	4	3	4	1	1	4
	Total	49	41	50	51	36	43	39	57	53
	2	33	19	36	25	16	24	16	18	27
	3	30	16	28	19	23	22	29	21	21
3	4	10	10	9	15	9	16	26	12	13
	5	1	1	3	3	0	7	4	0	4
	Total	74	46	76	62	48	69	75	51	65

measurement to the recorder. A total of 1,362 trees were sheared during this portion of the study. No remeasurement was necessary.

After recording, the data was compiled by two methods. One used the number of trees sheared in each class, Table 2 page 6, and one used the average time in seconds per tree consumed in shearing, Table 3 page 7. These tables are summarized in Table 4 page 8. The data was then analyzed statistically by means of the analysis of variance method, using the number of trees sheared per class, Table 5 page 8, and the average time per tree, Table 6 page 9.

It is believed that the statistical determination using the average time, Table 6, is a more accurate way of determining the significant differences. This method eliminates "weighting" in any particular tree class caused by a greater number of trees being sheared in one class than another. When the number of trees in each class is used there appears to be more error possible in interpretation of the results since any one class could have more or less trees within it than the others. This happened in this study due to the men shearing more trees in the smaller classes.

From Table 6, significant differences at the one per cent level were found for men employed, tree classes, and for tools employed. Calculated using the number of trees sheared in each class, Table 5, significant differences at the one per cent level were revealed in approaches employed and the interaction of tools and tree classes.

It was reasonable to expect a significant difference between men and it was anticipated that there would be considerable difference within tree classes due to the type of stand used. Tools employed, significant at the one per cent level, indicated one of the three tools was significantly more efficient than the other two. From an inspection of Table 4 it is evident that Tool A, or the hedge shears, had less average time and was therefore significantly more efficient than the other two.

The most efficient approach was not so readily apparent as was the most efficient tool. Approach was not found to be significant at the one per cent level when calculated by either average time or number of trees; however, it did appear, at the five per cent level, to be significant using number of trees. This indicated that approach used is not too significant statistically. It was therefore necessary to determine the approach that was most efficient by use of the notes collected during observations of the test and the summaries of the test results, Table 4.

Approach, from the observations made, appeared to be diversified in its effect upon the individuals shearing. When approaching trees from above, taller trees were sheared; when approached from below, the same trees might be left unsheared, apparently appearing too high.

Slope advantage is a true advantage and taller trees are sheared when the approach is from above on a moderate slope. On slopes up to about twenty per cent very little advantage is gained by approaching from above.

TABLE 3. INDICATING THE AVERAGE TIME, IN SECONDS PER TREE, UTILIZED IN TESTING TOOLS AND APPROACHES

		Tool A Approach			Tool B Approach			Tool C Approach		
Man	Tree Class*	A Sec.	B Sec.	C Sec.	A Sec.	B Sec.	C Sec.	A Sec.	B Sec.	C Sec.
1	2	28.1	29.4	25.5	28.5	26.7	37.5	29.0	31.4	31.5
	3	35.5	32.6	36.1	48.1	38.2	38.8	36.0	33.8	35.8
	4	37.9	48.8	46.0	50.6	46.0	56.8	47.0	41.9	43.8
	5	54.6	48.0	54.3	62.0	58.5	60.0	57.0	51.0	61.8
2	2	28.8	25.6	22.6	37.6	32.1	38.2	30.5	32.2	26.2
	3	31.2	31.6	25.6	38.6	52.1	41.2	29.8	36.1	28.8
	4	32.4	32.3	31.9	41.5	43.9	45.2	34.5	34.3	34.7
	5	46.0	42.2	35.0	58.0	65.6	64.0	61.0	46.5	38.2
3	2	17.5	19.3	15.6	25.3	23.9	22.9	16.3	18.0	17.3
	3	24.0	23.5	20.9	36.9	37.8	35.0	23.1	22.0	26.7
	4	25.0	31.4	24.7	49.5	46.8	43.3	29.1	29.2	31.8
	5	27.0	36.0	31.5	42.0	0	0	31.0	38.7	42.0

*Some class 6 trees were measured but too few samples were involved for analysis purposes.

TABLE 4. SUMMARY OF TABLES 2 AND 3 FROM PART I.

		No. of Trees Sheared From Table 2	Total Time in Seconds From Table 3
	1	378	1528.5
Man	2	419	1376.0
	3	566*	985.0**
	A	483*	1330.9
Approach	B	404	1287.4
	C	476	1271.2**
	A	460	1158.4**
Tool	B	441	1473.1
	C	462*	1258.0

*Indicates the man, approach and tool shearing the greatest number of trees.
**Indicates the man, approach and tool using the least total average time.

Approaching from below has definite disadvantage if the terrain has moderate to steep slopes since travel progress is slowed and shorter trees are sheared. Too, approach from below, or uphill, is tiring to the individual shearing and he tends to slack off on the quality, as well as the quantity of his production. The easiest method of approach on all terrain appeared to be from the side or along the coutour of the slope.

From Table 4 page 8, in a comparison of the number of trees sheared in the three approaches, the sidehill approach "C" was second in quantity of production. On the basis of average times, side hill approach held the lowest average time although it was not a great deal less than the next lowest, downhill approach.

From the statistical analysis, summaries, and observations, it was decided that tool C, hedge shears, and approach C, sidehill, were the most efficient and they were selected to be employed in the balance of the time study.

Miscellaneous observations concerning the tools and approaches tested during this phase were interesting and in some cases warrant consideration if shearing were to be done on a practical basis. The tools used varied considerably in their ability to do certain jobs well. The pruning clippers surpassed the other tools in ability to cut larger twigs, up to about one-half inch in diameter, and they also were effective on dried or dead material that it was necessary to cut occasionally.

The grass shears were probably the most accurate and excellent results were obtained, particularly when cutting succulent twigs. They also were easier for the men to manipulate since the spring forcing the jaws apart required less force to operate.

The hedge shears proved to be more adaptable to windy weather than the other tools, due to the relatively long cutting blades that could catch most of the twigs even if they were swaying in the wind. Breezy conditions caused the men shearing to catch the branches in one hand and manipulate the shearing tool with the other when using either the grass shears or pruning clippers. It is expected that hedge shears would be more accurate if used consistently for many days, although their accuracy in this test was entirely satisfactory.

TABLE 5. STATISTICAL DETERMINATION OF PART I COMPUTED WITH NUMBER OF TREES SHEARED IN EACH CLASS.

Variance	Sum of Squares	Degrees of Freedom	Variance	Actual F	Theo. 5%	"F" 1%
Total	6,753.44	107	63.12	—	—	—
Tree Classes	4,134.92	3	1,378.31	84.310	2.75	4.10**
Men	542.91	2	271.45	16.610	3.14	4.95**
Approaches	106.24	2	53.12	3.249	3.14	4.95*
Tools	7.46	2	3.73	.228	—	—
Men × Tree Classes	403.38	6	67.23	4.112	—	—
Tools × Tree Classes	235.28	6	39.21	2.399	2.24	3.09*
Men × Approaches	145.37	4	36.34	2.223	—	—
Men × Tools	24.98	4	6.25	.382	—	—
Approaches × Tree Classes	21.61	6	3.60	.220	—	—
Tools × Approaches	19.65	4	4.91	.301	—	—
Error	1,111.64	68	16.35	—	—	—

**Significant at 1 per cent level.
*Significant at 5 per cent level.

TABLE 6. STATISTICAL DETERMINATION OF PART I COMPUTED WITH AVERAGE TIMES

Variance	Sum of Squares	Degrees of Freedom	Variance	Actual F	Theo. 5%	"F" 1%
Total	17,104.94	107	159.86	—	—	—
Tree Classes	5,012.28	3	1,670.76	34.392	2.75	4.10*
Men	4,366.02	2	2,183.01	44.936	3.14	4.95*
Tools	1,437.27	2	718.64	14.793	3.14	4.95*
Approaches	52.96	2	26.48	.545	—	—
Men × Tree Classes	1,658.99	6	276.50	5.692	—	—
Tools × Tree Classes	516.74	6	86.12	1.773	—	—
Men × Tools	323.83	4	80.96	1.666	—	—
Approaches × Tree Classes	175.95	6	29.33	.604	—	—
Men × Approaches	165.90	4	41.48	.854	—	—
Tools × Approaches	91.42	4	22.86	.471	—	—
Error	3,303.58	68	48.58	—	—	—

*Significant at 1 per cent level.

Part II. Production Timing

Part II, of the time study, utilized the best tool and the most efficient method of approach as found in Part I, and the same three men did the shearing. A total of 5,713 trees were sheared during this portion of the time study. No remeasurement was necessary.

The test consisted of the three men shearing, one at a time for three days duration. Each shearer was prepared to begin work immediately upon arrival at the shearing area and the time was recorded from the moment he picked up the shearing tool until he returned it to the vehicle of transportation. All intervening time was accounted for.

The total time was broken into four categories; shearing, travel, necessary and unnecessary delays. Shearing time included only the time consumed in shearing each tree, beginning with the first cut and ending with the last cut on each tree. Travel time constituted all other time excepting delays, breaks and lunch periods, and included traveling to the first tree, traveling from tree to tree throughout the day, and traveling from the last tree. Travel time was considered in the same manner as in Part I. Necessary delays included items such as sharpening of the shearing tools. Unnecessary delays were deemed to be delays which were not necessary for the production of shearing. Each delay was recorded and a brief notation was made of its character.

TABLE 7. INDICATING THE NUMBER OF TREES SHEARED IN EACH CLASS IN PART II.

		1st Day		2nd Day		3rd Day	
Man	Tree Class	AM No. of Trees	PM No. of Trees	AM No. of Trees	PM No. of Trees	AM No. of Trees	PM No. of Trees
	2	93	105	93	127	112	73
	3	79	72	63	90	97	87
1	4	52	54	49	56	42	64
	5	20	36	40	25	29	41
	6	11	15	10	3	8	15
	Total	255	282	255	301	288	280
	2	55	97	130	86	88	106
	3	86	92	82	89	84	116
2	4	58	76	55	77	73	60
	5	53	44	35	46	46	28
	6	16	9	12	20	23	17
	Total	268	318	314	318	314	327
	2	94	79	115	137	160	104
	3	96	78	90	147	127	131
3	4	83	91	75	76	78	77
	5	82	40	37	56	33	41
	6	12	9	17	8	4	16
	Total	367	297	334	424	402	369

TABLE 8. INDICATING THE AVERAGE TIME, IN SECONDS PER TREE, SHEARED IN EACH CLASS IN PART II.

		1st Day		2nd Day		3rd Day	
Man	Tree Class	AM Sec./Tree	PM Sec./Tree	AM Sec./Tree	PM Sec./Tree	AM Sec./Tree	PM Sec./Tree
	2	29.24	27.75*	28.54	25.50*	26.09	24.12*
	3	35.63	30.97*	33.81	30.41*	29.32	28.74*
1	4	45.87	35.50*	40.10	38.52*	36.26	36.20*
	5	64.90	48.78*	58.58	52.60*	59.55	51.90*
	6	75.36	69.60*	78.20	67.00*	83.00	78.87*
	2	24.40	21.12*	24.86	22.23*	22.61	22.51*
	3	31.34	26.77*	28.99	26.63*	27.86	26.25*
2	4	35.07	32.97*	34.87	31.84*	29.90	33.28
	5	48.55	41.48*	43.49	41.00*	42.87	41.96*
	6	64.75	64.56*	67.50	56.65*	58.61	62.65
	2	16.11	20.37	17.34	14.36*	15.86	14.41*
	3	23.57	30.96	28.50	23.44*	25.58	25.50*
3	4	29.81	38.51	35.95	30.45*	33.96	33.21*
	5	39.01	48.60	46.16	40.07*	41.27	43.59
	6	53.92	59.56	59.59	57.88*	51.50	54.69

*Indicates less average time per tree than in AM of the same day.

All of the day and half-day periods consisted of the same number of hours and minutes. The time could be calculated at any point and it was thereby possible for the time recorder to direct the shearer when to stop work in order to keep the times constant.

The time record, titled Shearing Time Record, was kept on a cumulative basis for each day (Sample Form, page 14 in appendix.) It was titled to indicate pertinent identifying information. All timing was done with a wrist watch having a sweep second hand.

The location of the field work of this time study was conducted on the Lubrecht Forest and since the men employed on the forest resided in Missoula, their total travel time each day was not truly indicative of travel time in a typical situation. Missoula is located thirty miles from the Lubrecht Forest and travel time normally varies with weather and traffic. Also, after arriving at the entrance to the forest, the men still had to be transported several miles to the shearing area. In order to secure a typical average travel time to the shearing area that could be utilized in the analysis of data, the time consumed in traveling from the entrance of the forest to the shearing area was noted as the time desired. For cost analysis purposes the number of miles traveled to and from the shearing area and the forest entrance was also determined. The time was recorded to the nearest minute and the distance was recorded to the nearest tenth of a mile.

Part II. Results

As in Part I the data was compiled by two methods, one using the number of trees sheared in each class, Table 7 page 9, and the other basis was the average time per tree, in seconds, consumed in shearing, Table 8 page 10. These tables are summarized in Table 9 page 10. The data was then analyzed statistically using the analysis of variance method as in Part I. Tables 10 and 11, pages 11 and 12, contain the statistical analysis. As in Part I it is believed that the statistical analysis using the average time per tree, Table 11, is a more accurate way of determining the significant differences since it eliminates "weighting" in any particular class caused by a greater number of trees being sheared in one class than another.

From Table 10 the comparisons show significant differences at the one per cent level

TABLE 9. SUMMARY OF TABLES 7 AND 8 PART II.

		No. of Trees Sheared From Table 7	Total Time in Seconds From Table 8
	1	1661	1372.8
Man	2	1859	1137.6
	3	2193	1053.7
	1	1787	1215.0
Day	2	1946	1186.9
	3	1980	1162.1
AM		2797	1830.1*
PM		2916	1162.1*

*3 Days average time

for men employed and for tree classes. A significant difference at the five-per cent level was found for the interaction of days by tree classes.

Using the basis of average times, Table 11, significant differences at the one per cent level were found for men employed, tree classes and for the interactions of men employed by morning and afternoon production, and for men employed by tree classes. A significant difference at the five per cent level was found for the interaction of days of production by morning and afternoon production.

In computing the average time consumed to shear in each tree class, the results, Table 8 page , indicated that in eighty per cent of the cases, less average time per tree was used in the afternoon than in the corresponding morning. The difference in average time was not significant in the statistical analysis but when afternoon and morning results were computed in an interaction with men, and with days, a significant difference did arise. In the case of the interaction with men, since men by itself has a significance at the one per cent level, it was assumed this factor was great enough to carry the interaction into the significant level. In the case of the days by morning and afternoon production interaction, the significance was at the five per cent level indicating that erratic work habits or "off-days" are in a sense a reality and there is a true tendency to produce better average time results in the afternoon than in the morning in this particular activity. Comparisons have shown a significant difference, at the one per cent level, between men employed and tree classes in both Part I and Part II. These differences should, therefore, probably be termed limiting factors or at least important factors that could be limiting in production output.

The difference, in this study, between tree classes, could have been greatly lessened by having fewer classes with a greater range in height differences. However, to have kept the statistical difference insignificant between tree classes would have been misleading, as it is an important component of production time, particularly in variable height stands of trees. Though very little control is possible, of this element of shearing, the fact that it can influence production due to its variability is important to recognize.

The men who were employed in this study also varied significantly in their production in both Part I and Part II. This variability is believed to be normal and to be expected. Again, however, it is necessary to recognize that the variability is significantly great enough that it could materially affect production output. It is possible that the difference in production could become either more or less depending upon the amount of supervision or the character of the men concerned. Too, it is possible that differences would diminish over a long term basis due to "off-days" cancelling one another and due to uniformity through long practice. However, it must be recognized that some individuals would probably always maintain better production if for no other reason than that they possess a high manual dexterity.

TABLE 10. STATISTICAL DETERMINATION OF PART II COMPUTED WITH NUMBER OF TREES IN EACH CLASS.

Variance	Sum of Squares	Degrees of Freedom	Variance	Actual F	Theo. "F" 5%	Theo. "F" 1%
Total	127,606.5	89	1,433.78	—	—	—
Tree Classes	102,052.4	4	25,513.10	117.437	2.56	3.72**
Men	4,819.8	2	2,409.90	11.093	3.18	5.06**
Days	707.7	2	353.85	1.629	—	—
AM-PM	157.3	1	157.30	.724	—	—
Days × Tree Classes	3,697.2	8	462.15	2.127	2.13	2.88*
Men × Tree Classes	2,560.1	8	320.01	1.473	—	—
Men × Days	978.5	4	244.63	1.126	—	—
AM-PM × Tree Classes	673.9	4	168.48	.776	—	—
Days × AM-PM	523.8	2	261.90	1.206	—	—
Men × AM-PM	138.9	2	69.45	.032	—	—
Error	11,296.9	52	217.25	—		

**Significant at 1 per cent level.
*Significant at 5 per cent level.

TABLE 11. STATISTICAL DETERMINATION OF PART II COMPUTED WITH AVERAGE TIMES

Variance	Sum of Squares	Degrees of Freedom	Variance	Actual F	Theo. 5%	"F" 1%
Total	23,730.676	89	266.64	—	—	—
Tree Classes	20,542.785	4	5,113.20	601.77	2.56	3.72**
Men	1,823.79	2	911.86	107.32	3.18	5.06**
AM-PM	102.72	1	102.72	12.09	—	—
Days	46.72	2	23.36	2.75	—	—
Men × Tree Classes	534.43	8	66.80	7.86	2.13	2.88**
Men × AM-PM	158.00	2	79.00	9.30	3.18	5.06**
Days × AM-PM	74.23	2	37.11	4.37	3.18	5.06*
Days × Tree Classes	70.24	8	8.78	1.03	—	—
AM-PM × Tree Classes	19.15	4	4.79	.56	—	—
Men × Days	6.85	4	1.71	.20	—	—
Error	441.82	52	8.50	—	—	—

**Significant at 1 per cent level.
*Significant at 5 per cent level.

Observations during this phase indicated an important consideration to be made when men are shearing. The men should be assigned or instructed to shear a strip of trees approximately twenty to thirty feet in width. This is necessary to prevent the men from wandering and consequently missing some of the trees. Strip lines of string might also be worthwhile to keep the men in the proper area, since when they are shearing they do not tend to keep continuous track of their relative position. A width of thirty feet is probably the greatest that could be accommodated on fairly gentle slopes; as the slope per cent increases, the width of the strip should be decreased.

Production

The total of 5,713 trees sheared during Part II was further broken down, by per cent and number into the tree classes indicated in Table 12 page 12.

Time Breakdown

The delays incurred were all of a necessary nature and are, therefore, all added into the category of necessary delays. Two travel times are distinguished within the following computations also; Truck-travel is the one incurred in traveling to and from the shearing area by truck, from the entrance to the Lubrecht Forest. The other travel time is the one incurred traveling from tree to tree while shearing and traveling to and from the first and last tree sheared each day; this time is distinguished by the name of Shear-travel time. Table 13 page 12, contains a breakdown of the production time incurred in shearing the 5,713 trees.

To determine the average production per hour, of total production time, the total number of trees was divided by the total hours. This result indicated an average hourly production of 90.53 trees per hour for the entire phase. 90.53 multiplied by the number of actual working hours each day would give the average daily production. For example in an eight hour working day the production to be expected, per man, equals 8 multiplied by 90.53, or about 724 trees.

TABLE 12. THE NUMBER AND PER CENT OF TREES SHEARED IN EACH CLASS IN PART II.

Tree Class	Trees Sheared per Class	% of Total
2	1854	32.5
3	1706	29.9
4	1196	20.9
5	732	12.8
6	225	3.9
Total	5713	100.0%

TABLE 13. THE NUMBER OF HOURS AND PER CENT OF TIME USED IN PRODUCTION IN PART II.

	Number of hours	% of Total
Shearing time	49.67	80.1
Shear-travel time	5.57	9.0
Truck-travel time	3.3	5.3
Delay (necessary) time	.5	.8
Breaks	2.91	4.7
Total	61.95 Hrs.	99.9%

SUMMARY AND CONCLUSIONS

Douglas-fir Christmas trees represent an important source of forest income to western Montana. In recent years the quality of the trees produced has been so low as to be detrimental to the reputation of the western Montana producers. This has raised the possibility that many Christmas tree buyers may begin purchasing in other areas of the United States, with a subsequent loss to the Montana producers.

The problem of low quality can be corrected through the proper application of good forestry management principles. Among those principles are cultural practices which include shearing. Those factors affecting quality can be favorably manipulated by shearing.

The objectives of this study were to determine the production cost of applying shearing to typical wild stands of Douglas-fir and apply that cost in an analysis of the price structure prevailing in the industry, in western Montana, in 1956-57. Time studies were believed necessary to achieve reliable production records.

After participating in an instruction, training, and practice period, conducted by the writer, three men were chosen to participate in a timed study to determine the most efficient tool of three tested and the most efficient slope approach of three tested. After statistical computations and consideration of summaries and observations of the tests of tools and approaches, hedge shears and the side hill approach were considered to be the most efficient. Using the same three men, for a period of three days each, and using hedge shears and sidehill approach, time studies were conducted to determine hourly production.

An estimated 2,000 trees were sheared during the instruction, training and practice period. While determining the most efficient tool and approach, 1,362 trees were sheared and an additional 5,713 were sheared in the final phase.

A statistical analysis of the time study tests indicated highly significant differences, at the one per cent level, between men employed, and tree classes used. These differences, though expected, deserve special consideration in any situation such as a practical shearing operation. Either the men employed or the tree height distribution could materially affect production figures. It is believed that the men employed, if tested after a considerably greater amount of shearing had been accomplished, would have tended to be more nearly equal in their production. It is also possible that supervision would be advisable, until the dependability of the men as to work habits had been established and the less dependable ones removed. Tree height distribution will always warrant consideration due to its obvious effect on production. It would probably be profitable to conduct a sample cruise, in a proposed shearing area, to determine stand height distribution and compare it, percentage wise, to the results obtained in this study. The expected production per hour or day could then be adjusted accordingly, allowing a reasonable cost estimate to be made of the proposed shearing.

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TOOLS AND APPROACH TIME RECORD

Shearer's Name: ....

Date: ....

Weather: ....

Area Number: ....

Tool:
- A - Hedge Shears
- B - Hand Clippers
- C - Grass Shears

Approach:
- A - Uphill
- B - Downhill
- C - Sidehill

Time		Tool			Approach			Tree Classes					
Travel	Shear	A	B	C	A	B	C	1	2	3	4	5	6

SHEARING TIME RECORD

Shearer: ....

Date: ....

Area Number: ....

Time		Delays	Tree Classes					
Travel	Shear		1	2	3	4	5	6

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