areas of poor site quality and areas on which reproduction is poor.

7. -Order in which work will progress.

(12) Records of cost and accomplishment.

(a) Weekly progress of acreage covered to be shown on base map.

(b) A monthly record of man-hours and accomplishment on various lines of work, such as:

1. Snag falling.
2. Sanitation cutting.
3. Cleaning.
4. Thinning.
5. Slash disposal.

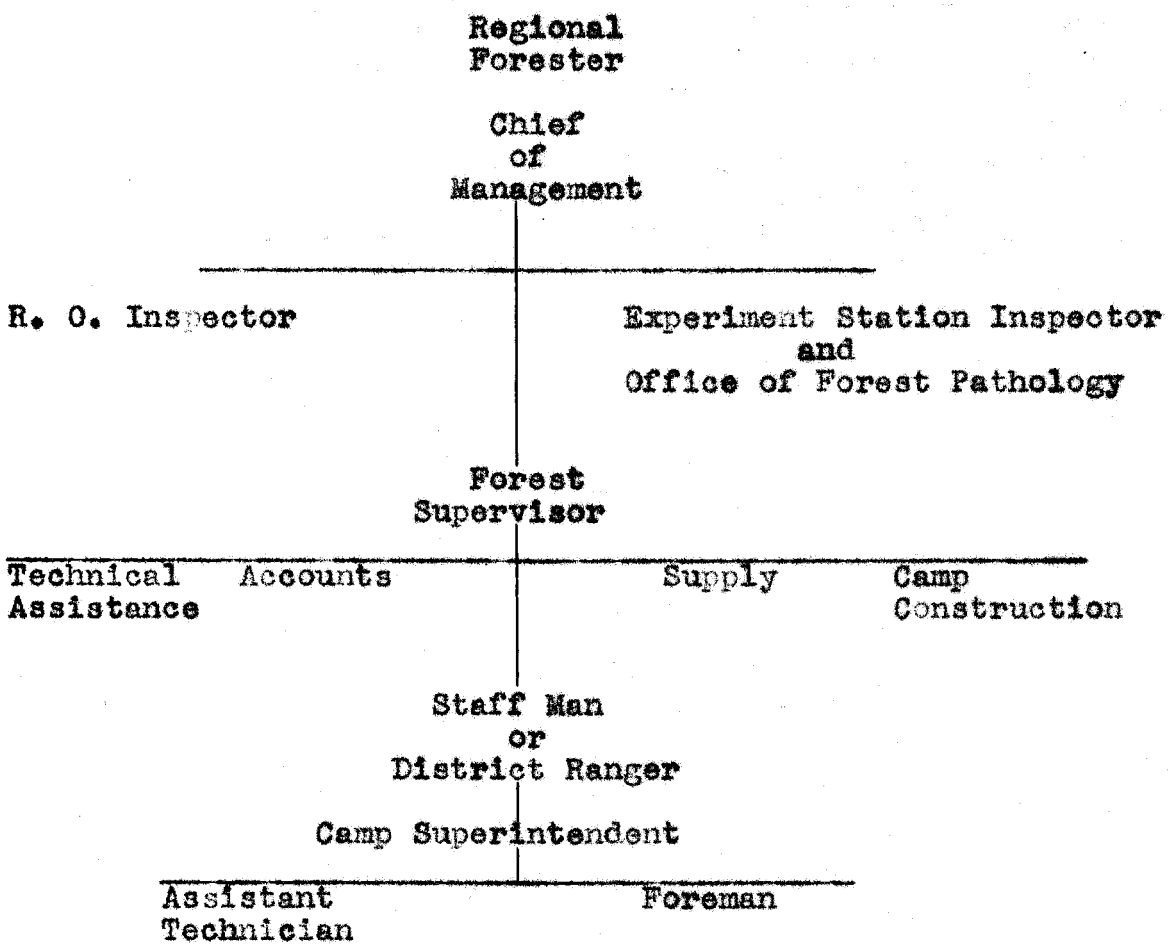
(c) A record by species and tree class (sapling, pole) of the number of trees released and number cut.

(d) A tally of the snags felled on area.

(e) A similar tally for sanitation trees felled on area.

ORGANIZATION

The set-up for the administration of this work can best be shown by a "line-staff" diagram:



DUTIES

As worked out for the California pine region[1] the chief of management, in addition to approving projects and preparing general plans and instructions for the work, makes the allotments, orders the equipment that can not be better ordered or purchased locally, and selects the camp superintendents and assistant technicians. The forest supervisor hires the labor and is responsible for the conduct of the work for camp construction, administration, supply and accounts. Experiment station men and regional office inspectors will ordinarily function in advisory capacities. The decision of whether a supervisor's staff man or a district ranger should be put in charge of the work must be made by the supervisor. Probably a staff man should be appointed since a ranger usually has plenty of work of the ordinary routine to keep him busy.

A thirty-man camp was found to make an efficient organization in the pine region. This unit consisted of a camp superintendent, two assistant technicians for the statistical field work, two or three "straw bosses," twenty-four laborers, one cook, one bull cook, and one flunkey.

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1. U.S.F.S. "Instructions and Information Concerning Stand Improvement Work, California Region." Pages 13-14, 1934.

The duties of camp superintendent would consist of complete responsibility for all camp activities, laying out work for the crews, making inspections, and submitting reports to the supervisor.

The duties of assistant technicians would be to establish area control lines, make progress maps, and take care of the "slave" work on details.

The "straw bosses", or foremen, would each have active supervision of a crew of 5 to 12 men and be responsible for the actual cutting work.

TECHNIQUE OF FIELD WORK

TRAINING

The first move in training the men ("cutters") is to make sure of the fact that they understand the desired objective. Obviously, the instructor must know what he is trying to impart to the workers. If he does not succeed in showing the men what is wanted, no amount of training will be beneficial. Just as any man can shove cants through a sawmill edger, and make "boards" without any knowledge of grades, so can the forest worker "slash down" trees and not know why he is doing it. To instruct the men in the "why" of the work, several methods are available. One way is to blaze the trees which should be cut

or left (it is preferable to mark the trees to be cut since scarred crop trees are liable to fungi attack) and follow along with the workers as they cut, telling them why such trees were or were not marked. The psychology of this method is to get the men to ask questions and to try and pick out any mistakes made by the markers. As the reader will perceive, this is more or less of a mechanical method, slow in results, but probably the best plan for workers who are not skilled woodsmen.

Another way is to tell the men what is wanted and let them go ahead and by trial and error, instruct themselves. This is a shorter method, but the initial results are not very encouraging. It presupposes that the members of the cutting crew are trained woodsmen and have sufficient intelligence to get a grasp of the situation.

A combination of the two methods is more desirable. This involves a short preliminary instruction of a day or two, whereby the men are told why the work is being done, followed by a demonstration of the methods to employ in different stands. They then begin actual cutting. Since no one method will meet all the conditions encountered, it is best to have expert marking in advance of the crew for a period of several weeks. The experience of the writer is that it takes approximately 4 to 6 weeks to train a crew properly. With inexperienced woodsmen the time may

be longer. Mixed stands are more difficult than pure stands. Uneven aged or sized stands are more perplexing than stands of the same general crown level. After cutting in a marked stand for a day or two, the foreman should assemble the men and select one man to designate the trees he would cut out of a small unmarked area. The superior then questions the worker to see that he understands the principles involved. He should have a reason for everything he has done. This type of "conference" does much towards bringing about satisfactory results as well as making the cutter interested in the work.

The man in charge of the crew should guage the progress of training in the light of accomplishment. If, within a week's time, the cutters have grasped the following fundamentals, satisfactory progress is being made:

1. That crop trees are selected on the basis of form and vigor, by species. Straight stems, length and width of crown, dense foliage, healthy appearance, and rate of growth are "indicators" to use.
2. That the primary objective is not exact spacing but to give the selected crop trees proper growing space and room for development. This reiterates the principle that

3. A tree is not cut unless its removal benefits another.

4. That individuals growing on the outer edges of groups should be favored if their removal would materially reduce the total crown space originally occupied by the group. The cutter should realize that this may entail the leaving of an undesirable species at times.

5. That leave trees cannot be chosen by looking at the bases of the trees. A "size-up" of the trees from the crown down is the only method of making selections.

APPLICATION

Cleaning and Thinning measures

Crews consisting of 5 to 12 men and one foreman are started out in designated workable areas, the areas being either encompassed by legal subdivisions or by topographical boundaries.

Standard equipment for crews in the fir region consists of 2½ pound double bitted axes[1] and in the pine region brush hooks and one to three axes.[2]

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1. U.S.F.S. "Report on Project Costs" Stand Improvement, Fremont, p.6, March 20, 1935.

2. U.S.F.S. "Instructions and Information Concerning Stand Improvement Work California Region." page 10, 1934.

The areas are worked in strips, the men abreast, with either end man acting as "wheeler" for the previously worked strip. In the ponderosa pine region a crew of 5 to 8 men is preferable since the reproduction generally occurs in groups with intervening open spaces. A larger crew would be spread out too much for one man to supervise. A strip one-half chain in width is about the average for each man. The width varies, of course, with the stand. In dense sapling stands of Douglas fir, the men might be working within 8 or 10 feet of each other. In such a case the size of the crew could be increased effectively to 10 or 12 men under one leader. The density and composition of the stand determine the size of the crew and the width of strip which each man can treat effectively. Like other activities in the woods, work should be done on an "up-hill" basis. To any one who has tried standing on sloping ground above a tree and cutting it, the difficulty is apparent. The bottoms of draws or ravines make good base lines in areas where the topography is broken. A "control" strip is made by cutting from the head of the draw up to the crest or point on one side. The crew then walks down to the bottom of the ravine and brings up another strip parallel to the first strip or

cutting into the initial strip, depending on the lay of the land. An added advantage of this "back-tracking" method is that the crew has an opportunity to look over the work and correct any mistakes. If a narrow bench is at the crest of the hill, the last strip run up the hill can "swing around" and treat the area, tieing in with the termination of the initial strip. The other side of the draw is worked in the same manner.

The foreman must watch and see that the crew adjusts itself to the varying density of the stand. The tendency is to cut too heavily in open stands and too lightly in dense stands. The former encourages soil deterioration through undue exposure of the site while the latter does not open the stand sufficiently to justify the work being done.

"Opening up" a Douglas fir stand unduly is much more harmful than in ponderosa pine areas. Pine, being less tolerant than the fir will shed its lower branches and prune up naturally unless opened too extensively. Fir, on the other hand, will continue to produce heavy side limbs even after the stand has closed from the thinning.[1]

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1. Meyer, W. H. "Thinning Experiments in Douglas Fir", Journal of Agricultural Research 43:537-548, September, 1931.

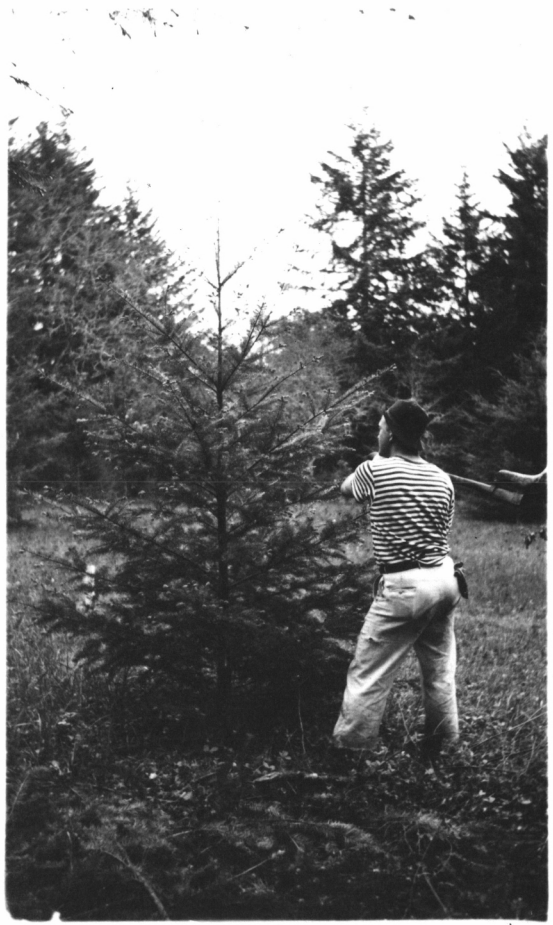
This would indicate that pruning is a complimentary measure in cleaning and thinning work, especially in the Douglas fir type. On pages 48 and 49 is shown an easy method for cutting in sapling stands.

Picture "A" shows a Douglas fir sapling with the worker ready to begin cutting. In Picture "B", two "swipes", one down each side of the bole, have been made. In "C", the top has been lopped off, and in "D" the operation is completed by felling the upright stem. With this method, only four blows with a brush hook or axe are required. Note how the slash is "pressed" close to the ground--no scattering or handling being necessary.

Liberation measures

Liberation measures can be carried on in one of two ways. They can be done by the cleaning and thinning crew in conjunction with their regular work or by two-man crews selected to carry on the work separately. In either case, where the liberation involves felling the undesirable overstory, such cutting should be done before the immediate stand is thinned or cleaned. If the understory is treated first, the leave trees are exposed to damage when the liberation is made. When such damage occurs it nullifies all previous work, since no trees are available to replace the injured crop trees. Where sufficient liberation work is necessary, the appointment of two-man crews is recommend-

Plate 4



"A"

"B"

Plate 5

"C"

"D"

ed. The decision of whether to fell an undesirable overstory (wolf trees) or to remove it by girdling (or poisoning) is often difficult. The answer depends upon whether reproduction is present or not beneath the tree, how much damage will be caused by the felling, whether the condition of the reproduction will stand sudden exposure, the size and age of the wolf tree, the fire hazard, and how much mechanical injury it will do to the crop trees when girdled or poisoned (at the present time no data is available on the use of poisoning on the Pacific coast although its use in some cases is recommended for the Eastern forests)[1]. Hawley[1] points out that unless cutting and taking out the merchantable material will at least pay all expenses of the work, girdling should be employed.

Throughout most of the ponderosa pine and Douglas fir regions oak (Quercus spp.) is a serious overstory problem in young stands. This oak should be removed, but the question is "how, and in what quantities?" No specific rule can be set down for the method of removal since "no two shows are alike," and the disposition of the oak must depend on the factors given. In general, it is cheaper to cut trees which are less than 8 inches in diameter breast-

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1. Hawley, R. C. "The Practice of Silviculture, Third edition, page 135, 1935.

high, and girdle those over 8 inches. Girdling, to be effective, consists of completely severing the cambium.[1] Even then, the tree is not always killed. One oak and one madrone (Arbutus menziesii), girdled on the McDonald forest, are continuing to live 5 years after the time of girdling. Conversely, mature trees were found to die either the first or second year. An axe is a good all around tool for girdling measures.

Small oaks, instead of being severed completely, can be left "hung to the stump" so that the flow of "sap" continues into the down tree, rather than being expended in forming stump sprouts.[3] I do not mean to imply that all oaks should be cut. Reproduction in both pine and fir stands comes in readily under oaks because of (1) lower temperature in the upper soil surface than would be the case in exposed areas, (2) higher soil moisture

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1. Churchill, H. L. "Girdling of Hardwoods to Release Young Conifers". Journal of Forestry, 25:709-714, 1927.

2. Starker, T. J. unpublished manuscript, 1936.

3. Appalachian Forest Experiment Station, "Forest Improvement measures for the Southern Appalachians. Technical Bulletin No. 476, page 20, 1935.

content, (3) suppression of competing vegetation, and (4) lessened acidity of oak leaf litter, as compared with pine or fir litter.

These observations were completed in the summer of 1935 by Charles Lord.[1] He found that on a day when the air temperature was 78°F., the soil temperature was as high as 113°F. on exposed areas.

The removal of wolf trees from the standpoint of fire protection, usually limits the method to actual felling in hazardous areas. This would probably include any areas outside of the so called "fog belt." If girdled by the crew, they only add to the fire hazard. Intensive protection for several years following the treatment would be the alternative measure.

IMPROVEMENT CUTTINGS

In making improvement cuttings, the crew is performing essentially the same operation as in cleaning or thinning, except that the operation is carried on in stands past the sapling stage.[2] Hawley states that improvement cuttings are needed only in stands in which cleanings were not made early in the rotation. It is recommended that the trees to be cut be marked, since,

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1. Lord, C. M. Unpublished Silviculture Manuscript page 4, 1935.

2. Hawley, R. C. The Practice of Silviculture, Third edition, page 177, 1935.

usually the time necessary for members of the crew to make decisions more than offsets the time of an expert marker. Also, when a crop tree is felled by mistake, the loss of such a tree amounts to something, due to the size and age classes represented. In stands of Douglas fir 60-70 years old on average sites, the Forest Service[1] suggests a spacing of 12 to 15 feet. In this type of work not all trees will be cut. At the present time, the Northwest Experiment Station is experimenting on eliminating defective or undesirable trees by cutting or girdling, or by a combination of the two. Old growth Douglas firs, balsam firs, and hemlocks are the worst offenders.

In the Douglas fir stands interspersed with alder (Alnus rubra), what we probably will do is fell or girdle the interfering alder. Since alder commands a good market price for furniture and match stock it deserves respresentation in the final stand, especially on easily accessible sites. One thing against alder though, is its short,

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1. U.S.F.S. "Stand Improvement" Forest Management Handbook, Region 6, part 3, page 9, 1935.

2. Pacific Northwest Forest Experiment Station "A Working Plan for Stand Improvement Study" in Defective Douglas Fir Stands" page 1, Sept. 12, 1935.

pathological rotation,[1] which Westveld sets at 50 years.

The crews are equipped with the regulation felling equipment, saws, axes, sledges, and wedges, along with the necessary saw oil. As indicated, the trees to be removed should be marked in advance by an expert marker who tags the trees writing on the tags whether the tree is to be felled or girdled, the d.b.h., and the species. As the tree is treated, the workers collect these tags and turn them in at nightfall. This procedure permits a check on each crew, as well as furnishing data for cost and treatment records. The rule of thumb that "an average day's work for a set of 'fallers' is 500 inches " should be the standard, although where the walking distance between trees is long or the topography is rough, this figure cannot be attained.

PRUNING

In pruning, the crew must understand that only final crop trees should be "dressed up." Common sense dictates this procedure, since pruning done on trees which do not enter into the final yield amounts to nothing more than wasted effort.[2] In the ponderosa pine type, Woodbury

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1. Westveld, R.H. "Applied Silviculture in the United States" p. 269, 1935.

2. Woodbury, T. D. "Memorandum Regarding Trip to Regions 2, 3, and 8 to study Stand Improvement Activities." page 2, 1935.

suggests that 60 trees per acre should constitute the final crop, which would mean actually pruning 80 trees per acre, thereby allowing a safety margin of 25 per cent. In the Douglas fir type, the United States Forest Service[1] states that 100 trees per acre should form the final crop (approximately 20' x 20' spacing) and here again, a replacement margin of 20 per cent should be provided. The straightest and cleanest trees in the stand should be the selected crop trees.

Stands above certain diameter limits should be passed up by the crew. Hawley[2], Starker[3], and others agree that trees over 4 or 5 inches d.b.h. should not be worked, since one of the principles of artificial pruning is to restrict the central knotty core to a small diameter, thereby favoring the development of as much clear wood as possible.

How much of the live crown should be removed (in addition to the dead branches) presents another problem. In the Douglas fir region, the United States Forest Service[4] recommends that only dead branches should be removed

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1. U.S.F.S. "Stand Improvement" Forest Management Handbook, Region 5, part 3, page 5, 1935.

2. Hawley, R.C. "The Practice of Silviculture."

3. Starker, T. J. "unpublished manuscript," 1934.

4. U.S.F.S."Stand Improvement" Forest Management Handbook, part 3, page 6, 1935.

in open grown stands but accords with others in stating that in closed stands, "live branches may be removed up to but not including the highest of those which interlace with the crowns of adjoining trees." A further provision is that where heights of trees permit, Douglas fir should be pruned to a height of 32 feet, and ponderosa pine to 17 feet. Starker[1] believes that all of the live lower branches and some of the live mid-crown branches are little more than self sustaining--that is, instead of providing for the growth of the tree bole, they manufacture only enough elaborated food material to keep themselves alive. He conducted several experiments on the McDonald forest which would indicate that there is a basis for such belief. The tabulated results are shown on the following page.

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1. Starker, T. J. unpublished manuscript, 1934.

RESULTS OF PRUNING PONDEROSA

PINE ON "BALD HILL", McDONALD FOREST

Average age of stand, 7 years.

Pruned December, 1934.

Measured October-November, 1935.

Number of trees in sample, 100

Leader length in inches:

	1934	1935
Unpruned	1816.75	1842.00
Average	18.17	18.42
Two whorls removed	1630.00	1680.75
Average	16.39	16.81
Three whorls removed	1767.75	1703.75
Average	17.68	17.04

RESULTS:

Greatest leader length for 1934-35, unpruned.
Decrease in growth 1935 under '34, 3 whorls removed.
Greatest accelerated growth, 2 whorls removed.

A pruning crew can consist of men working individually or in pairs.[1] Saubert found that in pruning Douglas fir plantations, age 26 years, that an eight man crew (with one supervisor and one marker) formed an economical unit where the work was carried on individually. He found

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1. Saubert, J. "First Report on Experiment No. 1, Mount Hebo, Siuslaw Forest--Methods of Pruning and Slash Disposal" page 3, January 14, 1936.

that with one man carrying two saws, or with separate men carrying long and short handled saws, the first method had the following advantages:

(a) The trees have to be located only once.

(b) It is more restful to use two methods of pruning. Pruning with the long handled saw is tiresome work, and it is restful to change often.

(c) Each man does an entire tree, and thereby permits a check on his efficiency (trees are tagged in advance and tags are collected as pruning is done).

Under no circumstances should a man be allowed to prune with an axe. Hawley[1] states that an axe is a dangerous pruning tool even in the hands of an expert axeman. It is virtually impossible to secure a smooth cut, while on the other hand a jagged wound usually results. Not only does such a cut cause pitch pockets to form but gives entrance to disease spores. A smooth cut close to the trunk which can be accomplished with short and long handled saws, is the most desirable method. In comparison, pruning shears seem cumbersome and slow for efficient use, as well as requiring considerable muscular effort to work them.

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1. Hawley, R. C. "The Practice of Silviculture" Third edition, page 185, 1935.

COSTS

Cost records are an important item in forest improvement work, since they furnish a measuring stick of what it is going to cost to treat a given stand. Due, however, to the variability of stands and the lack of sufficient data at the present time, cost figures can be used only as an indicator of what the approximate charges will be. Other considerations such as the desires of management, the type of labor, and the like, also influence the charges. Since we are interested in the present net worth of all future returns, it would seem that, mechanically, our technique of getting the basic information should call for high standards of accuracy.

Costs are divided into two categories--direct and indirect. Indirect costs include the charges made for supervision, and as such, cannot be allocated to definite units of accomplishment. Subsistence, camp housing, transport, and miscellaneous are other indirect costs. Probably the best procedure to follow with indirect costs is to charge them against accounts on the basis of man-hours of direct cost, and prorate them periodically. This step comes under ordinary bookkeeping procedure. Direct costs are costs which can be definitely segregated and charged to activities which are measurable in terms of acres or number of trees.

They include pruning, cleaning, thinning, sanitation, liberation, snag disposal, and slash disposal. It isn't necessary to delineate sanitation, liberation, and snag removal measures to any particular acre. Probably what we will do is put them on an average acre basis (divide total cost by number of acres treated), as well as compute the man hours per tree for each type of treatment. This is accomplished by means of the aforementioned system of advance tagging. Knowing the reason for, and the kind of treatment, total hours worked, it is a simple procedure to compute totals, daily and periodic, and ascertain on a percentage basis the number of trees, as well as total d.b.h. inches for each class of treatment. These percentages "times" the total man hours "times" the average rate of pay per hour gives results on a dollars and cents footing. This data is worked up in the office by plotting falling time per acre in terms of man hours of labor over total d. b.h. inches cut per acre.

In cleaning, thinning, and pruning operations, it is desirable to know, in addition to costs, the relationship between man-hours cutting time and the various diameter classes, the time required to treat an area, what happens to the stand after it is treated, the efficiency of various kinds of tools, and if approximate crop tree spacing and

selection requirements are being satisfied. To get the desired information plots are established and field studies conducted.

PERMANENT PLOTS AND TIME STUDIES

Plots for the purpose of time studies can be selected at random. In fact, it may be a good policy to choose the site upon which the time study is to be made and thereby secure a smaller spread of diameter classes for any one plot. In constructing curves from time studies - plotting cutting time per acre in terms of man hours of labor over total d.b.h. inches cut per acre - a better relationship can be shown.

On the other hand, what we are interested in obtaining is data for average stands, and usually we cannot do this by depending on ocular estimates. The tendency is to pick out only the best samples in this type of procedure. To avoid any warping of data we turn to the line plot system of selection. A mechanical method, it embodies the principles of sampling outline by Mason[1] in his writings:

a. Samples should be truly representative of the stand.

b. There should be few samples to a "place" but plenty of "places".

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1. Mason, E. G. "Forest Mensuration" second edition, p. 133, 1934.

c. Samples should be chosen systematically--"as they come". There should be no attempt to select them by ocular methods.

d. Samples should be accurately measured.

One man, using a hand compass and pacing, can lay out the plots at predetermined intervals. One way to delineate the plots from the surrounding area is by using string suspended from the branches of trees included in the plot, or, if no trees are near the "line," midway stakes may be used. The corners should be definitely located by driving in temporary stakes, which later can be replaced by "permanent" stakes, thus creating a permanent plot. These corner stakes are oriented by the compass and distances between them measured by a 6.6 "foot" stick. Plots one chain by a half chain (one-twentieth of an acre) are of sufficient size, and enough plots to represent one percent of the net acre should be set aside. The location of the plots is noted on the survey maps, and from this a permanent record is made. Before cutting into a plot, a stand table, by species, for both the "cut and leave" trees should be made. After cutting, the area is checked to see if the cutting practice coincides with the established standards. The crew, of course, while cutting through the plot is timed.

It is good policy not to tell the crew that it is being clocked, since there is then a tendency to speed-up the operation. Two technicians can best handle the checking and rechecking--one calling out the trees and the other tallying. The data obtained from this procedure permits the construction of curves which show the relationship between the different d.b.h. classes and the cutting time in terms of man hours, for the different types of treatment (cleaning, thinning, and pruning). On page 64 is shown a time curve for cleaning and thinning, based on 121 plots from 6 projects in the ponderosa pine region.

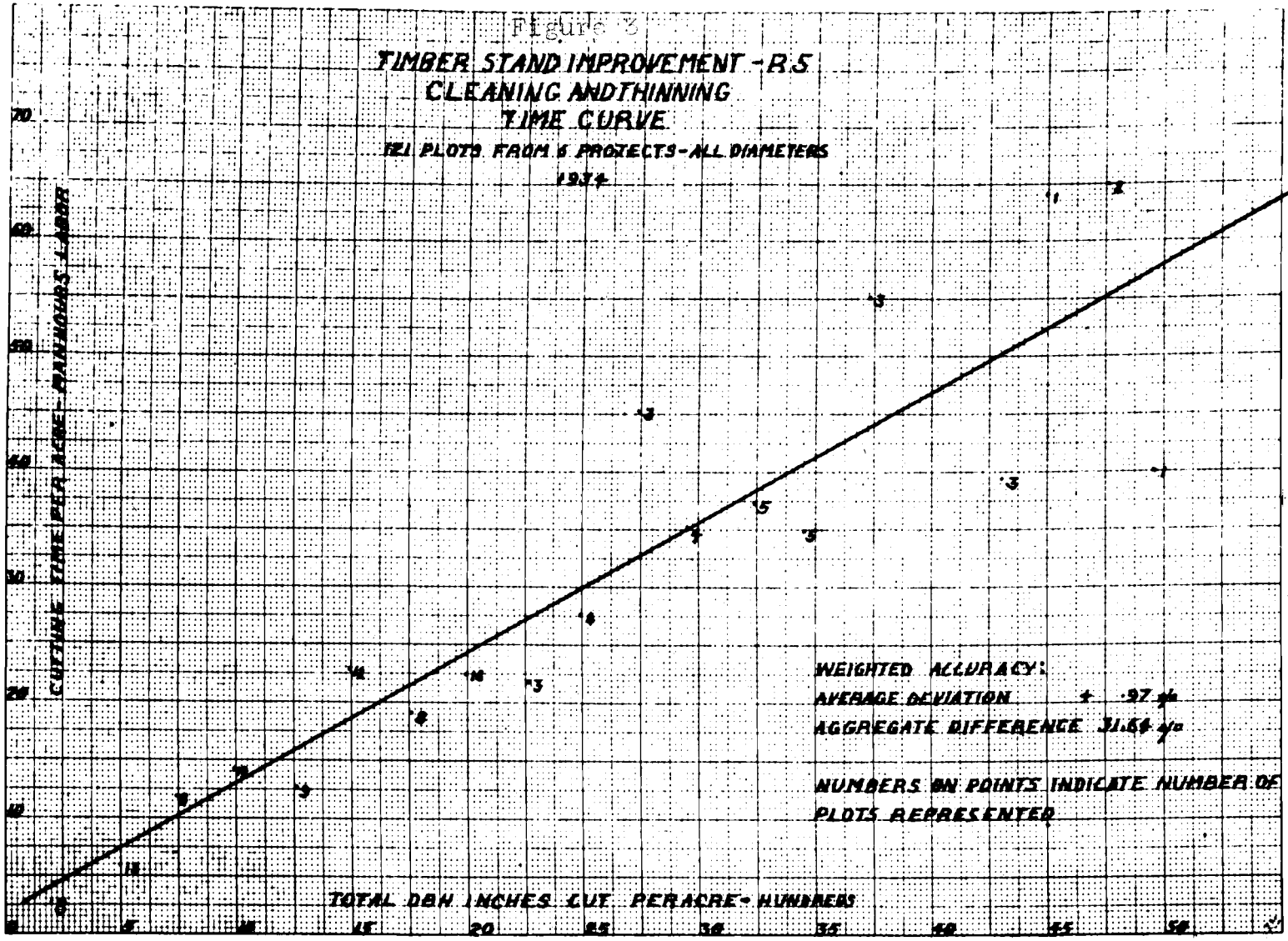
If a cost estimate is wanted, irrespective of diameter classes, all that is necessary is to make use of the following formula:

$$\text{Cost of treating sample} = \frac{\text{man minutes}}{60} \times \text{size of sample} \times \text{average rate per hour.}$$

To get the cost per acre merely requires putting the area of the sample on an acre basis.

A certain percentage of the plots should be set aside as "permanent" plots, so that periodic measurements can be

Figure 3


TIMBER STAND IMPROVEMENT - R.S
CLEANING AND THINNING
TIME CURVE
121 PLOTS FROM 6 PROJECTS - ALL DIAMETERS
1934
CUTTING TIME PER ACRE - MAN HOURS - LABOR
TOTAL DBH INCHES CUT PER ACRE - HUNDREDS
WEIGHTED ACCURACY:
AVERAGE DEVIATION ± .97 p/a
AGGREGATE DIFFERENCE 31.64 p/a
NUMBERS ON POINTS INDICATE NUMBER OF PLOTS REPRESENTED

taken. The crop trees in the plots are measured and then they are labeled with either painted numbers or metal tags. Metal tags are preferable, being more lasting, but often they are collected by "souvenir hunters."

Isolation strips should be provided where check plots are left in status quo for the sake of comparison. The purpose of the isolation strip is not to segregate the plot from the rest of the area but to create the same conditions on the sides of the plot as in the interior.[1] In other words, the isolation strip receives the same treatment as the plot itself.

To draw a conclusion on what it should cost to treat stands of the ponderosa pine and Douglas fir types is not easy. Woodbury[2] contends that costs for cultural forestry work of over $10 per acre in the ponderosa pine are not justified at the present time. On the following page is reproduced a chart which gives a summary of costs for treating 34,315 gross acres in the pine region.[3] The fault with

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1. United States Department of Agriculture. "Sample Plots in Silvicultural Research" Circular No. 333, page 11, 1935.

2. Woodbury, T. D. "Memorandum Regarding Trip to Regions 2, 3, and 8, to Study Stand Improvement Activities," page 12, June 12, 1935.

3. U.S.F.S. "Forest Management Handbook" Region 5, Part 3, Stand Improvement, page 13, 1935.

Figure 4

SUMMARY OF COSTS PER GROSS ACRE

	CAMP PROJECTS (10) Based on 28,216 Gross Acres				NON-CAMP PROJECTS (6) Based on 6,099 Gross Acres			
	Total Costs	Percent of Subtotal	Cost per Gross Acre	Percentage of Cost Per Gross Acre	Total Costs	Percent of Subtotal	Cost per Gross Acre	Percentage of Cost Per Gross Acre
DIRECT CHARGES								
Cleaning	30689.68	38.62	1.087 } (6.146)	25.57	14558.64	43.16	2.387 } 11.228	34.56
Thinning	7866.32	9.90	.279	6.56	2774.60	8.22	.455	6.59
Sanitation	10673.04	13.43	.378	8.89	3374.51	10.00	.553	8.00
Liberation	2009.26	2.53	.071	1.67	2190.15	6.49	.359	5.19
Snags	24591.63	30.95	.872	20.51	8210.30	24.34	1.346	19.49
Slash Disposal	3632.51	4.57	.129 (7.595)	3.04	2624.87	7.78	.431 (13.917)	6.24
Sub-Total Direct Charges	79462.44	100.00	2.816	66.23	33733.27	100.00	5.531	80.07
PRORATED CHARGES								
Supervision								
Area Selection		6.95	.026	.61		3.08	.031	.30
Mapping		26.36	.101	2.38		7.30	.050	.72
Project Plan		1.53	.006	.14				
Boundary Running		4.46	.017	.40		6.46	.044	.64
Time studies		8.33	.032	.75		17.19	.117	1.69
Maint. of Records		39.77	.152	3.57		14.77	.100	1.45
Project Reports		2.63	.010	.24		2.16	.015	.22
General Supervision		9.97	.038	.89		49.04	.334	4.84
Subtotal Supervision	10770.93	100.00	.382	8.99	4153.86	100.00	.681	9.86
CAMP HOUSING								
Construction		82.38	.324	7.62				
Maintenance		17.62	.069	1.62				
Sub-Total Camp Housing	11086.52	100.00	.393	9.24				
SUBSISTENCE								
Net Loss, Cook House	8047.47	100.00 100.00	.285	.285 6.70	6.70			
MISCELLANEOUS								
Small Tools		25.92	.097	2.38		39.27	.273	3.95
Transportation		26.19	.099	2.33		23.00	.160	2.31
Miscellaneous		47.89	.180	4.23		37.73	263	3.81
Sub-Total Miscellaneous	10618.01	100.00	.376	8.84	4248.13	100.00	.696	10.07
Sub-Total Prorated Charges	40522.93		1.436	33.77	8400.99		1.377	19.93
GRAND TOTAL	119,985.37		4.252 (10.60)	100.00	42134.26		6.908 (15.284)	100.00

the direct charges of cleaning and thinning in this chart is that they are figured on a gross acreage basis. The writer has computed the costs for cleaning and thinning on a net acreage basis and encircled them on the chart. The difference obtained is roughly equivalent to increasing the charges for this type of work threefold.

In the Douglas fir region, little information on costs is available at the present time[1]. However, some thinning work has been done and the cost figures for all such projects are listed.[2]

Total and Average Costs--All Projects

Total Allotment	$1,110.00
Material - 10 aces @ $1.76	17.60
Labor: Foreman (Axe man) 322 hrs. @ 80¢	257.60
Axemen-1280 hrs. @ 60¢	768.00
Truck driver-14 hrs. @ 80¢	11.20
	$1,054.40

1. U. S. F. S. "Forest Management Handbook" Region 5, Part 3, Stand Improvement, page 13, 1935.

2. Perry, W. J. "Report on Project Costs" Stand Improvement, R-5, page 1, March 20, 1934.

Transportation: Forest Service Truck transporting camp outfits @ 7¢ per mile	-Mi. 236 -	16.52
Private car taking crews to and from work @ 7¢ per mi.	189 Mi.	13.23
Forest Officer travels @ 5¢ per mile	336 "	16.80
Totals	761	46.55
Forest Officer supervision		99.00
Conditioning and storing equipment		3.00
Grand total cost		$1,202.95

Total acres treated---------- 1580

Average cost per acre - $ .761

Average acres treated per man-hour actually worked by axemen .98

Total area covered 1700 acres, of which 120 acres were very light work, hence reduction to 1580.

The big difference in costs per acre for the two regions is due to the method of treatment used. "Spot thinning," or selecting scattered thickets rather than the entire area for treatment, was practised in the fir region (white fir-ponderosa pine stands).

One rather interesting disclosure in the break-down of costs is that labor charges constituted 81.9 per cent of the total costs in the Douglas fir region and 82.7 per cent in the ponderosa pine.

In pruning work, Saubert[1] found that it took approximately 6 man hours per acre, or roughly $2.75 to prune 100 Douglas fir trees to a height of eighteen feet (age of trees, 26 years). Woodbury[2] believes that pruning can be done for 4 to 6 cents per tree in the pine region.

In general, costs for cultural forestry work must vary with the site, the period since logging (or, if uncut, the condition of the stand), the type of reproduction (whether mixed or pure), and the amount of merchantable reserve timber on the area (the area to be treated by cleaning, thinning, or pruning is reduced by an amount equal to the area covered by the crowns of the reserve trees).

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1. Saubert, J. "First Report on Experiment No. 1, Mount Hebo, Siuslaw Forest--Methods of Pruning and Slash Disposal." page 3, Jan. 14, 1936.

2. Woodbury, T. D. "Memorandum Regarding Trip to Regions 2, 3, and 8, to Study Stand Improvement Activities", page 12, June 12, 1935.

SPECIAL PROBLEMS

Slash disposal

The one main reason for slash disposal, in conjunction with cultural operations, is to afford protection to the treated stand. In the pine region, the first thought was to dispose of all slash, but later when the cost was found to run as high as $9.00 per acre for this type of treatment, the "fireproofing" was confined to strips along trails and roadways[1]. Kreuger[2] points out that one group of extremists believes "that in order to have proper fire protection, all brush resulting from cutting operations should be burned." Not only is this procedure costly but it results in a big humus loss. Vaughn[3], in another article, shows that a crown fire in unthinned reproduction "came down to earth" upon reaching a thinned area. In the light of all this evidence, it would seem that slash disposal in cultural operations,

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1. U.S.F.S. "Annual Stand Improvement Report" Region 6, page 5, 1934.

2. Krueger, T. "Practices and Problems in the Disposal of brush Resulting from Thinnings in Ponderosa Pine in the Black Hills National Forest" Journal of Forestry, 32;757, 1934.

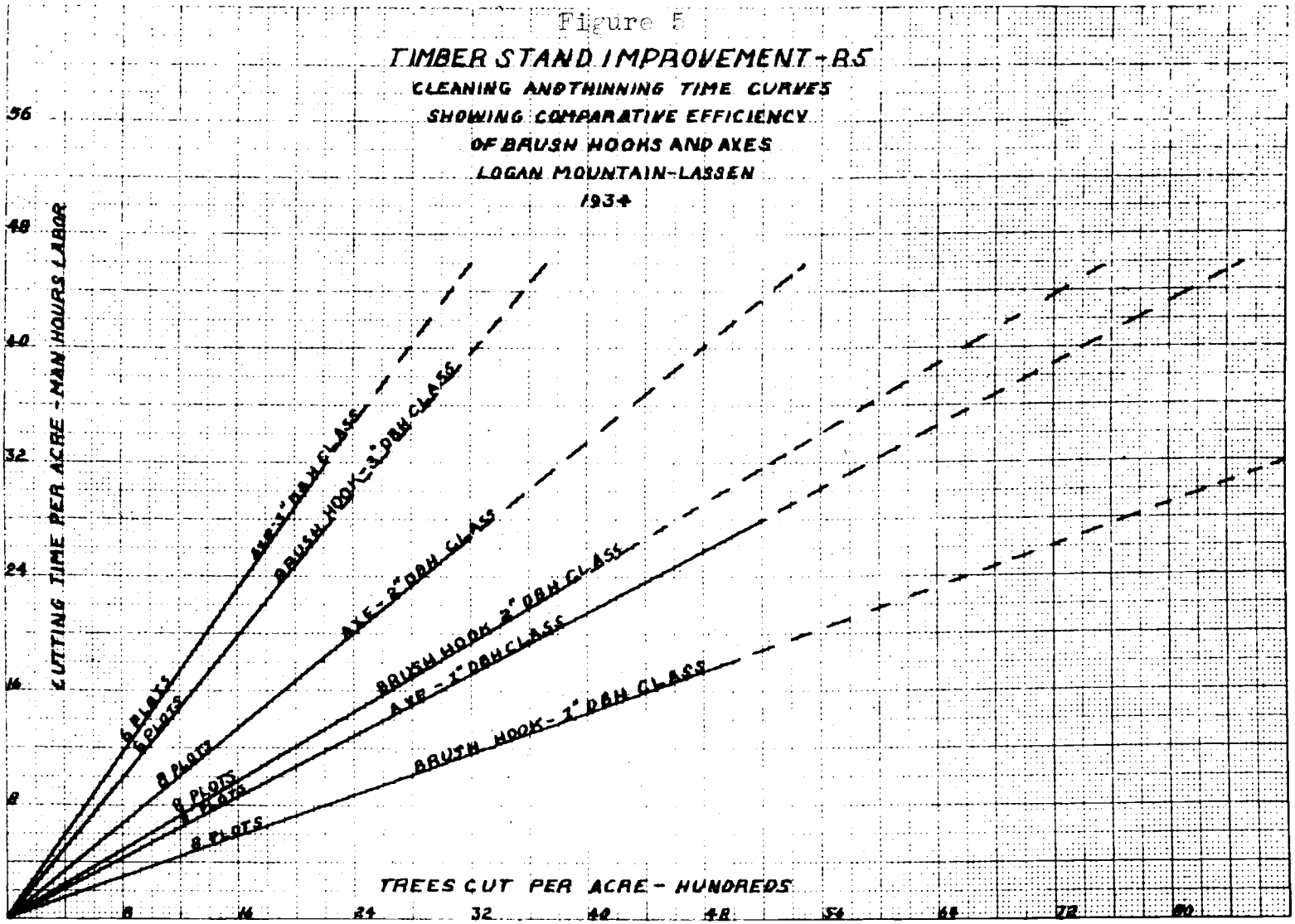
3. Vaughn, W. T. "Fire Control in Thinned Areas" Journal of Forestry, 32:883, 1934.

either in the ponderosa pine or Douglas fir regions is not justified, with the possible exception of piling and burning in strips along main arterials. Usually if a fire does originate or spread into a treated area, it is not difficult to control since the fire-fighter is able to get close to the blaze and rob it of cut material. It would seem to the writer that intensive protection could be substituted for slash disposal on the more hazardous areas, while other areas could be disregarded. Some lopping of slash may be necessary in dense stands of Douglas fir thickets, but only for the purpose of bringing the debris close to the ground and thereby hastening decomposition.

TOOLS

Little has been said about the type of tools for cleaning and thinning activities, except to mention that double-bitted axes have been used in the Douglas fir region and brush hooks (supplemented with one or two axes for material greater than 8 inches d.b.h.) in the ponderosa pine. I have included on the next page time curves which show the relative efficiency of the two types of tools. Practical experience has proven the brush hook to be superior to the axe, and the writer believes that more use could be made of this tool in the Douglas fir region than is now the case. The technique of using a brush hook is different

Figure 5


TIMBER STAND IMPROVEMENT-R5
CLEANING AND THINNING TIME CURVES
SHOWING COMPARATIVE EFFICIENCY
OF BRUSH HOOKS AND AXES
LOGAN MOUNTAIN-LASSEN
1934
CUTTING TIME PER ACRE - MAN HOURS LABOR
TREES CUT PER ACRE - HUNDREDS
AXE-1" DBH CLASS
BRUSH HOOK-1" DBH CLASS
AXE-2" DBH CLASS
BRUSH HOOK 2" DBH CLASS
AXE - 3" DBH CLASS
BRUSH HOOK-3" DBH CLASS
8 PLOTS
8 PLOTS
8 PLOTS
8 PLOTS
8 PLOTS
8 PLOTS
56
48
40
32
24
16
8
8
16
24
32
40
48
56
64
72
80

from that of using an axe, but once mastered, the superiority of the tool is apparent even to the most calloused lumberjack (though he may not admit it). It requires time and patience to convert an axeman to using a brush hook, but once accomplished, it is equally difficult to get him to revert to the axe. The advantages of a brush hook are due to a protecting point which keeps the cutting blade from striking rocks, a wide cutting surface, and safety in use.

Sharp tools are one of the first prerequisites of effective work. Nothing is more discouraging than attempting to work in the woods with dull tools. Good woodsmen take pride in keeping their tools sharp, and will welcome short rest periods during the day, at which time they will touch up their equipment. The felling saws for sanitation and liberation work can be sharpened by one man in the evenings or on weekends. If several camps are in close proximity, one man appointed as filer, may serve all the operations.

PART III

CONCLUSION

The writer is aware of the handicap of dealing with a subject which is very much in the experimental stage, especially in so far as this region is concerned. However, this treatise is an attempt to bring up to date a presentation of the more practical aspects of stand improvement measures in both the Douglas fir and ponderosa pine types. Some of the methods outlined indicate recent advancements, others are patterned after European methods. In either case, they represent the best "tools" that are available for use at the present time. I use the word "best" with reservations. If a plethora of factual data were available from which to select the ideals of doing, well and good; but since this is not the case, the author has had to rely upon empirical methods to acquire much of the necessary information. If it survives the test of time much is gained; if not, it must be remembered only as a transition in the development of cultural forestry.

RECOMMENDATIONS

From an economic viewpoint, stand improvement measures for the Pacific coast should aim at shortening the rotation necessary to produce quality saw timber.[1] As Woodbury explains, this region cannot compete with the southeast in producing timber for manufacturing common lumber. There, the farmer virtually must leave his back door open and be ready to "swat" the seedling trees as they emerge from the soil, lest he be penned in from his fields by the rapidly growing forest. Actually, such a statement is far-fetched, but the truth does remain that the southern pines in early life grow nearly twice as fast as the species in this region. Since our cultural work must be based on the belief that there always will be a good market for high grade lumber, it is necessary that we indicate some procedure which will permit the growing of quality stock on as short a rotation as compatable with present and near-future economic limitations, viz; that little or no intermediate dollars and cents return can be expected, and that the derived value of all cultural work must come from one

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1. Woodbury, T. D. "Memorandum Regarding Trip to Regions 2, 3, and 8, To Study Stand Improvement Activities" page 12, 1935.

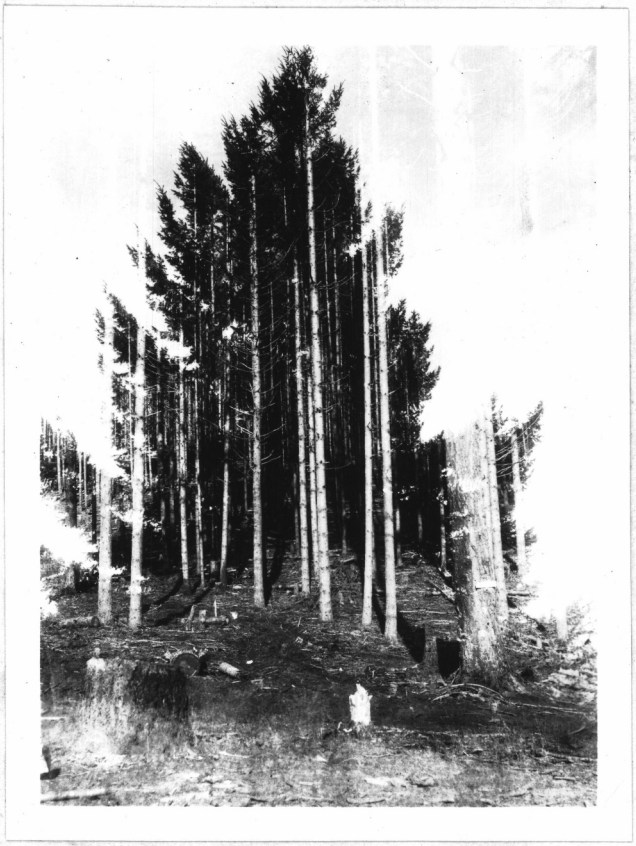
final yield. To stay within bounds financially, we must keep the costs of operation as low as possible, and yet achieve the desired results.

Two treatments during the development of the stand are recommended:

The first will be for the purpose of regulating the density of stocking through providing sufficient growing space for the crop trees. Any cleaning, thinning or liberation work should be done at this time--while the stand is between the ages of 10 and 20 years. Not all trees other than leave trees will be cut. Instead, many non-interfering trees will be left to act as "trainers" and protect the site from any deterioration which would result from undue opening-up of the stand. Any work which can be delayed until the time of the second treatment (probably between the 25th and 35th years, depending upon initial response) should be held over, thereby decreasing the time for which interest charges on costs must be carried.

The second operation will extend the pruning of crop trees to a height of 18 feet, as well as completing any necessary cleaning, thinning, or liberation measures. The reader may wonder if freeing the bole of limbs to a height of 18 feet is sufficient. In pine stands this height will be ample since most authorities agree that in the average stand of ponderosa pine, the first log of the tree contains

40 to 50 % of the total volume. In fir stands, the afterthought is that crop trees should be pruned to a height of 34 feet. This procedure will entail at least three operations, each one being done before the unpruned bole is more than 5 inches in its greatest diameter. Since pruning is a relatively cheap operation, it can be performed more than once. Whether two, three, or even more pruning treatments are given a Douglas fir stand, no doubt must remain as to the necessity of including them as a complimentary measure to cleaning or thinning. Munger writes that a series of measurements on 120 acres of representative Douglas fir plots reveals the interesting fact that the individual trees are just beginning to free themselves of dead limbs (age 79 years) and lay on clear lumber. Since 75 years is the length of rotation the author would like to suggest for use--the reason being that there is more wood volume in an immature stand of this age than in a very old virgin stand, and also because of the fact that it does not seem financially possible to practice improvement forestry for any but short rotations--the pruning of Douglas fir must be done and done early to be of value. Observe on the following page, if you will, a picture of a 50 year old "porcupine" forest of



A "porcupine" forest of Douglas fir, 50 years old. Early pruning would have aided this stand, even though the improvement cutting made has removed the worst trees.

Douglas fir. This picture, truly a remarkable exposure (secured by T. J. Starker,[1] 1936, after many costly and laborious attempts), shows the stand in the process of being treated to remove the more limby individuals. Reader, notice the numerous and heavy dead limbs attached to the boles of the residual trees. This stand is not understocked. It was understocked, though, during the time of establishment, and thick lateral branches developed which, though dead, are still present to cause loose-knotted common grade lumber when manufactured. Besides being costly, pruning could not benefit this stand for a rotation of 75 years. For, if pruned, the clear wood added to the bole would largely be wasted while "slabbing" the log in sawing. The picture, then, better than words brings out the fact that, if and provided we are going to raise quality timber in short rotations on the Pacific coast, improvement measures must be considered in their entirety if the desired results are to be obtained.

The writer does not wish to conclude without recommending that cultural forestry should not have as its goal, the conversion of mixed stands into pure stands by

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1. Starker, T. J. Professor of Forestry; Head of Department, Oregon State College, 1936.

eliminating the "inferior" species--merely to meet the present whims of the market. Remember, if you will, that the species "Red Gum" (Liquidambar styraciflua) was considered a "weed" tree, yet today is one of the most important hardwoods in the United States. Who knows, then, but what "the weed tree of today may be the 'need' tree of tomorrow".

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