LOGGING SURVEY PRACTICE IN THE DOUGLAS FIR REGION

By

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LOGGING SURVEY PRACTICE IN THE DOUGLAS FIR REGION

PART I. - INTRODUCTION

As far as the present day Logging Engineer is concerned, most of his work will, in all eventualities, be limited to the Douglas fir region here on the Pacific Coast. All his survey work will have to be accomplished in a region that is extremely difficult to operate in because of many adverse factors that constantly confront him such as the vegetation, rough terrain, and weather conditions. Thus, it is the writer's intention to present in this thesis a few of these special problems that the engineer will encounter, their solution, and how in turn they influence the size of crew, the type of equipment, and finally, the cost of engineering work. In other words, it is the purpose of this article to show how the general technique of surveying can be applied to the specific problems of the Logging Engineer in the Douglas fir country.
There are three main factors in this region that influence the work and its speed. They are the nature of the terrain, the type of forest and undergrowth and the heavy rainfall. A glimpse at each of these factors will better illustrate the difficulties of the engineer.

The Douglas fir area, in a general way, may be said to extend from the Cascade Mountains to the Pacific Ocean and, for all our purposes, in the states of Oregon and Washington. In this area the land elevation may be anywhere from sea level to five or six thousand feet. The higher ground is more or less characterized by long steep slopes while the country closer to the Coast line is, in the main, low in elevation but, on the other hand, choppy and cut up. Thus the terrain is one of the major problems.

The dense forest and undergrowth present another handicap. The timber in all parts of the region is of large size and extreme density which tends to lessen the visibility. The undergrowth problem is more or less confined to the Coast region or in places where the elevation is under six or seven hundred feet. In the higher areas the brush is considerably thinned out and, in most cases, is no factor at all in the speed of the work.

Last, but of major importance in our work are the weather conditions encountered. The whole region is characterized by its heavy rainfall. This coupled with the dense forests influence the plans of the engineer so he can work out
a well balanced program between his field and office operations. The coast region has this heavy rainfall throughout the fall and winter months often extending into the late spring while the higher areas have the winter months augmented with varying amounts of snow.

In addition to these physical difficulties encountered, there is also the fact that in the modern logging camps the engineering work has become more and more complex due to the scientific methods of operation. The first operations in this area used animals for power and so little attention was paid to roads and grades thereof. But, as logging changed from the horse and oxen set-up to the highly complicated steam, diesel, gas and electric machinery, more attention had to be paid to the logging operations from the engineering standpoint because of the heavy financial investments involved. Thus every tract of timber must be studied from many angles before the final decision is made in regard to the logging approach in connection with the location of the roads and type and placement of the machinery.

So in consideration of these problems, a special study of an area thought to be typical of the whole Douglas fir region was made. This area lay on the Siletz River in Lincoln County, Oregon. (See Fig. 1.) Here the ground elevation varies from sea level to 3000 feet, the climate is extremely wet, and undergrowth conditions are typical for both high and low elevations.
Figure 1—MAP OF LINCOLN COUNTY, OREGON SHOWING AREA IN WHICH STUDIES WERE MADE.
Data was obtained both from personal interviews with men familiar with engineering in this area and from the writer's own experience in actual field work. For purposes of check to show that this area was typical of the Douglas fir region, references were made to similar work in other parts of Oregon and Washington.
PART III - TYPES OF WORK

The logging engineer is faced with many types of problems in performing his everyday work. The main subdivisions of such a survey job are property lines, railroads and bridges, contour maps, truck roads, and progress maps. These various points were listed as they grew in importance. Originally, the only survey work done in a logging camp was that of locating the boundaries of the timber to be logged. As time passed and the operators moved from the valleys to the mountains, a more complicated system of transportation was developed. This necessitated a systematic location of railroads and bridges to facilitate the movement of large amounts of logs to the mills in the best and cheapest manner. From all this grew the need for more careful planning before a single saw or axe touched the timber. As a result, in the last twenty years it has been the common thing for the larger companies to make a contour map of their holdings immediately after purchasing the timber and before any logging plans are made or any actual construction is done. The last few years have marked a decided turn to auto trucks for cheap timber transportation and, as a result, there has arisen a need for a special type of road that is low in cost and consequently inexpensive as far as the engineering work is concerned due to the low investment. In view of the more systematic methods being used constantly in logging operations as far as the bookkeeping end is con-
cerned the logger has adopted the progress which is kept up to date and shows at any time the amount of timber left and the area logged in any preceding period. This map can also be used to show the amount of abandoned railroad, sidings and bridges for purposes of inventory.

In short, the problems just listed are the main ones facing the logging engineer in his everyday work. Conditions vary some but, on the whole, the engineer has arrived at a fairly uniform practice throughout the Douglas fir region. With this view of the situation let us look at some of the special problems he meets in this area and the men, equipment and costs he can plan on for each type of work.
PART IV - PROPERTY LINES

As the name signifies, this work consists of re-establishing boundary lines either in regard to purchase of a block of timber or to limit the cutting lines. In the main, this consists of re-locating original United States Land Office lines. The difficulty of this lies in the fact that many such surveys were run 60 to 70 years ago.

The first step of the engineer is then to procure all of this original data that he can, either from the County, State or Government. Such information may consist of field notes or maps of the area in question. A careful study should be made of all this information before ever entering the field in order that a clear idea as to the approach to be used in regard to entering and leaving the field can be best worked out to utilize as much working time as possible. This latter problem presents a great difficulty when the lines to be run are situated at some distance from roads or trails.

The next step is to learn the location of some established 1/4 section, section or township corner to start the operations from. The engineer well acquainted with the country from past work may at once know the location of some legal corner, near the line he plans to run. If not, much valuable information can be obtained from old-time residents of the vicinity.

For purposes of discussion, let us say that such a corner has been located at one end of the line to be run. The
next problem is to rerun the line as it was originally and not as it should be correctly run. Here the main trouble that arises is the fact that the declination as noted in the original notes or maps is, more often than not, in error and should never be accepted verbatim. With this in mind, the engineer may set off a declination as near to the actual present variation as he thinks conducive to good work and run on that.

Then the usual procedure in the Douglas fir region is to run a random compass line to the next corner. The line should be only lightly blazed or preferably not blazed at all if this first line is sure to be incorrect. On locating the next corner the correct declination is computed by the use of tangents and the line rerun to the starting point. This line is heavily blazed and after the practice of this region, tally stakes are set at every tally or 330 feet. This divides the property so that individual 40 acre tracts may be easily traced either for logging or cruising purposes.

Careful field notes should be kept, preferably in a loose-leaf field note book. These notes can be left in the office for plotting purposes at the end of each day's work. Level note sheets are convenient because both sides of the sheet can be used. The notes should contain the number of tallies run, the chaining points, the bearing of the ridges or streams and the size of the latter, the elevation at each point and the error in the completed line, if any.
Brief mention might also be made of the stake-setting system used in this type of work. Stakes, usually 4"x4"x4", are set at section or ¼ section corners so that each face is pointing towards a different section and then numbered accordingly. The tally stakes are about 1"x1"x6' and each one is marked with the number of the tally and its direction from the point of beginning. On section lines the adjacent section on each side is marked. On interior lines the tally number and direction is marked on two adjacent sides so that it is at once evident as to what part of the section the stake is located in. (Fig. 2.)

Due to the roughness of the Douglas fir terrain the speediest method of chaining seems to be attained when a 200 or 300 foot engineer's chain is used in conjunction with a degree Abney. This allows great flexibility in chaining as long shots in a clearing or across a wide canyon can be taken advantage of.

The accuracy of this method is somewhat better than might be expected under the circumstances. One case was noted in which four miles of line was run around a section. In this distance the elevation varied from 100 to 1500 feet above sea level and the country was badly broken up. The horizontal chainage checked to about ten feet and the vertical control to about 1.5 feet. As a result, the chaining is done to the nearest foot and the elevations calculated to the nearest tenth of a foot. Consequently it is often helpful to
Figure 2.--METHOD USED IN MARKING TALLY STAKES.
use a small pocket slide rule for conversion purposes. It is used in conjunction with a set of trigonometry tables.

The field party for such work may vary, of course, but for best average results or money allocated to this purpose a three man crew seems satisfactory. This crew should be able to run about two miles of line per week. There will be an axeman, chainman, and compassman in this set-up. As a general rule, visibility is bad in this region and it is impossible for the compassman to see far enough ahead to keep more than two men at work at all times.

The accepted procedure of a property line crew is comparatively simple. The axeman stays as far ahead as possible opening the line up as far as brush and overhanging limbs are concerned. He should also find time to make talley stakes and leave them at the proper intervals. The chainman follows clearing up any minor obstructions to the line of sight that the axeman may have overlooked and blazing all the trees close to line. He also establishes chaining points for the compassman to move to as well as acting as head chainman. The compassman gives line, acts as rear chainman, measures the vertical angle, and enters all such information in the notes. The head of the party may vary between the two latter men but is probably preferable in the hands of the chainman because an experienced man here can speed up operations by finding good set-ups for the instrument man as well as having more time for observation of the country.

Equipment for such work should be as compact as possible
because much line-running is done at some distance from the base and so entails much walking in and out to work. For a three man party as recommended above the following outfit would prove satisfactory—a degree Abney, a 200 foot engineer's chain, one staff compass, two light pole axes, a set of trigonometry tables, a loose leaf field book with level pages and keel. A small pocket compass and pocket slide rule can also be used to an advantage.

Costs of this type of work will vary little. Assuming two men at $5.40 and one at $6.00, the total wage per day will be about $16.80. At two and one-half days per mile of line, this figures to $42.00 per mile of line. Added expenses for supplies would be negligible.
PART V - CONTOUR MAPS

Having bounded his tract of timber with property lines, the logging engineer is next confronted with the problem of obtaining an accurate picture of the whole set-up. In order that he may plan his operations for years in advance, the contour map may be resorted to. This will give a complete view of the tract as regards topography and so it will be easy to approximate locations of roads and make detailed logging plans. One company is such a firm believer in this type of mapping that they have charted some 105,000 acres of land in their first few years of operation. (6)

There are many ways of securing the information necessary to build a good contour map. Because of conditions in the Douglas fir region, logging engineers have all more or less settled on a procedure in which the data is secured by means of Abney and chain. One recent operation in the Siletz country used this method and secured very accurate and inexpensive results. By following this work through from start to finish one should have a good idea of the methods and costs current to a Douglas fir region map.

The contour map survey may be divided into two parts—the establishing of a base line and the actual topographic work—and will be discussed as such in regard to this survey in the Siletz area.

Base Line

The first objective of the survey was to map that part of Township 9 South, Range 10 West that lay East of the
Siletz River. At the same time any base lines established would serve for any country mapped further north. As shown in Figure 3, a transit line was run from Kernville at the mouth of the Siletz River along the highway to Siletz. From here the line went east to the Range Line between 9 and 10 West. Then the base line followed the Range line north to the Northeast corner of the Township. Here it turned west along the township line and connected with the original line on the Siletz River in the Northwest corner of the Township. Secondary lines were also run with the transit and level. One followed up Thompson Creek, another up Euchre Creek, a third up the Euchre Mountain Trail and a fourth up Cedar Creek. These lines were all started from the Siletz River control line and tied in, as shown in the accompanying map, to either the Township or Range line to form a grid over the area.

These base lines were all run by transit and level. However, later practice found it possible to retain the vertical control by the use of angles. This was done in several cases where such elevations could be checked in on wye level bench marks every couple of miles and the resulting errors balanced back over the line.

Transit base lines such as these can be run at the rate of one-half mile per day. This includes a party of five men consisting of a head chainman, transitman who does the rear chaining and three axemen. The transitman also sets his own backsights in this type of work.
Figure 3.—TOPOGRAPHIC CONTROL SYSTEM USED IN THE SILETZ AREA.
Topography

Having established the control system, the work of obtaining the actual contours is begun. From the primary or secondary lines random compass-Abney lines are run, preferably down the ridges or wherever speed can be attained. Elevations from the original lines are carried forward by the Abney and marked on a nearby tree close to each set-up. Such line can be run quite fast in dense undergrowth if a small mirror is used by the head chainman for giving sights. A flash from the mirror can be seen when it is impossible to see another person through the brush.

The topographer works near this line crew and sketches in the controlling contours. From readings given to him by the compassman, he also can plot the bearing of the line and its elevation at each chaining point. The topographer will carry an aneroid barometer with him so that he may work at all times at some distance to either side of the line. His datum board can be of any light material, as cedar, and about 1½ inches square to accommodate the topographic sheets. They should encompass a ½ section and be on a 200 foot to the inch scale. Only controlling contours are drawn on this sheet, while the rest is filled in as soon as possible. In some cases it may be necessary to extend the Abney-compass line to cover blank spaces in the map. By this method of topography such errors will be apparent at once and can be corrected then. These field maps are transferred in the office to a large control map by the use of carbon paper.
The accuracy of the finished map depends to a great extent on the experience of the topographer. With an experienced man in such a position a contour map that is accurate to 10 feet in vertical control should be easily established.

This type of work is purely for map purposes and no cruising is done. The topographer, however, does take notes as to the quality and species of the timber.

The topographic end of this type of survey can be handled by three men. Two are required for running the Abney-compass line and one man to take topography. They should be able to map 50 acres per day on the average.

The complete list of equipment for this kind of survey should include much the same things as those for a railroad survey—a transit, wye level, 300 foot chain, Abney, staff compass, three bobs, level rod, two field books, hand level, aneroid, keel, four axes, vernier glass, datum board and tacks.

The completed map by the method used in the Siletz area should not cost over $1.00 per acre. Since the average cruise was about 60M per acre, the cost on this basis would only be $0.013 per M.

Similar work has been done in other parts of the Northwest and the costs compare favorably. One operator made maps of his area at costs ranging from $0.75 to $1.50 per acre. (7)

Some companies, if only desirous of a rough map, have it contoured by the cruisers. This will give a map accurate to not less than 25 feet and can be made at the rate of 80 acres per day. With one cruiser at $12.00 and a compassman at $6.00,
this type of map will cost about $0.225 per acre, including the cruise. This type of map will give a fair picture of the country but on a large scale; is not accurate for logging plan work.

This method uses paced distances and aneroid elevations. The latter are taken every 330 feet or on ridge tops and creek bottoms. Such maps are apt to be inaccurate due to the pacing, or changes in air pressure throughout the day that cause the aneroid readings to be incorrect. Failure to properly locate property lines may cause the map to infringe on the wrong area.

On the whole for best results, the method used in the Siletz area is recommended by experienced logging engineers both as to its speed and accuracy and also to its economy in the long run. If the work is properly referenced and noted in the field, much time can be saved in future surveys.
PART VI -- RAILROADS

The main purpose of the logging engineer in regard to the matter of railroads is to locate the finished grade so that the shortest distance and easiest grades are attained in reaching the body of timber to be opened up. Here he is faced with the problem of determining the accuracy of the work. This is usually varied according to the length of time the given railroad is to be used. Mainlines may be run in with considerable skill while short spurs may be located mainly by the use of hand instruments.

During the lean years in 1930-32, many logging operations were forced to curtail location expense. To locate their railroads they used a hand level for vertical control and laid in the curves by means of Tangent Offsets. This method was very inexpensive and in smooth or rolling country gave very good results. (2)

Another operator in rougher country in Columbia County, Oregon, used and has been using for some time, a transit control on the mainline and Abney control for the spurs. This has also proved economical. (3)

The method generally used in the Douglas fir region is one of complete transit surveys. Here the procedure is in most cases similar to any other type of survey. A reconnaissance survey is made over the proposed route with an aneroid barometer and compass. The distances are estimated by pacing, and certain saddles, ridges and creeks located as to distance,
bearing and elevation. With these as control points a preliminary transit line is run as near to the actual location as it is possible to estimate. Levels are run over this line, topography taken, and the actual paper location plotted in the office. From this data the field location is run.

After the first field location the engineer runs into the difficulty of keeping the line established until rails are ready to be put down. His first location will serve for the fallers and chunk-out crew. Immediately after the road is cleared, a second set of location stakes will have to be set that will serve the powder-monkey and the shovel or bulldozer crew. A final set of stakes will be set for the railroad center line. In some cases, it may be necessary to re-locate portions of the line twice as many times. (In that the line location may be started from practically any point an accurate and quick system of referencing transit points and bench marks has been adopted.)

The transit stations are referenced to stumps far enough to each side of the line that subsequent operations will not disturb them. The distance to hundredths is measured to one stump point and the bearing from the center line. By setting on this stump and sighting to the opposite one, stations can be quickly reset. In rough country it is wise to reference a point every 500 feet or so. Bench marks should be set close to grade in some position where they will not be covered. They should be as close together as the transit references
and located at every bridge "hole". An excellent location for bench marks is on the base of landing spar trees where they can always be easily relocated.

Bridge work can be taken care of by the location crew on their last location. Actual construction of the trestles will require the services of one levelman to give cut-offs.

In this type of work the chaining should be done to hundredths and the leveling to the same degree of accuracy.

On an average a three men crew will be satisfactory. It should consist of transit man, head chainman and rear chainman. As in other work in this area, the chief-of-party may well be the head chainman. Two men can be kept busy when it is necessary to have a man for bridge work.

On the average, a three man party should be able to run 3/4 of a mile of line per week completed. That would be the preliminary and the first location. In addition, they will be required to reset the location at least twice which will incur another week for the 3/4 mile of relocation. The bridge engineering, as far as actual construction is concerned, will require the services of one levelman for at least five days for each bridge.

The field equipment for railroad survey should consist of the following: a light mountain type transit, a large wye level for grade and bridge work, a light dumpy level for preliminary survey, two 13 foot rods, one 200 foot chain, vernier glass, two hand levels, at least four field books for preliminary, location, earthwork and bridge notes, one topographic
field book, 3 plumb bobs, a condensed set of trigonometry and curve tables, hub tacks and keel, and two light pole axes. An Abney and metallic tape will be found useful in preliminary work as well as in setting construction stakes.

Costs vary widely on this type of survey, and depend on the accuracy desired. By using a transit mainline and Abney for spurs, one operator built his railroad at $100 per mile. (3). Another by somewhat similar methods, gave his engineering costs at $125 per mile. (2) One textbook rates the work at anywhere from $60 to $300 per mile. (4) In the case of the three man crew as outlined above, costs would run considerably higher due to the accurate work accomplished. This type of survey might run up to $225 per mile. This would include one preliminary survey and three locations plus any bridges that would be on the line if of average size. This cost was made on the basis of two men at $5.40 per day and one at $6.00. The assumption was also made that they could do all work necessary in two weeks or ten working days.

It is thus apparent from the above figures that the railroad survey work, if done with any degree of accuracy, will entail the greatest cost of any of the engineering.
PART VII - TRUCK ROAD SURVEYS

The methods and costs of truck road surveys vary in nearly every operation. The accuracy of the survey based on the purpose the road is to be put to vary in several ways. High cost roads that are to be used for several years in all kinds of weather may entail as great an expense per mile as railroads. But due to the difference in grade line and curvature, such a road may tap the same amount of timber in a shorter distance than the railroad. For example, the maximum adverse on railroads should be not over 1% while trucks can negotiate 5% easily. Maximum grade on the railroad should not be over 6% while that on truck roads can be 12-18%. Grade breaks limit truck roads as such a procedure will cause slower speeds. Then too, the type of trucks to be used has an influence. Heavy duty trucks can be handled on steeper grades than small trucks. Length of the logs limit the curvature also. In regard to grades, one authority claims the following: A 1½-2 ton truck, if loaded, can haul economically on grades from 4-8% depending on the condition of the road. A 2½ ton or larger truck can be operated over grades from 6 to 12% loaded and as high as 18% unladen. (1)

Since mainline truck roads are constructed and engineered at much the same cost as railroads let us discuss the secondary road that is so popular in the Northwest for feeding into railroads.

The surveying on this kind of a road is done with Abney
and compass. The first operation consists of running an Abney vertical control line over the approximate location of the road. This line will have no regard for horizontal control but will be used merely to establish a rough grade line for the final location. It will be controlled by saddles, summits and landings. These landings will in turn come from the topographic maps and are of course determined indirectly by the property lines.

Having figured the grade necessary, the location of the road is run in with a staff compass and chain. Curvature is laid in roughly by eye and is determined by the length of logs to be hauled.

It might be well to note, that more care should be taken in a survey of this type if the grade hovers near the maximum that the trucks can operate over. Errors on steep grades may cause much trouble and added expense by slowing down the operating speeds. In this case, it may be wise to run a line of levels over the proposed route.

Since most of these roads are constructed by bulldozers, the only stakes that it is necessary to set are high ones every fifty feet on center line. These should be set so that the bottom of them are approximately on grade. In heavy timber, the line may be marked by blazes on trees that fall on the line. The roots of such trees should also be on line. Deep cuts or fills should be marked at the point where the grade intercepts the ground line.
Two men are sufficient on this survey. One should be a compassman and the other goes ahead, determines the location of the road as to grade and curvature and marks the stakes or trees. With this method of procedure, two men can easily run in a mile per day either of vertical control or final location. Highly satisfactory roads have been constructed in this manner with little time involved.

For such a survey varied instruments will be unnecessary. The two man crew will need an Abney, staff compass, 200 foot chain, one axe, a field book, and keel. An aneroid may also be used for reconnaissance work.

Costs for this light type of road that is to be used only a few months or so are extremely low in regard to the engineering. On the basis of two men, one at $6.00 and the other at $5.40 per day, one survey will cost about $11.40 per mile. However, it is usually necessary to make three trips over the line. One is for vertical control, one for location and one for construction purposes. At this the finished road should cost about $34.20 per mile which is about 15% of the railroad cost.
PART VIII - PROGRESS MAPS

In the last few years the logging engineer has adopted the progress map as a pictorial representation of the amount of land logged by each side and for each month. This map can also be made to show the amount of abandoned roads and bridges for calculating depreciation charges and amount of equipment on hand. Such maps, by showing the timber logged, help in lowering taxes as soon as possible. Such maps are low in cost and quickly made. They are worth many times their cost.

The finished map (Figure 4) will show the logged areas by means of shading or coloring. These areas are designated as to the month or year they are logged in.

Basic work is done on the same sheet the railroad is plotted on. Then, in other surveys, the spar trees are tied on to this paper location by means of Abney chainage and compass bearings. These shots may be taken at any time when it is convenient and plotted on the work sheet. These spar trees, both landing and yarder, are used as control points for all future work on the progress map. At some definite period, preferably the last day of each month, the cutover is mapped. By use of an Abney, chain and staff compass, a quick line is run around the logged area for that month and plotted on the work sheet. In cases where two or more plotted spar trees can be seen from the edge of the cutover no chaining is necessary as compass bearings can be more quickly taken and plotted. It is possible to map a month's cutover on one
Figure 4.--COMPLETED PROGRESS MAP SHOWING AREA LOGGED, ROADS, STREAMS AND PROPERTY LINES.
side from two or three compass settings.

From this base map a small map is made to be filed for each month's cutover. A larger map is made at the end of the year and shows the total logged area for that year. A still larger map is kept up to date by colors as each month's cutover is compiled. This large map will show the cutover shaded in various colors for each month. In addition it may show the ownership of all timber areas adjacent to the logging. This may be done by using different colored border lines.

Progress maps can be constructed by two men easily. By the compass-Abney method they should be able to take cutover for at least four sides per day. This would mean that they could map a month's logging or about 130 acres in about eight hours.

Equipment for this type of work should consist of a staff compass, Abney, 200 foot chain, one axe, a field book and tables.

Cost is quite out of proportion to the value obtained from a progress map. With one man at $6.00 and one at $5.40, 130 acres could be mapped at the cost of $11.40 or about $0.087 per acre.
PART IX - EQUIPMENT

When it comes to choosing the equipment necessary for logging survey work there are several factors to take into account. The weight should be as little as possible because of the long distances it may be necessary to pack to and from work. The accuracy of the instruments should also be taken into consideration, as the purchasing of a high priced piece of equipment would be unwise due to the hard service and medium accuracy required. In view of all this, a list of equipment was worked out that should prove satisfactory for the work outlined before with minimum cost.

**Transit**

The preferred type seems to be the one listed as "Light Mountain" by several manufacturers. Its weight is 22 pounds complete. Other features are a 4" horizontal limb, which has a double opposite vernier reading to one minute and equipped with plate levels that are sensitive to one minute. The vertical circle likewise, is 4" in diameter and also reads to one minute. The telescope is 8½" long, is internal focusing, magnifies 18 times, and has 1 x 100 stadia hairs. The level on the telescope is 3½" long and sensitive to 30 seconds. The compass should be divided in quadrants with a variation ring to set off various declinations. The transit should have an extension tripod. This type of transit is light, accurate enough for this type of work and waterproof.
**Levels**

Two levels are recommended, one heavy and sensitive instrument for use along the grade during construction, and a lighter one for use on the preliminary surveys. The first should be a wye level with an 18" telescope magnifying 32 times. It should be internal focusing to keep moisture out and should have a 6" level sensitive to about 20 seconds. A split leg tripod is preferable. This instrument will weigh about 23 pounds. The other level should be a dumpy level with a 13\frac{1}{2}" telescope that magnifies 21\frac{1}{4} times. The level tube should be sensitive to about 30 seconds and the whole instrument should weigh around 14 pounds.

**Compass**

For running all compass lines a staff compass with a 4\frac{1}{2}" needle will serve admirably. The circle should be divided every half-degree and numbered every 10 degrees with a variation ring that reads to 5 minutes. It should have folding sights and be equipped with a Jacob staff and ball and socket joint to attach the latter. A 2" needle pocket compass in the metal case is also handy on numerous occasions.

**Abney**

This can be of any standard make but, to fit conditions outlined in this paper, should be graduated in degrees and percent. The arc should have graduations to 60 degrees with a vernier reading to 10 minutes and the percentage scale should read from 0 to 100% to the nearest 5%.
**Hand Level**

Any standard make 6" long and with stadia hairs in it will be useful for determining level chainage or estimating short distances in topographic work.

**Barometer**

A small aneroid barometer is very essential for both reconnaissance survey to get a general idea of the topography of the country and also for contour map work.

**Level Rod**

Two standard self-reading Philadelphia 13 foot rods will suffice for this work. One rod can be used on preliminary work and the other on construction.

**Chain and Tape**

One 200 foot chain should be the best for all purposes. It should be the style with babbeted numbers for easy reading and 5/16" wide.

A couple of 50 foot metallic tapes come in handy for topographic and cross section operations.

**Field Books**

For transit and level work any canvas bound books with oiled pages are satisfactory. Stiff covered loose-leaf field books are handy for property line surveys. A good topographic book is one 11\(\frac{1}{2}\)" x 7\(\frac{1}{4}\)" with the center line running at right angles to the crease through the center.

**Miscellaneous**

This listing should include three 16 oz. plumb bobs, several pounds of hub tacks, a box of keel, vernier reading
glass, pocket slide rule and three axes. The latter should be of the light 2½" handle style with at least one single-bitted to facilitate driving stakes.

The above list of equipment should be satisfactory for any kind of work that would arise in logging surveys. Following is a list of this material and the costs of each article as compiled from current trade catalogs.
## AMOUNT AND COST OF FIELD EQUIPMENT FOR TYPICAL LOGGING SURVEY

<table>
<thead>
<tr>
<th>Article</th>
<th>No. Required</th>
<th>Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mountain Transit</td>
<td>1</td>
<td>$410.00</td>
<td>$410.00</td>
</tr>
<tr>
<td>2. Wye Level</td>
<td>1</td>
<td>225.00</td>
<td>225.00</td>
</tr>
<tr>
<td>3. Dumpy Level</td>
<td>1</td>
<td>155.00</td>
<td>155.00</td>
</tr>
<tr>
<td>4. Staff Compass</td>
<td>1</td>
<td>40.00</td>
<td>40.00</td>
</tr>
<tr>
<td>5. Jacob Staff</td>
<td>1</td>
<td>7.00</td>
<td>7.00</td>
</tr>
<tr>
<td>6. Pocket Compass</td>
<td>1</td>
<td>4.50</td>
<td>4.50</td>
</tr>
<tr>
<td>7. Abney</td>
<td>1</td>
<td>21.50</td>
<td>21.50</td>
</tr>
<tr>
<td>8. Hand Level</td>
<td>2</td>
<td>6.00</td>
<td>12.00</td>
</tr>
<tr>
<td>9. Aneroid Barometer</td>
<td>1</td>
<td>35.00</td>
<td>35.00</td>
</tr>
<tr>
<td>10. Level Rod</td>
<td>2</td>
<td>22.50</td>
<td>45.00</td>
</tr>
<tr>
<td>11. Engineer's Chain</td>
<td>1</td>
<td>15.00</td>
<td>15.00</td>
</tr>
<tr>
<td>12. Metallic Tape</td>
<td>2</td>
<td>3.00</td>
<td>6.00</td>
</tr>
<tr>
<td>13. Field Books</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canvas bound</td>
<td>6</td>
<td>1.30</td>
<td>7.80</td>
</tr>
<tr>
<td>Loose-leaf</td>
<td>2</td>
<td>2.50</td>
<td>5.00</td>
</tr>
<tr>
<td>Topographic</td>
<td>2</td>
<td>1.30</td>
<td>2.60</td>
</tr>
<tr>
<td>14. Plumb Bobs</td>
<td>3</td>
<td>1.70</td>
<td>5.10</td>
</tr>
<tr>
<td>15. Vernier Glass</td>
<td>1</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>16. Pocket Slide Rule</td>
<td>1</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>17. Axes</td>
<td>3</td>
<td>2.50</td>
<td>7.50</td>
</tr>
<tr>
<td>18. Hub Tacks</td>
<td>5 lbs.</td>
<td>0.40</td>
<td>2.00</td>
</tr>
<tr>
<td>19. Keel</td>
<td>1 doz.</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**TOTAL OUTLAY IN SURVEYING EQUIPMENT** . . . . $1012.00
PART X - DEVELOPMENT OF TYPICAL AREA

To give a better understanding of the costs of a typical Douglas fir region survey, an area was selected for an example of average operations (Figure 5) and engineering expenses figured on it. This area comprising one section lay in Township 9 South, Range 10 West, and was Section 19. The area was actually developed and logged in 1937-38.

In order to better analyze the expenses involved and to arrive at an average for the tract, three methods of surveying were considered. The first was the survey that would open the tract to logging in the most inexpensive manner. The second method was based on the fact that this area was only one of large holdings of the company and so, on such a big scale operation, would entail the highest engineering costs. The third consideration was based on the costs that were actually put in on the area. This latter figure was about an average of the first two.

Expenses, as in other parts of this paper, were based on one man in each crew at $6.00 and the remaining members at $5.40. Cruise of the area was taken to average 60 M per acre.

Depreciation on all the engineering instruments was based on a six months period and was figured at 5% per year. Supplies over this time were added as were replacements in certain types of equipment. These latter values were taken as constant for all the surveys as the same instruments were used in all cases.
Figure 5.--Map of typical area selected to compute engineering costs on.
DEPRECIATION, SUPPLIES USED AND REPLACEMENTS
ON SURVEY EQUIPMENT

Depreciation

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit</td>
<td>$10.25</td>
</tr>
<tr>
<td>Wye Level</td>
<td>5.62</td>
</tr>
<tr>
<td>Dumpy Level</td>
<td>3.87</td>
</tr>
<tr>
<td>Other Instruments</td>
<td>4.02</td>
</tr>
</tbody>
</table>

Replacements

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 200-foot chain</td>
<td>15.00</td>
</tr>
<tr>
<td>Metallic Tape</td>
<td>3.00</td>
</tr>
<tr>
<td>Field Books</td>
<td>10.40</td>
</tr>
</tbody>
</table>

Supplies Used or Lost

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plumb Bob</td>
<td>1.70</td>
</tr>
<tr>
<td>Axe</td>
<td>2.50</td>
</tr>
<tr>
<td>5 lbs. Hub Tacks</td>
<td>2.00</td>
</tr>
<tr>
<td>1 doz. Keel</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Total depreciation, supplies used and replacements to be applied on each survey is $69.16.

Method #1

In this method, which would be the least expensive of all, railroads were not used at all and the mapping was done by the strip method at the same time the area was cruised.

<table>
<thead>
<tr>
<th>Survey</th>
<th>Amount and Rate</th>
<th>Cost</th>
<th>Days Required</th>
<th>No. Men</th>
<th>Man Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. L.</td>
<td>4 mi. @ $42.00</td>
<td>$168.00</td>
<td>10</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>C. M.</td>
<td>640 A. @ $0.225</td>
<td>144.00</td>
<td>8</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>R. R.</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T. R.</td>
<td>1½ mi. @ $34.20</td>
<td>42.75</td>
<td>5</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>P. M.</td>
<td>640 A. @ $0.087</td>
<td>55.68</td>
<td>5</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

Plus Depreciation, etc. $430.43

Total Cost $499.59
Cost Per Day $18.00
Cost Per Man Day $7.50
**Method #2**

This method entailed the most expense of any and would be applicable only where the developed area was one part of large holdings. Mapping was done very accurately and railroads used.

<table>
<thead>
<tr>
<th>Survey</th>
<th>Amount and Rate</th>
<th>Cost</th>
<th>Days Required</th>
<th>No. Men</th>
<th>Man Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. L.</td>
<td>4 mi. @ $42.00</td>
<td>$168.00</td>
<td>10</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>C. M.</td>
<td>640 A. @ $1.00 (10' interval)</td>
<td>640.00</td>
<td>46(B.L.)</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>R. R.</td>
<td>2 mi. @ $218.40</td>
<td>436.80</td>
<td>26</td>
<td>3</td>
<td>78</td>
</tr>
<tr>
<td>T. R.</td>
<td>None</td>
<td>$601.87</td>
<td>58</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>P. M.</td>
<td>640 A. @ $0.087</td>
<td>$55.68</td>
<td>5</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

Plus Depreciation, etc. $1344.48
Total Cost $873.64
Cost per Day $17.00
Cost Per Man Day $6.50

**Method #3**

Method #3 was about an average of the other two surveys and was similar to the actual costs used in developing this area.

<table>
<thead>
<tr>
<th>Survey</th>
<th>Amount and Rate</th>
<th>Cost</th>
<th>Days Required</th>
<th>No. Men</th>
<th>Man Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. L.</td>
<td>4 mi. @ $42.00</td>
<td>$168.00</td>
<td>10</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>C. M.</td>
<td>640 A. @ $0.225 (25' interval)</td>
<td>114.00</td>
<td>8</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>R. R.</td>
<td>2 mi. @ $218.40</td>
<td>436.80</td>
<td>26</td>
<td>3</td>
<td>78</td>
</tr>
<tr>
<td>T. R.</td>
<td>None</td>
<td>$55.68</td>
<td>5</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>P. M.</td>
<td>640 A. @ $0.087</td>
<td>$55.68</td>
<td>5</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

Total Cost $873.64
Cost per Day $17.00
Cost Per Man Day $6.50
From the results of these methods it is possible to arrive at an average for survey work in the Douglas fir region as follows:

Summary:

<table>
<thead>
<tr>
<th>Method</th>
<th>Total Cost</th>
<th>Days Required</th>
<th>Man Days</th>
<th>Per Day</th>
<th>Man Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>$499.59</td>
<td>28</td>
<td>66</td>
<td>$18.00</td>
<td>$7.50</td>
</tr>
<tr>
<td>#2</td>
<td>$1413.64</td>
<td>58</td>
<td>177</td>
<td>24.00</td>
<td>8.00</td>
</tr>
<tr>
<td>#3</td>
<td>$873.64</td>
<td>49</td>
<td>134</td>
<td>17.00</td>
<td>6.50</td>
</tr>
</tbody>
</table>

With these figures it is possible to arrive at an average cost for developing this 640 acres of land as far as engineering costs are concerned. Since various engineers might use combinations of all three methods, an average figure should give a good idea of the expenses involved.

AVERAGE COST OF ENGINEERING ON 640 ACRES IN DOUGLAS FIR REGION

Average number of days required 45
Average number man days required 126
Average cost per day $19.66
Average cost per man day 7.33
Average total cost $928.96

Since an average cruise in this area might run 60 M/Ac., there would be 38,400 M on this Section or engineering would cost about $0.024 per thousand board feet.
PART XI - SUMMARY

The contents of this discussion on logging survey methods and cost may be summed up in the following brief outline:

The five types of survey work the logging engineer can expect to meet in every day work are property lines, contour maps, railroads, truck roads and progress maps. (Figure 6.)

Property lines can be run with a 3 man crew at the rate of 2 miles per week. Costs will be $16.80 per day or $42.00 per mile.

Contour maps can be made with a crew of 3 men (5 men for the base lines) at the rate of 1 mile per 2 days for base lines and 50 acres per day for topography. This will cost about $1.00 per acre complete. By the strip method, 2 men can map 80 acres per day at about $0.225 per acre.

Railroad surveys can be run satisfactorily by 3 men and will take about 13 days per mile to complete 1 preliminary and 3 location surveys. The cost will be about $16.80 per day or $218.40 per mile.

Truck roads, if for long use, may cost the same as railroads. For short time roads 2 men can run 1 mile in 3 days complete. That would include 2 preliminary surveys and 1 location. This would be $11.40 per day or $34.20 per mile.

Progress maps can also be made by 2 men. They can map an average operation's logging for a month. That would be around 130 acres at $11.40 per day or $0.087 per acre.
Costs for the development of a typical area will vary according to the methods used but on the average would probably come to around $900.00. This would be for 1 section or 640 A.

Figuring that cruise on this area might run about 60 M per A., the cost per thousand board feet would average around $0.021 per M.

In connection with all surveys it is wise to tie all work to some transit line and base all future work on a system of coordinates. This will save much field work at times and will serve as a check on all the engineering in the field. The only added cost will be in figuring in the office.

From this article it is apparent that methods of survey practice in the field may vary from one operation to another. How these choices are made in each case will vary according to the size of the operation and working capital. Operations with large tracts of timber may be inclined to invest more in their engineering than small outfits.

With this view in mind, it is hoped that information in this paper will serve to aid the engineer in his choices in each case by demonstrating what an average logging survey practice in the Douglas fir region would entail as to engineering expenses.
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8. Catalogues of the A. Lietz Company, San Francisco; The Eugene Dietzgen Company; and the Keuffel and Esser Company, New York