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SUGGESTIONS FOR GETTING MORE FORESTRY IN THE LOGGING PLAN [1/]

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By

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INTRODUCTION

The staggered-setting system of clear-cutting is fast becoming prevailing practice in the Douglas-fir region. The trend is away from large, continuous clearcuts to clear-cutting smaller units of timber of less than 80 acres. These are called staggered settings because the surrounding stand is left uncut to provide seed and serve as a firebreak. Major aims of this system are to obtain better regeneration and reduce fire losses.

Moving into an undeveloped drainage to cut staggered settings needs careful advance planning. For example, the initial road system built to log the units to be cut first must necessarily go through the intervening areas of green timber reserved for systematic harvesting later in the rotation. Consequently, this road development should be designed to serve not only the units of the first cut but also the reserve units. What is required is a detailed plan that considers all the economic, silvicultural, engineering, fire protection,

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1/ This work was started and directed by Robert Aufderheide, formerly with the Pacific Northwest Forest and Range Experiment Station. See "Getting Forestry Into the Logging Plan" by Robert Aufderheide, Timberman 50 (5):53-56, 96. March 1949.

and watershed needs of the drainage. It should be prepared before any cutting is done. This forestry-logging plan cannot be prepared in the office alone; it must be based on intensive planning in the field. Roads and landings for logging the entire drainage should be located and posted on the ground; then settings to be taken in the initial cut can be selected and their cutting boundaries posted.

The development and use of such plans are being studied on experimental areas. This paper presents some preliminary suggestions resulting from preparation of forestry-logging plans on five Forest Service experimental timber sales in western Oregon. These staggered-setting cutting plans were made for 100-, 150-, and 400-year-old even-aged stands on the coast and in the Cascades covering in all approximately one-quarter billion board feet of which 56 million has been designated for the initial cut. The principles and techniques described are based on experience during the first four years of the study. Undoubtedly many of them will be improved, modified, or discarded as the study is continued.

PREPARATION OF THE FORESTRY-LOGGING PLAN

On the experimental areas it was found that the quality of forestry practice obtained on the ground depends on the training of the man responsible for the forestry-logging plan and on how well acquainted he becomes with the area and its problems. He should be trained in both forestry and engineering. What is desirable silviculturally often conflicts with practical economics and logging conditions. Successful forest management depends upon the forester-engineer's skill in compromising the conflicts for each cutting unit and then binding all the units together into a combined forestry and logging plan.

Knowledge of the area and its problems is no less important. Study of a topographic map and such other material as aerial photographs and cruise reports can be helpful, but in the end there is no practical substitute for leg work. Both forestry and logging considerations require intimate, on-the-ground familiarity with every part of the area. Maps and aerial photos can best serve to aid in preliminary planning and in making decisions on the ground.

The Paper Plan

The preparation of a logging-transportation plan in the office (the paper plan) was one of the early jobs undertaken. A trip through the area or an observation of it from vantage points was needed for general orientation. However, it was felt that time could be wasted on too much preliminary reconnaissance. It was more efficient to continue the reconnaissance after preparing a tentative logging-transportation plan on the topographic map. This gave the forester-engineer a detailed knowledge of his map and most of the basic forestry and logging problems he wanted to solve. Then some effective work such as preliminary road location could be combined with the reconnaissance.

The paper plan should be a complete layout on a map of the roads, landings, and cutting boundaries needed for the first and succeeding cuts on a forest area. But it is made to be modified. It is taken into the field where topographic and stand conditions that present unforeseen obstacles to application of the plan can be spotted in the course of marking out the roads and landings. As each difficulty is encountered, the plan is altered to fit conditions on the ground. Sometimes an alteration itself will require still other changes. By this process, a pattern of roads and landings that will serve the entire area is developed. Then the units to cut first and those to leave until later are decided upon, and the boundaries for the first cut are posted. Thus, the paper plan evolves into the final forestry-logging plan.

In preparing such a paper plan, the available information on existing roads, land ownership, and timber types was plotted on the topographic map. Then the new roads, landings, and cutting boundaries were planned as one step. Planning these features independently is not practical; for example, the road system planned by itself will probably miss many of the best landings. Nor is it practical to pick out the best landings and expect to tie them together with an efficient road system. For convenience in writing, these operations are described separately, but it should be kept in mind that the work was done in one step.

Planning the Road System

It was essential to plan the most economical road system that would efficiently serve the area. Careful planning to reduce total length and cost per mile will materially reduce logging costs. The efficient road system will have proper spacing of road levels, and appropriate standards of alignment and grade.

The economic balance between road and yarding costs depends upon proper road spacing. Longer yarding distances would permit less road; on the other hand, more road would permit shorter yarding distances. Formulas are available [2] for determining this balance, which varies with kind of yarding equipment and with local conditions. In the Douglas-fir region yarding distances of 500 to 800 feet are preferred by most loggers Double these distances, 1,000 to 1,600 feet, is the presently used rule for spacing of roads in gentle topography. In rough topography it is better to use somewhat wider spacing because road building costs increase more than yarding costs. In rugged topography where road building costs are prohibitive, cable skyline systems (swinging) may be substituted for some roads. However, other things being equal, road construction is better than swinging because it leaves a permanent improvement on the ground. Generally, it is more economical to locate roads on the most favorable topography even if somewhat poorer spacing results.

Road standards used should minimize hauling and maintenance costs. The ideal road system has all nearly level or favorable grades. Adverse and steep favorable grades both are to be avoided because they increase hauling and maintenance costs. Main roads serving large timber volumes should have the highest standards. Standards may be gradually reduced for spur roads as volumes served by them decrease. However, any road that must be maintained until the next rotation or to serve a leave unit must meet certain minimum standards to avoid excessive maintenance costs. These minimums include adequate drainage, sloped banks, and moderate grades.

Several considerations were kept in mind while plotting the trial road system on the topographic map. An attempt was made to locate most of the roads on favorable topography and through suitable landings. On steep topography where high-lead yarding was necessary, roads were located far enough up the slopes so that most of the yarding would be uphill. On gentle topography suitable for tractor yarding, roads were located below the timber to permit downhill yarding. Roads near streams were located so that fill material would not be dumped directly into the stream. Roads on steep hillsides were avoided whenever possible; besides being expensive, such

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2/ Matthews, D. M. Cost control in the logging industry. 1942. McGraw-Hill, Inc., New York.

roads increase erosion and often take up the whole hillside with their long sidecasts and backslopes.

Another consideration was to avoid an excessive amount of roads by plotting a systematic pattern of road levels on the topographic map. The first step was normally to plot the lowest level of road up the main drainage. This road may be located near the stream or 500 to 800 feet up the slope, depending on the proportion of tractor and high-lead ground. In steep canyons having mostly high-lead ground, the road needs to be up on the slope. In wide drainages with gentle slopes favorable to tractor yarding the road needs to be near the stream. The latter location will be particularly important in future rotations, in which intermediate cuttings using tractors can greatly increase the yield. In steep canyons where thinning is not practical, a location 500 to 800 feet up the slope will better serve the streamside timber, and will require fewer road levels for the drainage.

The next step was to plot the pattern of roads to serve timber farther up the slope, joining them with the lowest road level. The shortest road system results when landings are spaced at economic distances for yarding along roads that proceed by the shortest route from one landing to the next. This results when regularly spaced road levels are developed. Areas of expensive road construction, difficult topographic features, or lack of suitable landings may justify road and landings being spaced at less than the most economic yarding distance. But such spacing, as well as the number of roads that climb from one level to the next without serving specific landings should be minimized to reduce total length of the road system.

Settings

The basic unit of any logging plan is the setting, which is made up of a tractor or high-lead landing and the timber tributary to it.

The size of a setting is limited by economic yarding distances. The distance for high-lead yarding uphill should be 500 to 800 feet, but reaches several hundred feet longer can sometimes be justified for timber otherwise inaccessible. Sidehill and downhill yarding distances should be shorter. This is because hang-ups behind stumps are more frequent, and the spar tree is not always high enough to provide for lifting logs over minor ridges and out of ravines. Somewhat longer yarding distances downhill are economical with tractors.

If yarding distances are kept within these limits, settings generally will range in size from 15 to 30 acres. Larger cutting units result from combining two or more settings.

On the topographic map the gentle topography suitable for tractor settings should be separated from the steeper topography suitable only for high-lead settings. Besides topography, the basis for this separation includes yarding costs, watershed values, and provision for partial cuttings and future thinnings. On most moderate topography, tractor yarding is often less expensive. As slopes become steeper costs go up and soil disturbance increases. It is better to change to high-lead yarding before it becomes necessary to grade tractor roads along the contour. To prevent this source of undue soil disturbance and resulting damage to the watershed, generally it is best to limit tractor yarding to slopes not exceeding 25 to 35 percent. Below these limits tractor settings should be favored to facilitate harvesting intermediate cuttings during future rotations. On some settings both tractor and high-lead yarding can be done to one landing. This is often the case when the road is located along the edge of a bench. Then high-lead yarding is used for the steep ground below the road, and tractors are used on the bench above.

Good landings should have sufficient space to deck the logs and a strategic location within the setting. Normally 100 feet or more of relatively flat ground is required. For tractor logging the landings are generally located near the lower edge of the setting to provide easy downhill yarding. They also should be located so as to avoid yarding across streams and over ridges. On high-lead settings, landings should be located nearer the top of the setting to provide a high proportion of uphill yarding, and in a position that will assure sufficient lift out of ravines, over minor ridges, and to the far corners of the setting.

Yarding distance from the landing roughly determines the setting boundary. The exact location may be one of six possibilities discussed below:

(1) Roads are excellent cutting boundaries since they form a ready-made fire line for slash burning and make salvage of windfalls easy.

(2) Main and spur ridges are good boundaries because they are natural fire breaks. In high-lead logging, the ridge-top location of the tail block gives extra lift to the logs. The timber

edge left on the ridge is subject to heavy winds, but the trees are relatively windfirm.

(3) Benches and gentle slopes make good cutting boundaries because slash fires can be easily held on this kind of ground, and because the sliding of logs across the cutting line is not a problem. A cutting line on a bench at the toe of a steep slope should be far enough out on the bench to provide space for trees that slide down the hill and for easy fire line construction. However, swampy and waterlogged ground should be avoided because the risk of windfall is high there.

(4) Streams or streamside cutting boundaries avoid an erosion problem that would be created by yarding large volumes across the streambed and dragging debris from the opposite hill into it. Then too, wide streams make good fire lines. Small creeks in steep canyons, however, fill with logging slash when the timber is felled, and may carry a fire to the uncut slope. Since timber along streams is susceptible to windfall, the cutting boundary may have to be moved in places to avoid areas of waterlogged soil or the direct exposure to high winds.

(5) Cutting boundaries at right angles to the contour are the best alternative if none of the above are used. This is because slash and accidental fires would tend to run up the slope parallel to such cutting lines and are relatively easy to control. Cutting boundaries not at right angles to the contour are undesirable, particularly on steep slopes. When one setting is directly above another on a steep slope, trees tend to slide across the cutting line into the lower setting, and fires from below may run into the setting above. Ledges and long rock outcrops are sometimes used for cutting boundaries on steep slopes because yarding over them is often impractical and they usually form an adequate firebreak.

(6) Type lines are often used as cutting boundaries. They should be used when they result in economic yarding distances and meet the other forestry needs of a setting. Such a case is on gentle topography where slash burning is not difficult, and the numerous road possibilities allow the logging plan to be efficiently designed to fit type patterns. In rough topography it is expensive and difficult to do this since good road and landing possibilities are generally scarce. To break a setting on a type line on steep ground often means extra road and extra landings when the leave settings are taken. In addition, type boundaries as cutting lines often meander

across slopes and stream patterns to create logging, slash-burning, and erosion problems. However, the use of type boundaries may be necessary when the adjacent type is immature or non-commercial.

After several attempts on the map the range of possibilities for roads, landings, and cutting boundaries can be narrowed to one pattern. This constitutes the paper plan. For the five experimental areas studied, the paper plans ranged from very sketchy to very complete. It became apparent that a more complete plan than the sketchy one used on the first area could save considerable field work. Better maps were available and more complete plans were prepared for other areas to reduce the amount of reconnaissance that was necessary. However, it would not be practical to prepare the final plan on paper because the cost of so detailed a topographic map would be prohibitive, and field checks would still be necessary.

The next step was to take the preliminary plan into the field to check road and landing locations. These checks were also done as one step, but again they are described separately for convenience in writing.

Location of Roads in the Field

Even the best paper plan will not eliminate the need for many alterations when road locations are checked in the field. So that little investment in finished location would be lost when alterations became necessary, the first trials were made using quick, rough methods. On the experimental areas this usually was done by a man working alone. Using aluminum tags made of bright foil to mark the grade line made this possible. By backsighting on a tag he could place himself on grade, staple another tag on a nearby tree, and move forward for another backsight. Thus he left a line of tags at grade level as he moved along.

It was found that a 1-man crew was more efficient for most of this rough location work. For safety reasons two men usually went out together but worked on different jobs.

Aluminum tags have several advantages for posting both road locations and unit boundaries. They are economical, durable, easily fastened to trees with a stapling hammer, show up well in the woods, and can be permanently inscribed with a pencil. They can be pulled off if necessary to alter the road location or cutting line, thus eliminating the confusion of several blazed lines.

The rough locations usually revealed the major obstacles to road construction, the probable construction costs, and whether control points could be reached; they also helped familiarize the forester-engineer with the area. If the paper plan locations were not satisfactory, alternate locations were tried using the same rough methods.

When suitable locations were found, the control points were given the most attention. Stream crossings, switchbacks, landings, road junctions, rock outcroppings, saddles, and sharp ridges and ravines had to be carefully marked because they could not be changed without changing the entire plan. Between these points grade lines were run only to ascertain that there were no serious road-building problems. On the experimental areas detailed center line locations and profiles were left to be prepared later by the timber operators as the area was opened up.

In marking the roads through control points, considerable reconnaissance is justified because of the high construction costs involved. Good stream crossings are usually scarce. To utilize them, often means adjusting the plan over a considerable area. Bridges are always expensive. If one is required, the location should provide solid foundations to avoid washouts, sufficient height for maximum floods, and allow good alignment of the approach roads. Even on smaller streams, extra reconnaissance is justified to find the best place for a culvert installation. For example, a saving can sometimes be made by crossing below the forks of a stream to eliminate one culvert. It should be remembered that road construction near streams is one of the main sources of sedimentation. Often a crossing can be planned so that earth that might otherwise be side-cast into the stream can be used as fill material at the crossing.

Good switchback locations are difficult to find since they require nearly level ground. Failure to locate them may mean using a less desirable alternate plan. A technique used to check doubtful locations on the experimental areas was to place a stake at a trial center of curvature for the switchback. From this stake the minimum acceptable radius was measured horizontally in several directions and tagged. By following the curve marked by the tags the switchback could be visualized. The cuts and fills were computed and the switchback accepted or rejected. This method can be used by one man employing a 10-foot stick for measuring horizontal distances.

Road junctions should be carefully marked if one road will be built first. This will allow for proper junction of the second road. Gentle topography is best so that sidecast from one road does not interfere with construction of the other.

Rock outcroppings are important because they necessitate very high construction costs. When they are encountered, alternate road locations should be sought. If there is no practical alternative, hours of rigorous searching for the very best location through the rock is worth while.

Road locations at sharp ridges and ravines must be checked to meet minimum standards of curvature.

When a road location became definite, it was usually traversed and used as a control for further field work such as checking landing locations and yarding distances and in preparing the final map.

Checking the Settings in the Field

Landing sites shown on the paper plan were examined as they were reached in running the road locations. On tractor ground, because of the gentle topography, good landings were generally found when needed. On steeper ground, where high-lead methods were used, landings were scarce. Often the location picked on the map did not meet all the requirements. An ideal high-lead landing would have a suitable spar tree with at least one log length of relatively flat ground on all sides for landing logs. It would have additional space for the yarding and loading machines. For boom loading there should be straight road the length of a truck and trailer pointing directly into the spar tree. A turning space for trucks should be located nearby.

If the planned landing was unsuitable, alternatives were to improve the site or find a better one on the same road, change the road location, locate a spur road to a better site, or adjust the adjacent settings to eliminate the need for the landing. Improving the site often required costly heavy grading to provide enough flat ground. Changing the main road location or locating a spur to reach a better landing was sometimes less expensive. These changes were limited by grade standards and often involved changing other landings and road locations in the vicinity. Building a short spur usually meant yarding across the main road. This could hold up traffic and damage the road bed. A deep curve in any road within a high-lead setting also usually meant yarding across the road. For this reason roads should point as straight as possible toward the spar tree. Changing the adjacent settings to eliminate the landing was necessary when no suitable landing was available within the planned setting.

On the experimental areas tentative spar trees were marked to designate the landings so that yarding distances could be measured. However, the logger was permitted to use another tree if he desired. Spar trees for high-lead yarding should be straight, sound, and large enough to support the logs yarded to them, but some sweep or lean can be tolerated. Suitable spar trees were not always strategically located on the landing. One on a poorer location could be used, or a tree cut elsewhere could be erected. "Raising" a tree may increase costs as much as $500, but one operator in second growth states that the extra cost is offset by the advantages in limbing, attaching the pass block, and doing part of the rigging while the tree is on the ground. On tractor settings landing trees are used only for loading, and requirements are less exacting.

In locating a tentative landing the forester-engineer must be familiar with the surrounding topography and stand conditions. It was necessary to see if any obstacles such as sharp, minor ridges and ravines, long convex slopes, or rock outcroppings not shown on the map prevented reaching out economical yarding distances. This was especially important in areas of sidehill and downhill yarding where providing sufficient lift to yard logs was already a problem. Timber beyond economic yarding distance (long corners) may be better yarded to an adjacent landing. This possibility was checked on the ground.

As the forester-engineer checked his yarding problems within the setting, he studied and made notes on the stand conditions that would influence his management decisions. Settings containing mostly overmature timber that is deteriorating rapidly should be in the initial cut, and those with immature age classes left until later. When both are intermingled in the same setting, there is the possibility of changing the landing and cutting boundary to separate them. If this was not practical on the experimental areas, as was often the case in high-lead settings, the values that would be lost through postponing the cut in old growth were balanced against the values that would be lost by cutting the young stand. In tractor settings it was easier to separate the immature stands, or even possible to log the scattered old growth from them. The opportunities for intermediate harvest cuttings on gentle topography were also noted.

The distribution of timber within the setting was noted. If it was heavily concentrated on one side, it was sometimes better to move the landing in that direction for more efficient yarding. However, provision then had to be made for a centrally located landing to serve future rotations when the stand was likely to be more uniform.

How to obtain regeneration on the setting was considered. If the trees in the adjacent leave settings were not old enough to provide seed immediately, planting was considered. The cutting boundaries were generally located to facilitate efficient slash burning. However, settings with adequate thrifty advance reproduction or very thin soil were noted since they are best left unburned. Brushy areas that would be hard to regenerate with trees were noted because they required special attention to eliminate the brush during logging and slash burning.

The forester-engineer also should visualize what effect the pattern of skid roads might have on erosion. The pattern resulting from yarding uphill tends to fan out and spread the runoff water; downhill yarding tends to concentrate the water and increase erosion. Tractor yarding, since it is almost always downhill, is certain to concentrate the runoff water unless special provision for lateral drainage at regular intervals is made.

As each setting was checked in the field, its road, landing, and cutting boundary were plotted on the map to be sure they would tie in with adjacent settings. On the experimental areas the road traverses were used as a control for plotting. Yarding distances were scaled from the map or measured on the ground. This procedure showed up any "long corners" that could not be economically reached in the first or succeeding cuts. There was some temptation to classify this timber as inaccessible, but by adjusting landings and cutting boundaries a satisfactory method of logging it was always found.

The Final Plan and Initial Cut

As the forester-engineer completed the field checks and alterations of the roads, landings, and cutting boundaries on these experimental areas his paper plan evolved into the final forestry-logging plan. Sometimes this final plan was entirely different from the original one on paper. But it was a better plan. It was based on an intimate knowledge of the ground conditions on each setting. Such a plan enabled the forester-engineer to make the best compromise between economic and forestry considerations, not only for each setting but for the entire stand. He was sure that his road system was one of the most economical that would serve the timber, that construction and maintenance costs would not be excessive, that good landings and efficient yarding distances would be used. Besides providing for economical logging, his plan included many practical provisions for long-range forestry. Regeneration of cut-over areas would be facilitated by an adequate seed source and proper ground conditions, the slash and accidental fires could be efficiently controlled, and erosion and siltation would be minimized.

It would be possible to plan a cheap road system to serve only the staggered settings of the first cut, but this would leave behind fragmentary settings needing expensive additional roads to harvest later cuts. The complete forestry-logging plan avoids these problems.

The next step was to select settings for the initial cut. The forester-engineer's intimate knowledge of the area and his notes on each setting helped make these decisions. The settings selected were those silviculturally most in need of cutting. They had overmature, degenerating, or poorly stocked stands, poor quality species, patches of brush in need of regeneration, or areas of windfall or insect damage. The settings left for harvesting later in the rotation had young, vigorous stands, the best-preserved old-growth stands, or were on gentle topography where mortality could be salvaged. Occasionally settings in need of cutting were left and vigorous stands taken to follow the staggered-setting pattern which would assure adequate seed supply and reduce fire hazard.

If the initial cut had too many low-value settings, some high-value ones which could have been left until later were included to make an economical operation. A proportion of the high-value settings at low elevations were reserved to be cut with marginal settings at higher elevations. This provides a longer operating season, more steady employment, and helps carry the cost of the marginal settings. Some settings had to be combined to make larger cutting units. This was necessary when swing settings were used. Since a landing on a road in an adjoining setting was required, this setting was usually logged too. Also on long, steep slopes where logs would slide from one setting to the other or a fire would be hard to hold, both settings were put in a single unit. Sometimes as many as three settings were grouped to make a larger cutting unit when more volume was needed to pay for the initial road development.

The road system needed for the initial development depends on the selection of settings. Cutting units can be selected to provide roads through good topography where salvage is needed. They can be adjusted to provide maximum fire protection. Or the pattern may be designed to build a main road through the stand to open up the timber beyond. It will also determine how much of the total road costs will be charged against the initial cut.

After the units had been selected for the initial cut, the cutting boundaries were posted with aluminum tags. Some variations from the boundaries shown on the forestry-logging plan were made to include brush patches, snag patches, and road rights-of-way in the take settings and to leave immature age classes in the leave settings. Single trees just outside the cutting line that leaned into the unit were marked for cutting. Cutting boundaries were traversed as they were posted to provide an accurate check on yarding distances and to prepare a map. This traverse can be made to sufficient accuracy by one man using a hand compass for direction and a 10-foot pole to measure distance. Before the boundary was traversed, a field map was prepared showing the landings in the unit and the adjacent landings. As the locator moved along he plotted his position on the map. When he encountered some trees that could go to more than one landing, he scaled the distances to the spar trees involved, and considered the effect of the local topography in deciding where the trees would go most economically. Creeks, ridges, roads, and trail crossings were mapped and location markers posted as the boundaries were traversed. The resulting maps were used later for planting and slash-burning plans.

To obtain an accurate map of the forestry-logging plan, the cutting unit traverses were combined with the traverses of the road locations.

A volume and quality cruise was made as a basis for appraisal of the initial cut. Only the settings to be cut were cruised. Road length, estimated cost per mile, length of fire line needed, acreages to be planted, average and maximum yarding distances, proportion of tractor settings, and cost of special silvicultural requirements all had to be estimated. Data already collected plus intimate knowledge of the area provided sound basis for these estimates.

In subsequent sales involving the leave settings the only remaining jobs are posting of cutting boundaries on the uncut units, cruising, and retracing some of the road locations.

Costs

Preparing an intensive forestry-logging plan that considers both cut and leave settings and the entire road system of an area is necessarily more expensive than planning only for the staggered settings to be cut in the initial development, but few figures on the extra expense are available. Therefore, accurate cost records were kept on each of the experimental areas. Eventually it will be possible to evaluate whether the increased planning costs will be more than offset by savings resulting from a complete forestry-logging plan. Present indications are that the costs of these systematic layouts will be repaid manyfold by resulting benefits. The records from five different areas show that the intensive plans have cost about 12 cents per thousand board feet for the initial cut (table 1). When the total volume on both the first cut and leave units is considered, the costs averaged only about 3 cents per thousand. Additional layout costs for the leave settings should be low.

The costs shown in table 1 include the following items:

(1) General reconnaissance of the area to gain intimate knowledge of all the forestry and logging problems.

(2) Centerline or grade-line road locations for all settings, both cut and leave.

(3) Posting cutting boundaries for cut settings and reconnaissance of boundaries for leave settings.

(4) Preparation of maps showing both cut and leave settings.

(5) Travel time, subsistence, and annual leave.

Cost of topographic mapping and cruising is <u>not included</u>.

The first intensive sale layout was made for a mature Douglas-fir stand at Henderson Creek, near Florence, Oregon, in 1947. Costs were higher than on other areas probably because of an inexperienced crew and considerable travel time. The two sales on Cascade Head Experimental Forest near Otis, Oregon, were in young stands of spruce and hemlock and two on the Blue River Experimental Forest near McKenzie Bridge, Oregon, were in old-growth Douglas-fir. Staggered settings ranged in size from 13 to

66 acres. A few of them on moderate topography were tractor settings. Topography was moderate to steep on all except the Blue River 1949 sale, which was in extremely rough country.

It is interesting to note that there is not much variation between the sales in cost of layout per M sold. This was true even though the work was done by several different crews and under wide variations in age class and location. The accumulation of experience is evident from the small but gradual reduction in cost per M shown in table 1.

A preliminary estimate of the total cost of all the pre-logging jobs involved in an intensive forestry plan can be made by taking the cost from table 1 and adding to it the average cruising and mapping costs for any particular area. As an example, the additional costs for the Blue River 1950 sale were 0.7 cents per thousand for mapping and 1.7 cents for cruising. A topographic map made from aerial photographs was used in this sale, and only those settings sold were cruised. This brought the total cost per thousand for the entire intensive pre-logging job to 13.1 cents.

SUMMARY

In this paper techniques and principles used to prepare intensive forestry-logging plans on five experimental areas are presented as preliminary suggestions for practicing foresters. Using staggered settings a combined forestry and logging plan was prepared for the entire stand before any cutting was done. Without this complete plan, areas left for later harvesting would not have been logical logging units, the roads might not have served them, and the opportunities for silviculture, fire protection, and watershed management would have not been known. To gain fullest benefit from such planning, one man--trained in both forestry and engineering--should be responsible for the plan. He will utilize maps and other aids, but the quality of his final plan will depend on his intimate knowledge of the ground and stand conditions of every setting.

In preparing the forestry-logging plan a brief reconnaissance is made and then a logging plan is drawn on the topographic map before further field work. This plan is a tentative layout on a map of the roads, landings, and cutting boundaries needed for the first and succeeding cuts in the stand. It is taken into the field, where obstacles to application of the plan can be spotted in the course of marking out the roads and landings and the plan altered to fit conditions on the ground. When a final pattern of roads and landings that will serve

Table 1.--Intensive forestry-logging plan costs on five areas in western Oregon [1]

Area designation	Age of stand	Size of area: Initial cut	Size of area: Total[2]	Timber volume: Initial cut	Timber volume: Total[2]	Man days	Cost of plan: Total	Cost of plan: Per M initial cut	Cost of plan: Per M served by plan	Cost of plan: Per acre served by plan
	Years	Acres		M bd.-ft.			Dollars			
Henderson Creek	150	253[3]	416	11,000	35,000	90	$1,575	$.143	$.045	$3.79
Cascade Head #3	100	138[3]	395	5,230	27,650	38	608	.116	.022	1.54
Blue River, 1949	400	192	860	9,000	43,000	60	1,045	.113	.024	1.22
Cascade Head #5	100	160[3]	740	7,750	51,800	47	812	.105	.016	1.10
Blue River, 1950	400	356	1,850	23,600	111,000	150	2,829	.107	.024	1.53
Total		1,099	4,261	56,580	268,450	385	$6,869	--	--	--
AVERAGE PER M INITIAL CUT						.0068	$.121	--	--	--
AVERAGE PER M TOTAL STAND						.0014	$.026	--	--	--

1/ These do not include mapping and cruising costs.

2/ The total area and volume served by the plan including both cut and leave areas.

3/ These areas include one or more partial cutting units.

the entire area is developed, this becomes the forestry-logging plan. Then the units to be cut first and those to leave until later are decided upon and the cutting boundaries posted for the first harvest.

The principles observed to obtain an efficient road system were:

1. Road levels were spaced to provide an economic balance between road construction and yarding costs. Connecting roads that do not serve logical settings were kept to a minimum.

2. For economy, road standards were varied depending upon the volume they served.

3. Roads were located so as to minimize stream siltation and to be useful in salvage operations and future thinnings.

4. Quick methods, employing one man, were used in the field to discover and find solutions for problems in road construction on these locations.

In evolving the pattern of settings, the guiding principles were:

1. The choice between tractor and high-lead settings was based on topography and considered relative yarding cost, the risk of soil disturbance, and the need for salvage as well as present and future partial cuttings.

2. All landings were checked in the field for space to land logs and strategic location within the setting.

3. Cutting boundaries were located so they would assure economic yarding distances from known landings, make fire protection easier, hold logs within the setting, minimize erosion, and prevent windfall loss.

4. Checks were made within the setting for obstacles to yarding such as ridges, ravines, and rock outcroppings.

5. Stand conditions that affected management decisions were noted. These included age, stocking and vigor of the stand, salvageable mortality, seed source, reproduction, brushy areas, and erosion problems.

Most settings selected for the initial cut had stands that were overmature, degenerating, poorly stocked, or damaged. Some had poor species composition or brushy areas. Settings usually ranged from 15 to 30 acres. They were selected as individuals or lumped into larger units. The pattern was adjusted to consider salvage logging and fire protection, to enhance the stumpage value of leave settings, and to gain access to timber beyond.

Final steps were map preparation and appraisal of the initial cut.

Records from the five experimental areas show that costs of intensive forestry-logging plans, based on the initial cut, were about 12 cents per thousand board feet. Based on the total area included in the plan costs were about 3 cents per thousand. Present indications are that the cost of this planning should be repaid many times through more efficient logging of the timber covered by the plan.